National Environment Protection
(Ambient Air Quality) Measure

- Revised Impact Statement

NEPC

NEPC
NATIONAL ENVIRONMENT PROTECTION COUNCIL

Copies are available from:

National Environment Protection Council Service Corporation
Level 5 81 Flinders Street
ADELAIDE SA 5000
Telephone: (08) 8419 1200
Facsimile: (08) 8224 0912

This document is also available on our website: http://www.nepc.gov.au

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GLOSSARY OF ACRONYMS AND TERMS

Glossary of acronyms

ADR...................... Australian Design Rule
ALGA................... Australian Local Government Association
ANZECC............. Australian and New Zealand Environment and Conservation Council
CO......................... Carbon monoxide
COAG................... Council of Australian Governments
COPD .... Chronic Obstructive Pulmonary Disease
EPA....................... Environment Protection Authority
FEV_1 .... Forced Expiratory Volume (one second)
IGAE..................... Inter-Governmental Agreement on the Environment
FVC .... Forced Vital Capacity
JRN....................... Jurisdictional Reference Network
LOAEL................. Lowest Observed Adverse Effect Level
MAQS................... Metropolitan Air Quality Study (NSW)
NATA................... National Association of Testing Authorities
NEPC.................... National Environment Protection Council
NEPM................... National Environment Protection Measure
NGO .... Non-Government Organisation
NO_2 .... Nitrogen dioxide
NO_x .... Nitrogen oxides
NOAEL................. No Observed Adverse Effect Level
NMHC.................. Non-methane hydrocarbon
NHMRC .... National Health and Medical Research Council
O_3 .... Ozone
PM_{10}...................... Particles which have an aerodynamic diameter less than 10 μm
$PM_{2.5}$ .... Particles which have an aerodynamic diameter less than 2.5 μm
PPM...................... Parts per million
PRC....................... Peer Review Committee
ROC...................... Reactive organic compound
SO_2........................ Sulfur dioxide
SoE .... State of the Environment
TSP .... Total suspended particles
VOC...................... Volatile Organic Compound
WHO..................... World Health Organisation
μg .... Microgram (1 millionth of 1 gram)

Glossary of terms

Repetitious Population Exposure: a measure of outdoor population exposure to air pollution, obtained by summing over a year and over all locations in a region the multiplication of the population residing at a given location by the estimated number of exceedences of a nominated population level at that location.

Population affected: a measure of the population affected by one or more exceedences per year of a defined pollution level, obtained by summing over all locations in a region the population residing at a given location if the annual maximum pollution level exceeds a nominated pollution level at that location.

INTRODUCTION

NATIONAL AIR QUALITY STANDARDS FOR AUSTRALIA

BACKGROUND

As a signatory to the "Rio Declaration" Australia is committed to achieving ecologically sustainable development.

Clean air is essential to this aim but how clean is clean? The National Environment Protection Council (NEPC) was established to develop, among other things, national ambient air quality standards that would provide Australians with a bench mark to assist in achieving the objective of ensuring that people enjoy the benefit of equivalent protection from air pollution.

In setting air quality standards the NEPC has examined the latest health related air pollution research from around the world, examined the information available on the current state of our major airsheds and, taking into account the technology that is readily available, assessed what level of air quality we could achieve within ten years, without significant social and economic disturbance.

The resulting standards are a first step in establishing a consistent approach to managing air quality around Australia, with the ultimate aim of providing equivalent protection to all Australians wherever they live. Compliance with the standards will be assessed by measurements made at designated performance monitoring stations or by equivalent methods approved by the NEPC. Reports on compliance will be publicly available.

The national standards in the NEPM will replace state by state standards, guidelines, goals or objectives, some formally adopted, some informally used for reference, that have been in use for many years. By having a common set of air quality standards and consistent methods of measuring compliance Australians will be better able to assess the quality of the air they breathe and will be better able to compare their air quality with other cities. Governments will also benefit by being in a better position to assess the relative importance of air quality in setting priorities and industry will be better informed when making investment decisions.

Programs to improve and protect air quality will still be the responsibility of each individual State and Territory and the Commonwealth. However, a number of national programs, such as the control of motor vehicle emissions, will continue to be conducted at the national level.

THE PROCESS

The National Environment Protection Council (NEPC) was established in 1995 through legislation passed by all State, Territory and the Commonwealth parliaments. NEPC is empowered, on the basis of a two third majority vote by its members, to make national environment protection measures that automatically become law within each jurisdiction in accordance with the legal framework of each jurisdiction. The objectives of the NEPC

Acts is to provide equivalent environmental protection to all Australians *wherever they live* and to ensure that markets are not distorted by environmental decisions.

In making a National Environment Protection Measure (NEPM or Measure) the Council must, as a minimum, follow the process set out in the *NEPC Act, 1994*. In developing a NEPM for ambient air quality, Council, recognising the need for significant input on this important issue, expanded the process beyond that required by legislation.

In summary the process involved:

- *a decision to commence the process to develop ambient air quality standards for the major pollutants for the purpose of protecting human health, a monitoring protocol to assess compliance with the standards, and a goal to be achieved within ten years;*
- *advertising that decision, with an invitation to anyone with an interest to make a submission;*
- *release of an initial public information sheet and hosting of a stakeholders' workshop in Adelaide;*
- *establishment of a project team and a Non-Government Organisation (NGO) Advisory Committee;*
- *commissioning of a number of consultancies to provide informed input to the project team's deliberations and technical review panels of relevant experts (some nominated by industry) were formed to provide peer review comment on the consultant reports;*
- *meetings between stakeholder groups and government officials;*
- *publishing a 200 page paper for discussion which set out proposals for the NEPM and submissions invited (over 100 were received);*
- *public meetings and meetings with key stakeholders that were held around the country and meetings conducted by professional groups were serviced;*
- *the formal submissions and comments made at the various meetings were analysed and taken into account in preparing a draft NEPM and impact statement;*
- *release of a draft NEPM and impact statement for three months public comment;*
- *public meetings held around the country (again) as well as meetings with stakeholder groups; (more than 50 meetings were held throughout the process);*
- *the formation of a Key Stakeholders Group with representatives from industry, the environment movement and government (with a wider audience than previously involved) with an independent facilitator to identify outstanding issues and recommend mechanisms for resolving them;*
- *the analysis of all of the formal submissions (171 received) and comments from formal and informal meetings and preparation of a response document for written submissions;*
- *the revision of the draft NEPM on the basis of the consultation program and externally reviewed by an international air quality specialist;*
- *the consideration of the final NEPM and accompanying documentation by all state and territory governments and the Commonwealth; and*

- *finally the consideration of the NEPM by the NEPC in terms of the requirements of the NEPC Acts and the decision was made to make the measure*

HOW DOES THE NEPM APPLY?

All governments are required to report annually on progress towards meeting the goal of the NEPM. To comply with the NEPM, governments are required to adopt the standards and the monitoring protocol as the means for assessing air quality against the goal of the NEPM. There is no other requirement placed upon governments but most state governments have active air quality management programs which are expected to continue into the future. The success of these programs may, in part, be judged by their effectiveness in meeting the goal of the NEPM.

There is no requirement on governments to change their programs or to introduce new 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 will provide a sound basis for assessing the extent of any problems in the major airsheds and, therefore, assist governments in setting priorities.

The annual compliance reports from each jurisdiction to the NEPC will be tabled in each of the parliaments and made public. Jurisdictions have also undertaken to make detailed monitoring data from the performance monitoring stations available to the public in a form that is readily understood.

WHAT IS THE SCOPE OF THE NEPM?

A number of issues were raised during the consultation process about the scope of the NEPM. The NEPC Acts confine the role of this NEPM to ambient air quality. That is it can only deal with air quality outside buildings. Many Australians spend much of their time indoors and it would therefore be expected that indoor air quality might be a more significant health influence than ambient air quality. However, most of the epidemiological research on air quality (the relationship between community health and air pollution) has related to ambient air quality. This means that such relationships will encompass some unknown degree of influence from indoor air quality. But since indoor air starts off as outdoor air, strong relationships between ambient air quality and physiological symptoms are likely, if anything, to be understated.

In recognition that this is the first ambient air quality NEPM the NEPC determined to confine it to impacts on human health of the major pollutants within the general mass of air in the major airsheds. Unless there is evidence to the contrary, small settlements are assumed to have acceptable air quality. Therefore, physical monitoring of these areas is not required under the protocol. The major exceptions are those settlements where the local air shed is heavily influenced by a major pollutant source.

Conversely, the air quality of some localised areas within major airsheds are dominated by local activities such as that experienced in a road tunnel or a heavily trafficked canyon street. Air quality management in these areas is complex and needs a different approach to that directed at meeting ambient standards intended to reflect the general air quality in the airshed. The NEPM is intended to apply to the latter (ie. general ambient air) allowing for the protection of the overwhelming majority of Australians wherever they live in Australia. In the case of ozone, the highest concentrations generally occur many kilometres from the source of primary emissions, often over populated areas. Accordingly, the NEPM standard for ozone will represent a level which jurisdictions will work to achieve in accordance with the monitoring protocol for this NEPM.

HOW WERE THE STANDARDS CHOSEN?

NEPC commissioned a leading respiratory physician, with a long standing reputation and interest in the health impacts of air pollution, as a consultant to review the relevant scientific literature and provide advice on the health impacts of air pollution and identify the range of concentrations necessary to protect public health from the six pollutants of concern. This work was formally reviewed by a team of other Australian specialists. While there was not complete consensus on the concentrations of concern there was a high degree of agreement. The consultant’s work was sent to overseas specialists for comment and its conclusions supported.

The health research drawn on was largely epidemiological studies supplemented by laboratory studies on individual or groups of subjects. Research of this kind, dealing as it does with the physiological responses of the human body, is never precise and is still evolving. There is thus no ‘right’ concentration of pollutants that will guarantee total health protection for all citizens. Indeed, health authorities have declined to set threshold limits for some pollutants because concentration limits that produce no ill effects have yet to be identified. Air quality standards are thus set by considering the levels at which health effects occur and the levels that are realistically achievable.

The airsheds in Australia covering the major urban settlements have been monitored to varying degrees for up to thirty years. The available data were examined to determine, within the limitations of the data, the pollutant status of the airsheds. Following a review of the technologies readily available for the control of polluting emissions, an assessment was made of the improvements that could be achieved in air quality around the country over the ten-year period of the NEPM. A set of standards and a ten-year goal in relation to meeting them was then proposed. Following public comment these were reviewed and amended where appropriate. A copy of the final Measure is annexed to this document.

The standards, therefore, represent a high degree of consensus among leading health professionals, varied to reflect what is realistically achievable in Australia over the next ten years. Some industry groups have expressed the view that in some isolated cases the goal cannot be met even in a ten-year time frame. However, jurisdictions will have the capacity to allow for a longer period to reach the goal if necessary in such isolated cases. Given the pace of technological change and the global pressures on companies to adopt ‘best practice’ in environmental management it is likely that any reductions in pollutant emissions which may be required to achieve the standards can be achieved within or close to the ten year goal.

ISSUES

Implementation

Implementation of the NEPM will involve preparation of monitoring plans by each jurisdiction, in accordance with the Protocol, within three years of the Measure coming into effect. One of the major benefits of the NEPM will be the development of nationally consistent databases for the major airsheds. To achieve this, monitoring systems will need to be consistent while reflecting the characteristics of the different airsheds and different monitoring approaches. A Peer Review Committee (PRC) of monitoring specialists will be established to assess monitoring plans and advise on their appropriateness. The PRC will comprise a nominee from each jurisdiction, two nominees from industry, two from the environment movement and one from local government. The Terms of Reference for the PRC will be determined by Council following advice from the PRC.

Each jurisdiction will be required to provide an annual report to NEPC on progress towards implementing the Measure. These reports will address progress on preparation of monitoring plans, implementation of monitoring plans and assessment of air quality, in accordance with the Protocol, against the Goal of the Measure.

As already mentioned, most jurisdictions have well developed air quality management programs and at the national level, there is a well-developed process for adopting motor vehicle emission controls. These will continue to develop as knowledge increases and new technologies become available. In major urban centres road transport has been identified as the most significant source of polluting emissions. Australia is effectively locked into international technology for motor vehicle emission controls and government policy is to harmonise Australian emission standards with those promulgated by the UN Economic Commission for Europe (ECE). This will mean automatic continuous improvement in emission control technology. However, because of the age of the Australian fleet and its slow turn over, Australian governments may need to address in-service emission issues more effectively than in the past to offset increasing vehicle numbers. Such measures are already contemplated and, while not flowing directly from the NEPM, will be assisted by it since the effectiveness of national measures are best assessed against national standards.

Benefits and Costs

In establishing a set of national ambient air quality standards and associated monitoring protocol the NEPM 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 air pollution. 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 those with high sensitivity to air pollution) and possibly behavioural change. Overall the adoption of the NEPM should lead to improved protection of public health.

Because the NEPM deals only with the assessment of air quality by governments the direct costs are incurred by governments except where other bodies are required to provide ambient monitoring facilities which are incorporated in a jurisdictional monitoring plan.

Jurisdictions will need to assess the most cost-effective means of complying with the monitoring protocol. In most cases some changes to existing programs for assessing air quality will be required but definitive costs cannot be identified until the PRC has been established and proposed jurisdictional monitoring plans assessed.

Over the past thirty years hundreds of millions of dollars have been spent by industry, motorists and governments in reducing discharges of pollutants to air. Similar programs will continue in individual jurisdictions and at the national level. Procedures are in place to ensure that any regulatory measures adopted as part of such programs are exposed to public scrutiny including the costs and benefits. It is also worth noting that voluntary programs are playing an increasing and effective role in air quality management strategies. These include both industry emission reduction programs and behaviour change programs by motorists often sponsored by motoring organisations.

Equivalent Protection and market distortion

The objects of the NEPC Acts are to ensure that, by the establishment and operation of the NEPC, people enjoy the benefits of equivalent protection from air, water or soil pollution and from noise, wherever they live in Australia; and decisions of the business community are not distorted, and markets are not fragmented, by variations between participating jurisdictions in relation to the adoption or implementation of major environment protection measures. No single NEPM will of course achieve these objects but each must be consistent with them. This NEPM contributes to equivalent protection by providing a common set of indicators of air quality (through standards and the monitoring protocol) and access to information on air quality for all Australians. The common standards will also facilitate the development of greater consistency in emission control requirements and, in particular will facilitate the more effective development of national emission standards where these are appropriate.

Regional environmental differences

Air quality is determined by a combination of pollutant emissions and meteorology complicated in some cases by physical factors such as topography and urban form. NEPC has considered the relevance of regional environmental differences in Australia in setting national air quality standards. While recognising the wide variation in climatic and other environmental conditions and taking into account the wide variation in physiological responses across any community, NEPC has concluded that there is no practical way of reflecting regional environmental differences in ambient air quality standards with the present state of knowledge. Where special regional environmental conditions exist NEPC believes these are best addressed through tailored air quality management strategies and are therefore outside the ambit of the NEPM.

Monitoring

Achievement of the ten-year goal is to be assessed by the approach specified in the Monitoring Protocol. Since differences in the way monitoring stations are located, samples collected or in the analytical methods used, can produce quite different results, there is a need to establish a standardised approach to monitoring and reporting data. There are however, practical difficulties such as in finding suitable locations for monitoring stations and in servicing them. Further*more*, analytical methods and instrumentation are constantly improving and it would not be beneficial to exclude such advances from the NEPM. NEPC has therefore determined not to be prescriptive in the Protocol but to put in place a mechanism that will achieve the dual objectives of consistency in assessing compliance and comparability of data between airsheds.

These objectives will be achieved through adopting Australian standard methods as the main reference methods. A requirement is made that any alternative methods used must provide information equivalent to measurements which would otherwise be provided by the reference method. The siting of performance monitoring stations will be subject to assessment on advice from the PRC to ensure comparability between airsheds.

In some jurisdictions physical monitoring is carried out in conjunction with computer modelling. This allows for compliance to be assessed at a larger number of sites and for more complete information on an airshed to be obtained. Monitoring plans will be able to include this approach by demonstrating its accuracy and identifying how its outputs will be integrated with the information obtained by conventional monitoring.

Finally, since ambient monitoring is expensive, maximum value from expanding monitoring networks will be obtained where assessment indicates air quality is consistently 50% or more of a given NEPM standard.

The standards

Some of the proposed standards raised particular concerns during the public consultation.

Some industry representatives queried the need for a short-term (1 hour) sulfur dioxide standard. However, such a standard already exists in most jurisdictions either in a formal sense or by adoption of the NHMRC goals. Environmental/community groups strongly recommend that a shorter-term 10 minute standard be introduced. The health review conducted for NEPC recommended a shorter term (10 minute) standard and this was generally supported by the Technical Review Panel of experts drawn from industry, health and environment groups. Further support came from health authorities in some jurisdictions and from representatives of the environment movement. However, having reviewed the industry position, along with the health expert and environmental groups comments, and the capacity to validly monitor compliance with a 10 minute standard at this point in time, Council decided that the 1 hour standard for sulfur dioxide should be adopted, and has further agreed to a review of the practicability of developing a 10 minute sulfur dioxide standard within 5 years (see Future Actions below).

Particles are clearly an area of major concern and one where the science continues to evolve. NEPC has already made clear its commitment to keeping this issue under review, collecting more Australian based data and revisiting the question of appropriate size fraction at an early stage.

Lead is a significant issue for both industry and community representatives. NEPC recognises that actions already taken at both the national level and within individual jurisdictions has significantly reduced lead concentrations in urban air and will continue to do so for some years. The standard proposed is now met in most locations. Regional centres with stationary source or historical problems would seem to be able to meet the ten year goal on the information available. Given that lead has no known beneficial biological role, the standard represents a useful benchmark for the future and is proposed so as to maintain the gains already achieved in reducing lead pollution.

FUTURE ACTION

This NEPM is the first step in developing a more consistent approach to air quality management in Australia so that Australians can enjoy equivalent protection from the adverse health impacts of air pollution and markets are not distorted etc.

To further facilitate this objective the following actions will be taken:

- ***establish a Peer Review Committee with NGO representation to advise on jurisdictional monitoring plans;***
- ***establish a taskforce to investigate a risk assessment approach to guide the application of standards, to report within 3 years;***
- ***by 2001 commence a review of the particles standard, in particular, the need for a standard less than 2.5 microns;***
- ***by 2003 commence a review of the practicability of developing a 10 minute sulfur dioxide standard;***
- ***by 2003 commence a review of the practicability of setting a long term goal (> ten years) of achieving a one hour average standard for photochemical oxidants of 0.08 ppm measured as ozone within the major urban airsheds;***
- ***make public all jurisdictional monitoring plans assessed as complying with the NEPM;***
- ***make public annual monitoring reports prepared by the jurisdictions in accordance with the NEPM; and***
- ***commence a review of the NEPM in 2005.***
- ***jurisdictions will commence or continue programs for monitoring particles less than 2.5 microns in major airsheds to provide the basis for NEPC to review the need for a related standard***
- ***Jurisdictions will collect and collate information to enable a review of the practicability of a 10 minute standard for sulfur dioxide.***

CHAPTER 1
EXPLANATION OF THE NEPM

1.1 BACKGROUND

The National Environment Protection Council (NEPC) is a body established by each State and Territory and the Commonwealth Government to work cooperatively at a national level 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 member Governments. The NEPC stems from the *Inter-Governmental Agreement on the Environment (IGAE) 1992*, which agreed to establish a national body with responsibility for making National Environment Protection Measures (NEPMs or Measures). The operation of NEPC is covered by the *National Environment Protection Council Act, 1994.*

NEPMs are broad framework-setting statutory instruments which, through an extensive process of inter-government and community/industry consultation, reflect agreed national objectives for protecting particular aspects of the environment.

1.2 CONTEXT OF THE AMBIENT AIR QUALITY NEPM

Air pollution is an undesirable by product or waste from the use of fossil fuels and other sources related to a broad range of industrial, rural/agricultural, commercial and domestic activities which underpin our modern industrial society and support the Australian lifestyle. The most common pollutants discharged to the air are oxides of nitrogen, carbon monoxide, sulfur dioxide, and airborne particles including lead.

In urban areas the pollutants of most concern are **ozone**, **nitrogen dioxide**, **particles** and to a lesser extent **carbon monoxide.** Ozone, is a secondary pollutant formed in sunlight by chemical reactions between oxides of nitrogen and reactive organic compounds (ROCs) from evaporating solvents, liquid fuels and fugitive vapours. These pollutants are produced largely by motor vehicles, domestic and commercial heating and cooking, and industrial activities. In regions outside the major urban areas, air pollution is mainly produced by power generation, mining and minerals processing and agricultural activities. As well, **sulfur dioxide** is produced in the roasting of sulfur-containing ores. **Lead** sources include the exhausts of vehicles fuelled by leaded petrol and particulate discharges from the smelting of lead-containing ores.

When considering the need for air quality standards it was recognised that Australia does not have the significant air quality problems faced by other developed and developing countries. However, there are a number of areas where problems do exist and the potential for air pollution to become a problem remains.

The OECD have recently published (1998) a report on Australian air management in its "Environmental Performance Reviews" series. The following text reports the OECD's findings as reported in the 'Conclusions and Recommendations' chapter of the report.

"Overall Australian cities do not have the acute air pollution problems found in a number of major cities in OECD countries and air quality in Australia is generally good. Urban air quality has improved over the past ten years as a result of both air pollution management (characterised by voluntary approaches and the case-by-case method of licensing stationary sources) and structural changes such as the increased use of natural gas. The introduction of three way catalytic converters in new vehicles in 1986 helped reduce emissions of NO_x, VOCs and CO. Recent reductions in airborne emissions of lead represent another achievement for Australia's air management policy, and one that can be considered exemplary in terms of co-operation among different levels of government, industry and the public. SO_2 concentrations in major urban air sheds are well below levels of concern: power stations are generally far from urban areas and the sulfur content of Australian coal is low. Efforts are being made in several cities to integrate air management considerations in transport and land use planning.

Nevertheless, surveys indicate that Australians' major environmental concern is air pollution and public expectations for air quality management are high. A priority is to ensure that the improvements of the past ten years are not offset by increased pollution pressures from industrial, agricultural, energy and transport activities. Substantial breaches of SO_2 guidelines have occurred near some industrial and mining sites. Agriculture is responsible for large shares of CO, NO_x, CO_2 and methane emissions. Total and energy-related CO_2 emissions are increasing. Urban areas, where 70 percent of the population is concentrated, experience episodes of high pollution by CO, photochemical smog and particulates. Further measures to reduce NO_x, VOC and particulate emissions should be considered in the near future. Concerning new and in-use vehicles and fuel quality, a range of essentially regulatory measures applied in other OECD countries could make a cost-effective contribution to reducing emissions of these pollutants, which play a major role in urban air quality, particularly in areas of rapid growth such as south-east Queensland, Perth and western Sydney. The lack of a national approach to the adoption of ambient air quality guidelines has resulted in inconsistencies among States and Territories, and progress in setting national ambient air quality standards has been slow. The current air quality monitoring programme covers six capital cities and major industrial centres, but about 8 million people live outside monitored areas. Where air quality and emission data exist, they are dispersed among different industries and government agencies. As a result, Australia lacks a national database on air quality and emissions, which is essential for better definition and evaluation of air management strategies. Initiatives already in place, such as the National Pollutant Inventory and the call in the Intergovernmental Agreement on the Environment for a national approach to data collection and handling, could help rectify this situation, though neither initiative has yet been fully implemented.

It is recommended that consideration be given to the following proposals:

- *take concrete actions to ensure compliance with the National Environment Protection Measures, which will set national ambient air quality standards;*
- *establish a national database on air quality and emissions;*

- *extend monitoring to cover more of the 8 million people currently living outside monitored areas, and to better measure ground-level ozone, PM_{10} and air toxics;*
- *in consultation with the oil industry, define a programme for improving fuel quality, notably with respect to reducing vapour pressure, sulphur [sic] content and benzene and other aromatics;*
- *speed up the pace at which leaded gasoline is phased out;*
- *ensure that new vehicles are subject to emission standards equivalent to "best practice" standards in other OECD countries, for both gasoline and diesel vehicles;*
- *take measure to improve the maintenance and emission performance of in-use vehicles, including mandatory regular pollution checks for all cars; consider the cost-effectiveness of measures to accelerate fleet renewal, such as a premium for scrapping old vehicles;*
- *strengthen policies on energy efficiency, notably by accelerating the adoption of efficiency standards for non-residential buildings, domestic appliances and motor vehicles;*
- *intensify transport planning response to air pollution, with the aim of reducing the need for private vehicle travel, notably in urban areas."*

- from "Environmental Performance Reviews - Australia"
OECD 1998, pp 25-26.

1.3 HEALTH EFFECTS OF AIR POLLUTION

Air pollutants cause adverse effects on human health if they are present in air at sufficient concentrations and for a sufficient length of time. Health effects associated with the six common pollutants include respiratory effects, ranging from minor symptoms such as cough to the more serious, eg chest congestion and asthma, to the very serious such as chronic illness and possibly death. Where a relatively minor symptom occurs the aggregate effect can often be very debilitating, particularly for susceptible subgroups. Other effects of air pollutants include damage to vegetation, buildings and materials, and reduction in visibility. While the pollutants referred to in this paper can adversely affect human health both individually and in combination at sufficient concentrations, their effects are generally assessed separately in setting ambient standards.

1.4 AMBIENT AIR QUALITY MEASURE

On 21 June 1996 the NEPC resolved to make a national environment protection measure for ambient air quality for the following six pollutants:

carbon monoxide	nitrogen dioxide
photochemical oxidants (as ozone)	sulfur dioxide
lead	particles

A Notice of Intention to prepare a draft of the NEPM on ambient air quality was published in the *Commonwealth of Australia Gazette* (No. GN 28, 17 July 1996), and in *The Australian* and major newspapers in each State and Territory. The Notice advised of the Council's intention to prepare a draft NEPM on ambient air quality which would include a **goal**, ambient air quality **standards** for the above mentioned pollutants and monitoring and reporting **protocols** for the six identified pollutants.

1.4.1 What is a goal?

A national environment protection goal means a goal:

- that relates to desired environmental outcomes, and
- that guides the formulation of strategies for the management of human activities that may affect the environment.

A Goal may be something desirable in the future and not immediately attainable but should represent the aspiration of the Australian people for environmental quality.

The Goal of the draft Ambient Air Measure is to achieve the standards (allowing for exceedences) at performance monitoring stations in 10 years.

1.4.2 What is a standard?

A National Environment Protection Standard means a standard that consists of quantifiable characteristics of the environment against which environmental quality can be assessed. In other words, a standard provides a quantifiable target for ambient environmental quality.

The draft Measure for ambient air proposes standards for carbon monoxide, nitrogen dioxide, photochemical oxidants, sulfur dioxide, lead and particles.

1.4.3 What is a protocol?

A national environment protection protocol means a protocol that relates to the process to be followed in measuring environmental characteristics to determine:

- whether a particular standard or goal is being met or achieved, or

- the extent of the difference between the measured characteristic of the environment and a particular standard or goal.

The protocols of the Measure focus on the monitoring and reporting of ambient air quality for the substances for which standards have been developed.

The Council also resolved to develop an impact statement which would, amongst other things, identify and assess the economic and social impact on the community (including industry) of making the measure. The Council determined that the focus of the NEPM should be on human health rather than on a broader range of environment protection outcomes.

The decision to prepare a NEPM also reflected the importance of air quality as an influence upon human health and a desire to ensure that a uniform set of national ambient air quality standards for the protection of human health was developed. The Council was also cognisant of the need to deal with air pollutants that are generally accepted as indicators of air quality and to provide greater certainty to industry and the community.

1.5 THE OBJECTIVE OF AMBIENT AIR QUALITY STANDARDS

The objective of this NEPM is to develop a set of nationally acceptable ambient air standards or ‘quantifiable characteristics’, which will effectively act as benchmarks against which the quality of ambient air can be assessed. The standards are designed to be measured at specifically nominated ‘performance monitoring stations’ located to give an ‘average’ representation of general air quality and of population exposure to the six main pollutants. The NEPM monitoring protocol does not apply to monitoring and controlling peak concentrations from major sources such as heavily trafficked roads and major industries. Any monitoring of these major ‘point sources’ continues to be the responsibility of each individual jurisdiction and is outside the scope of this NEPM. Of course, where monitoring at point sources is used to control pollutant emissions then this will also assist in meeting the standards at the NEPM nominated monitoring stations.

Once these standards have been adopted all jurisdictions will then be able to assess their own particular air sheds using the standards as a benchmark. If the data collected by these nominated monitors show that there are particular air pollution problem areas then jurisdictions are able to investigate the sources of that pollution and take whatever action is considered appropriate. Under the NEPC Act there are no penalties resulting from the adoption of these standards. If the nominated monitors show that some areas (or air sheds) in a particular jurisdiction are above the recommended standard then it is entirely at the discretion of that jurisdiction as to what action should be taken to manage the problem. There is a mandatory requirement that all jurisdictions provide an annual report to NEPC using the standards to assess their ambient air quality. This report will be included in the NEPC Annual Report and tabled in each Parliament.

Jurisdictions will maintain flexibility when considering their options for achieving and maintaining ambient air quality standards. When considering these options jurisdictions would need to consider the level of human exposure to the main pollutants, as well as the economic and social impact on the community (including industry) of any strategy developed to manage that particular air pollution problem. It is recognised that existing or new policies/technologies which could influence air quality eg cleaner production technologies, transport and planning policies etc, need time to bring about their intended changes. Accordingly, a fairly long term goal has been set for this NEPM which is to achieve the recommended standards within ten years from the NEPM being made (June 2008).

1.6 IMPLEMENTATION OF THE NEPM

The NEPC Act deliberately leaves the implementation of the standards to each individual jurisdiction. This allows for local knowledge, conditions and systems to be considered and applied in managing air pollution.

The goal of the measure is to achieve the standards within 10 years. This fairly long time frame is appropriate in order to take into account a range of factors including:

- the period required for the development of appropriate air-shed management strategies;
- the length of time changes to motor vehicle design rules take to have a substantial impact because of the slow turnover of Australia's motor vehicle fleet;
- the long investment cycles of industry where over a ten year period we might expect one or two minor and perhaps one major investment in major capital equipment or process technologies which will have a substantial impact on the environmental performance of companies; and
- the long period of time required to effectively influence and change community behaviour patterns which have an adverse effect on air quality.

1.6.1 Industrial sources

It is recognised that companies are motivated to improve their environmental performance by a variety of factors including:

- a corporate commitment to environmental excellence;
- a desire to maintain good relations with their local community;
- a need to comply with environmental law; and
- a desire to gain the benefits of waste minimisation and cleaner production.

Systems to manage the environmental impacts of major industrial sources have been developed by jurisdictions across Australia. In most cases these systems, including non-coercive encouragement and educational strategies, environmental licensing and planning instruments, require the development and use of environment protection approaches. There may be a very small number of cases where air quality is affected almost exclusively by a single source of a single pollutant. This is usually in a non-metropolitan area where a particular industrial process is the source of significant quantities of a particular substance (eg. sulfur dioxide from ore smelting). It is recognised that in cases where the single source is close to a residential area air quality management strategies are usually in place. In situations such as this, existing pollution control strategies may need to be reviewed by the firms in question in consultation with the relevant government in order to ensure that an appropriate management approach continues which minimises costs and maximises benefits. These include the development of codes of best practice, business licensing, industry accreditation schemes, and the use of a range of incentive systems. Governments will continue to use a range of educational and other mechanisms to encourage firms to identify and adopt opportunities for cleaner production and best practice environmental management.

In urban areas, air-shed management programs already in place involve a diverse range of strategies to manage the discharge of polluting substances. Where the standards are currently not being met, strategies to improve air quality may be developed.

1.6.2 Motor vehicle sources

Motor vehicles are the major source of a number of air pollutants in urban areas. They are key sources of lead, carbon monoxide and nitrogen dioxide in many urban centres. The introduction of unleaded fuel coupled with the turnover of Australia's motor vehicle fleet has meant that lead from motor vehicle sources has progressively reduced over the last decade, and in the near future lead will no longer be an urban air quality issue except where other sources exist. It is expected that existing and planned motor vehicle control methods such as the introduction of a revised Australian Design Rule (ADR 37/01) over 1997-99 which adopts US 1981 emission standards will lead to substantial improvements in levels of emissions from motor vehicles.

1.6.3 Urban form issues

Transport and land planning is particularly significant to air quality in relation to the level of motor vehicle use, and how cities are planned to accommodate the need for mobility and the provision of goods and services. Provision of services, employment, educational and other facilities close to where people live, or close to public transport facilities minimises the need for travel by motor vehicles and encourages the use of alternative travel methods including walking and cycling. Encouraging car pooling to reduce the number of vehicles on the roads is another strategy that could be adopted.

1.6.4 Domestic and other sources

There is a range of other sources of pollutants, including domestic solid fuel heaters (including open fire places), the use of natural gas in heating and cooking, backyard incineration of domestic waste. These activities can be major sources of carbon monoxide, nitrogen dioxide and particles in some situations, and can contribute to the generation of ozone.

Strategies to manage these sources of air pollutants include public education to raise awareness of the environmental impacts of activities such as the use of open fire places and backyard incineration. Public education can and has led to shifts in behaviour away from these activities to the use of other forms of heating or waste disposal.

1.6.5 Fire Risk Management

Jurisdictions are working to ensure that the two critically important objectives of (i) protecting public safety and public and private property by reducing the potential for bushfires through planned prescribed burning programs and (ii) protecting public health by reducing air pollution are both achieved. Fires, particularly planned, prescribed, well managed hazard reduction fires have been and will continue to be an integral part of keeping forests and grasslands healthy. They help prevent the larger, unplanned, catastrophic wildfires that can pose a serious threat to public safety.

Fire authorities and land managers have developed a range of management practices to reduce the likelihood and impact of bush fires. As prescribed burning for fuel reduction is required over large areas of land in order to have any impact on high intensity, widespread fires, prescribed burning for fuel reduction is the method most economically and ecologically relevant. This is especially the case for large scale operations, but prescribed burning for fuel reduction is also often essential for very small strategic protection. Public and private land managers also use established fire management practices for purposes such as creating fire breaks and removing crop residues associated with agriculture and forestry.

In some limited circumstances involving generally modified habitats, the following practices may also be utilised: grazing, slashing of vegetation, pruning (softwood forests), and other methods such as mulching, ploughing, herbicide application and rolling. Such methods must be compatible with flora and fauna objectives and cognisant of their wider impacts.

Strategies have been developed in many states to ensure that the timing of activities is considered so that, for example, prescribed burning for fuel reduction is not conducted on days when there is a high risk of ozone production or when particle levels are expected to be high (assuming the burn-off can be rescheduled safely).

It is recognised that in some jurisdictions fires are set for Aboriginal cultural reasons eg in the Northern Territory the traditional owners of Kakadu National Park use fire as part of traditional activities such as hunting and habitat manipulation. In most cases these 'burns' are not expected to impact on urban air quality as most will take place in remote areas. Such 'cultural burns' will need to be provided for while recognising the need to also consider any potential health impacts which might result.

1.6.6 Implications for governments

The main implications for governments depend on whether the standards are already achieved or not. In all but a few areas it is expected that the standards will be achieved. Reporting against the standards implies monitoring and reporting of ambient levels in accordance with the protocols stated in a NEPM. Most jurisdictions already conduct monitoring programs. These are mostly for capital city regions, but some jurisdictions also conduct monitoring programs in a number of regional centres, and some report industry monitoring data. Some jurisdictions that have sophisticated monitoring programs may well exceed the minimum NEPM requirements, while others will have to invest in developing or upgrading their monitoring programs to meet the NEPM requirements. The costs will be dependent on the nature of the air shed to be monitored, what pollutants need to be monitored and whether existing monitors are suitable for nomination as a 'performance measuring station'.

The use and costs of industry monitoring data for performance monitoring is a matter for jurisdictions. The NEPM stipulates that monitoring and reporting in accordance with the protocol be achieved within three years of adoption of the Measure.

The NEPM commits jurisdictions to report the implementation of the NEPM every year. The decision as to whether Governments or others bear the costs of monitoring is a matter for jurisdictions.

1.7 THE AIR NEPM DEVELOPMENT PROCESS

1.7.1 Funding

Approximately $1m has been allocated in direct funding to this NEPM. In addition, jurisdictions contributed resources in the form of data collection/generation, seconding of officers, consultation processes and policy input. Industry and community/conservation groups contributed significant resources in the form of additional data and comments/reviewing of material etc. Considerable savings were made through the use of existing local and international data.

1.7.2 Process

The first phase of the development of the NEPM began in early 1996 when an unfunded working group developed a proposal for an Ambient Air Quality NEPM. The NEPC agreed to develop the NEPM in June 1996 and work commenced on the collection, synthesis and analysis of technical, scientific and economic information necessary for the preparation of a draft NEPM and Impact Statement.

A small project team, with expertise in air quality and policy development, drawn from a range of participating jurisdictions, was established to develop the draft NEPM and associated impact statement. A jurisdictional reference network, with members drawn from each participating jurisdiction, was established to provide input to the project team. A number of consultancies were commissioned to provide expert advice in specific aspects of the project. A series of technical review panels was also established to review these consultancies and advise the project team. An Air NEPM advisory group consisting of peak NGO representative groups was convened to provide policy advice to the NEPC Committee.

1.8 NEPC Act requirements

The NEPC decision to make the Ambient Air Quality NEPM was made having regard to the requirements identified in section 15 of the *National Environment Protection Council Act, 1994* (Commonwealth) and the equivalent provisions in the corresponding Acts of the participating jurisdictions. The following sections identify how the NEPM meets the requirements of the *NEPC Act*.

1.8.1 Section 14

Section 14 provides explicit direction for the making of a Measure for ‘ambient air quality’ (Section 14(1)(a) which is referenced in the introductory section of the Measure).

The ambient air quality NEPM comprises of standards, a goal and protocols, in accordance with subsection 14(3).

1.8.2 Section 15

Section 15 sets out what the National Environment Protection Council is required to have regard to in making a NEPM:

- **whether the measure is consistent with section 3 of the Intergovernmental Agreement on the Environment (s15(a)).** The NEPC Committee has been mindful to ensure that the principles of the Agreement have been considered and taken into account where appropriate during the development of the Measure;

- **the environmental, economic and social impact of the measure (s15(b)).** Every effort was made to ensure that the available scientific, social, environmental and economic data was considered when developing the Impact Statement for this NEPM, as well as the comments made during the public consultation phase. The NEPC had regard to this information when making the NEPM. These issues were also comprehensively addressed in the Summary/Response document;

- **the simplicity, efficiency and effectiveness of the administration of the measure (s15(c)).** The NEPC Committee has guided the development of the Measure so that its administration is simple, effective and efficient e.g. the monitoring protocol recognises that some of the existing monitoring infrastructure and methodologies can be utilised for this NEPM;

- **whether the most effective means of achieving the desired environmental outcomes of the measure is by means of a national environment protection standard, goal or guideline or any particular combination thereof (s15(d))**. The NEPC considered various options for achieving the desired environmental outcomes of the measure and having considered all the options arrived at the conclusion that a NEPM involving a combination of standards, a goal and protocols was the most effective to achieve the environmental outcomes of the Measure, this issue was addressed in the Impact Statement;

- **the relationship of the measure to existing inter-governmental mechanisms (s15(e))**. It appears that the only inter-governmental mechanisms of relevance to this Measure are firstly, the COAG requirements contained in the Principles and Guidelines for National Standard Setting and Regulatory Action by Ministerial Councils and Standard Setting Bodies. The Impact Statement has been developed keeping this in mind. Secondly, the Ambient Air quality NEPM will assist with the information requirements of State of the Environment reporting.;

- **relevant international agreements to which Australia is a party (s15(f))**. While there are no relevant formal international agreements to which Australia is a party in the context of this Measure, the Ambient Air Quality NEPM will assist in meeting some of the aims of the Rio Declaration to which Australia is a signatory;

- **any regional environmental differences (s15(g))** have been considered. In the context of the Ambient Air Quality NEPM it was considered that there were no definitive differences in the natural state of the atmosphere which could be meaningfully reflected in the different ambient air standards for the protection of human health (refer to section on Regional Environmental Differences in the Impact Statement); and

The requirements to give notice of intention to prepare a draft of the NEPM; to prepare a draft of the NEPM and Impact Statement; and to undertake public consultation under Sections 16, 17 and 18 respectively have been appropriately fulfilled.

1.8.3 Section 19

Section 19 sets out what Council is to have regard to, in addition to Section 15:

- *the impact statement that relates to the measure (s19(a)).* The Impact Statement relating to the draft Measure was released as part of the public consultation process in November 1997. Following comments from the public the Impact Statement was revised (contained herein) to reflect the comments made and the additional information provided;

- *any submissions it receives that relate to the measure or to the impact statement (s19(b)).* A summary of the submissions received during the consultations on the 'Draft Measure and Impact Statement' has been prepared and is contained in the 'Summary and Response' document. The document also includes the NEPC responses to these comments. These responses outline the reasoning for the changes made from draft to final and explain the reasons why some suggested changes have not been adopted; and

- *any advice from the NEPC Committee or from a committee established under section 33* (s19(c)). The NEPC Committee advises that the Summary/Response document provides a satisfactory assessment of the views of interested parties and further information on impacts.

As required by Section 18 of the *NEPC Act* the 'Draft Measure and Impact Statement' was made available for public consultation for a period of at least two months (actually three months). The National Environment Protection Council has also considered the statutory requirements of the *National Environment Protection Council Act 1994* and corresponding Acts of each participating jurisdiction and has accepted, as conforming to the provisions of Section 14 of the *NEPC Act*, the National Environment Protection (Ambient Air Quality) Measure, and has accepted, as conforming to the provisions of Section 17, the Impact Statement for the Ambient Air Quality National Environment Protection Measure. The Council also accepted the summary of submissions and the responses of the National Environment Protection Council to those submissions.

CHAPTER 2
PUBLIC CONSULTATION

2.1 PUBLIC CONSULTATION PROCESS

Early in the development of this NEPM, a Non Government Organisation (NGO) Advisory Group, involving key industry, environment and professional bodies, was established. This Group met approximately on a quarterly basis to discuss policy and technical issues as the NEPM progressed. At the request of this Group the NEPC Committee developed a 200 page Discussion Paper on the proposed draft NEPM and Impact Statement and released it to stakeholders, which in effect provided stakeholders with a draft copy of the proposed draft NEPM and Impact Statement for comment prior to its formal release as a public document. A two months consultation period was provided on this Paper. Over 32 meetings with stakeholders were held in every jurisdiction. The addition of this consultation significantly increased the transparency of the NEPM development process.

A draft NEPM and Impact Statement was then developed using the information and comments which resulted from the Discussion Paper. This process added an extra six months in total to the NEPM development process. Extra funding was also provided for this process.

To ensure all parties had time to consider the draft NEPM and Impact Statement, one extra month was included for consultation (beyond the two-month period required under the NEPC Act) on the formal draft NEPM and Impact Statement. To further enhance the transparency of the consultation process a ‘Key Stakeholder Consultative Forum’ was established with an independent Chair (Prof Ian Rae), to ensure that key stakeholders (industry, environmental groups etc) were provided additional opportunity to consider the issues and provide comments and information to the Project Team prior to the NEPM being finalised.

Every effort was made to ascertain the environmental, social and economic impacts of the NEPM on the community (including industry) during this process. The final NEPM and Impact Statement reflects these and other considerations such as regional environmental differences. The Summary and Response Document gives a detailed summary of the comments made on the draft NEPM and Impact Statement. In many cases the comments were acted upon and are reflected in the draft final NEPM and Impact Statement.

Intense consultation on this NEPM was delivered through the following processes:

- on going consultation (meetings with government agency representatives, briefings, papers) involving all governments on the content of the draft NEPM;

- consultation with the NGO Advisory Group (key industry, environment and professional groups), including the release of consultants reports, during the NEPM development process involving face to face meetings, briefings etc;

- release of a Discussion Paper on the proposed draft NEPM and Impact Statement in June 1997 involving 2 months consultation with over 32 meetings held nationally with key stakeholder and the public, over 500 copies distributed;

- release of a formal draft NEPM and Impact Statement for three months public consultation involving over 50 meetings with the public and stakeholders (Minerals Council of Australia, Australian Institute of Petroleum, Chambers of Commerce etc) and government agencies nationally – advertisement in all newspapers and direct mail to over 1200 interested parties and posting of the documents on the Internet with over 2000 copies downloaded. Several hundred copies were also distributed by jurisdictions to local stakeholders and the public;

- consultation with industry (Mineral Council of Australia, Australian Institute of Petroleum, Chambers of Commerce etc) and environmental groups (National Environment Consultative Forum) by all jurisdictional governments on the NEPM proposals and implementation issues;

- targeted meetings with key government agencies and stakeholders by the Project Team and presentations at conferences/seminars; and

- establishment of a Key Stakeholders Consultative Forum which included major workshops held in Perth, Sydney and Melbourne hosted by key stakeholders and funded by the NEPC.

2.2 PUBLIC SUBMISSIONS ON AMBIENT AIR QUALITY DRAFT NEPM AND IMPACT STATEMENT

A draft NEPM and Impact Statement on ambient air quality was released in November 1997. A three month consultation period followed which involved public meetings in every jurisdiction. There were a wide range of submissions received on the draft NEPM and Impact Statement. Some of the issues included:

- Standards should/should not differ from those recommended by health experts because of economic or social factors especially for Ozone, SO_2, particles;
- Inconsistency in standard setting process. Standards vary in rigour or ”strictness”. Should use US or Canadian standards;
- Lead standard – too high/too low, insufficient justification because we are already meeting NHMRC Blood Lead Level targets, IQ Calculation flawed, particle size should be specified for lead;
- NO_2 and SO_2 Annual Standards – too high/too low. No health basis/justification. Standards should be based exclusively on health considerations;
- Ozone – 4 hr standard not justified, evidence supports 8 hours;
- $PM_{2.5}$ standard more relevant than PM_{10} – should have both standards;
- Air toxics should be included;
- Particles standard too high/too low. Annual Standard should be included for PM_{10}/$PM_{2.5;}$
- 5 exceedences for particles too few/too many;
- Monitoring protocol – inadequate/adequate, should/should not cover point source, number of monitoring stations inadequate, general criteria not detailed enough to

achieve consistency, NGO input required in developing terms of reference for Peer Review Committee in NEPM, requirements for data to be readily available;

- Shorter averaging time needed for CO. CO standard supported;
- Insufficient linkage between person events and health impact;
- NEPM should make it clear that continuous monitoring is required;
- Process deficient/inadequate consultation/under resourced;
- Review period for particles is too long;
- 10 year goal too long/not long enough/supported
- Impact Statement inadequate – either under represents/over represents costs and benefits;
- Standards should be guidelines; and
- NEPM should carry mandatory penalties for breaches of Standards.

Each of the submissions were analysed and a comprehensive summary of the submissions and a response to the issues raised was then developed for consideration by NEPC. A number of changes to the detail of the NEPM and monitoring protocol were made as a result of the submissions. This Impact Statement on the Measure also reflects the comments made and additional information provided in the submissions. Each chapter on the pollutants addresses some of the significant issues raised in submissions on the individual pollutants.

The submissions reflected significant differences of opinion between environmental and industry groups on the standards presented in the Draft NEPM. Generally environmental groups viewed the some of NEPM standards and the method of monitoring as not being stringent enough and wanted the NEPM to compel (by way of penalties) individual jurisdictions to impose greater levels of controls on major pollution sources.

In contrast industry groups generally argued that some of the proposed standards were too stringent and registered their apprehension that the NEPM provided individual jurisdictions with the potential to impose unnecessary controls on their activities which could have an effect on their competitiveness.

Environmental groups suggested that the process could have been more transparent, had more funding been provided, to allow their representatives to attend meetings thus providing more opportunities to input into the development of the standards. Some industry groups also believe that the process did not allow them enough input into the development of the standards and have suggested that governments should have spent between $50 – 200 million on the development process, commensurate with their understanding of what the potential impacts of this NEPM might be.

A comprehensive formal response to these submissions is contained in the Summary and Response Paper. The final NEPM and Impact Statement also reflects the responses to the submissions made.

CHAPTER 3
METHODOLOGY

3.1 INTRODUCTION

The original proposal for the development of this NEPM envisaged the process starting from an established benchmark - such as current guidelines and standards with national, State or international status - for example NHMRC or WHO guidelines. It envisaged that the development of the NEPM would be conducted through a series of reviews addressing key issues which flowed from the intent of the measure, the protection of human health and well-being. Identified key issues included the health effects of the pollutants, air quality levels and population exposure. No major new work was envisaged, with the reviews intended to focus on work already undertaken within Australia and internationally.

3.2 HEALTH EFFECTS REVIEW

A report was commissioned on the current state of knowledge of the human health effects of the six pollutants, with the consultant tasked to identify adverse health impacts on both the general population and on any susceptible subgroups. The consultancy also required the identification of a 'dose response relationship' for each pollutant, and the determination of any concentration 'thresholds' for the pollutants' effects on human health. The outcome of the consultancy was a series of recommendations on the ambient levels (or pollution concentration ranges) that would provide protection from the lowest observable adverse effects on susceptible sub-groups in the population.

Advice was subsequently sought from a Technical Review Panel on whether or not the consultant had taken all the relevant information into account, and the Panel was asked, on the basis of the information in the report, to make recommendations for acceptable ambient levels for each pollutant. These recommendations were based solely on the protection of human health.

A number of issues arising from the review included the use of chamber studies in determining appropriate ambient air quality levels, difficulties in separating the health effects of individual pollutants from the effect of a mixture of the pollutants and the interactions between allergens and pollutants, and the complexity associated with determining unambiguous dose-response relationships. An additional challenge was the absence of health effects 'thresholds' for some of the pollutants. Studies indicated that as adverse health effects were investigated at increasingly low levels of exposure, the level of uncertainty increased.

3.2.1 Determination of range of ambient levels

As it was considered likely that in a number of instances the starting point for the development of a standard - the lowest observed adverse effect level - would need to be revised upwards as other costs and benefits were considered, a range of possible ambient levels was developed. The preferred levels identified by the Technical Review Panel were taken as a starting point, and were added to by considering the relevance (in terms of recent health studies) of any pre-existing standards (such as the NHMRC and WHO guidelines). Where the standards were relevant, they were included in the range, and where there was considerable divergence between the two levels, an intermediate level was included. Where the levels recommended by the Technical Review Panel and those established by other agencies were similar, the range of levels to be considered was increased by including an additional level.

3.3 POPULATION EXPOSURE ASSESSMENT

In order to identify and evaluate the relative costs and benefits (typically avoided health costs) associated with the introduction of different ambient air quality standards, it was necessary to ascertain the likely exposure of the Australian population to each of the pollutants at each of the different possible standards or ambient levels.

The ‘population exposure assessment’ conducted as part of the development process involved two interrelated exercises - an ambient air quality review, followed by an exposure assessment. The exposure assessment used the results of the ambient air quality review and developed methodologies to estimate exposure using a range of potential standards for each pollutant. The methodology included the use of existing monitoring data and surrogates for populations in regions with sparse or no ambient data.

3.3.1 Ambient air quality review

The overall objective of the ambient air quality review was to establish a data base of ambient pollutant levels for all parts of the country where monitoring is conducted. The frequency distribution of ambient pollutant concentrations in units and time averages consistent with any proposed standard, together with the spatial distribution of ambient pollutant concentrations, were considered necessary for this exercise.

Consideration of the health data and existing (Australian and international) ambient standards suggested that data would be required which would allow the averages outlined in Table 3.1 to be computed. It was considered that for particles, data on both PM_{10} and $PM_{2.5}$ would be desirable, but it was recognised that there might be insufficient data on $PM_{2.5}$ particle levels. It was agreed that the frequency distributions should include the top ten values, and the 99th, 98th and 95th percentiles.

Table 3.1

Data required/sought for the ambient air quality review

Pollutant	Averages	Frequency distribution
Ozone	1 hr, 4 hr, 8 hr	1 hr, 4 hr and 8 hr daily maxima
Sulfur dioxide	10 min (or 6 min), 1 hr, 24 hr, Annual	10 minute values, 1 hr daily maxima, 24 hr values and annual averages
Nitrogen dioxide	1 hr, 24 hr	1 hr daily maxima and 24 hr values
Carbon monoxide	1 hr, 8 hr	1 hr and 8 hr daily maxima
Lead	3 month (or 90 day)	1 month average
Particles	24 hr, Annual	24 hr values and annual averages

Jurisdictions and industry were asked to provide the data for the calendar years 1993, 1994 and 1995. A three year period was chosen as it was recognised that a single year of data might distort the statistics due to the possibility of atypical meteorology etc. The advantages of using five or more years of data were appreciated, but data for this longer time period were found to be less available from jurisdictions as well as being more limited in network coverage. The possibility of such data including significant deviations due to trend changes in emissions (either up or down) was also an issue. The downward trend in lead during those years is an example.

It was recognised at the outset that monitoring networks were essentially limited to major metropolitan areas, and that within these areas the networks would differ in densities and in their spatial and temporal extent. An agreed method was therefore required for representing pollution distribution. Options which were considered included using each station as representative of a defined area (x square kilometres) or population (y people); averaging across stations and using a single set of figures; representation by station classification (eg urban-residential, urban-traffic, industrial etc); and interpolation between monitoring stations. Of these, interpolation was the preferred method.

In addition, it was recognised that many of the sites within networks were established for purposes other than monitoring general population exposure (for example, stations may variously be described as residential, light industrial, heavy industrial, rural etc), some stations were designed to monitor peak levels. This non-uniform approach to network design suggested that data from different jurisdictions might not be strictly comparable, and that as a result care would need to be taken in interpreting the results.

The timely establishment of a useable, consistent national ambient air quality data set was hampered by data from a number of jurisdictions not being available in a useable format, and requiring processing. The exercise was also complicated by the sheer volume of data involved. Data were also sourced from a number of industries.

3.3.2 Exposure assessment

Exposure assessment involves a convolution of air quality data (taken either from measurements or from models) with population data - that is, pollution distribution maps are superimposed on population density maps to estimate the population weighted exposure.

A report was commissioned to provide estimates of exposure to each of the pollutants for population centres of 10 000 or more people, and for areas influenced by significant emission sources. Communities in smaller settlements and/or not exposed to emissions from major point sources were considered highly unlikely to be exposed to significant levels of the pollutants in question. The monitoring data used for the study were those developed for the ambient air quality review. The Australian Bureau of Statistics (ABS) population data from the most recent census, and ABS projection factors were used to obtain estimated 1995 population levels.

As monitoring data were not available for many of the smaller population centres, the consultant was required to develop methodologies for estimating exposure both with and without actual ambient monitoring data. Two exposure models were developed for each pollutant. In the first model, population exposure was estimated by convoluting the statistical distribution of measured air quality data with the spatial distribution of populations in urban centres and major industrial areas (that is, ambient concentrations of the pollutant were assumed to vary as a function of the population).

The results of this assessment suggests that there has been an overestimation with pollutants like carbon monoxide, sulfur dioxide and lead predictions for Sydney and Adelaide where maximum values from peak monitoring stations (ie stations sited to measure maximum levels, not population exposure) have been included in the interpolation. Consequently, the exposure estimates in cases like these should be regarded as the potential maximum population exposure, rather than an estimate of actual exposure.

3.3.3 Indoor air

While some research indicates that for some pollutants, indoor concentrations may be less than outdoor concentrations, the 1996 Australian State of the Environment report found that the quality of indoor air is often poorer than that of outdoors (SOE Advisory Council, 1996).

It was considered that the indoor/outdoor air quality issue could be addressed by either assuming that indoor concentrations are essentially the same as outdoor concentrations (which has typically been the case in many US studies although this is beginning to change) or by applying a coefficient to exposure calculations which adjusts the estimates to reflect the specific contribution arising from indoor air.

It was considered that standards developed in part on potential overestimates of community exposure would afford better protection to susceptible subgroups in the community.

3.4 HEALTH RISK EVALUATION

As risk evaluation had not been used before in Australia for the purposes of setting ambient air quality standards, its use in the NEPM development process was in effect experimental - an examination of how applicable the process would be, given the available information sets. As a result, a Technical Review Panel was established to both provide guidance on the specifications for the consultancy and to evaluate its outcomes. It was recognised that while the method used in the study to derive risk was novel and its validity unproven, it did offer the advantages of combining estimates of risk with the proportion of the population affected.

Stakeholder concerns were expressed about the suitability of the end points used for three of the pollutants - sulfur dioxide, particles and lead. As both the risk assessment exercise, and the method employed were essentially experimental, these were not regarded as insurmountable problems, and a subsequent workshop was held on health end-points to revisit the issue.

The workshop recommended the use of lung function for 24 hour sulfur dioxide, and the effects on lower respiratory function on children for particles. The most appropriate health end-point for lead, for the purposes of this specific exercise, was considered to be blood lead, although this was qualified by the recognition of the complexity of deriving relationships between atmospheric lead and blood lead. It was suggested that given the multiple exposure pathways (inhalation, ingestion) and the fact that lead risk is cumulative, it would be more useful to conduct an holistic systems study of lead risks.

After detailed analysis of the risk evaluation and taking into account both the expert and key stakeholder advice on this matter, it became clear that in order for the results of the risk exercise to be useful in evaluating the respective merits of the range of standards under consideration, the exercise needed to be able to estimate incremental changes in risk as the standards changed. Unfortunately neither the methodology nor the available information sets allowed this to be undertaken. As a result, the outcomes of the health risk evaluation have not been used in the development of the draft NEPM and impact statement.

3.5 ASSESSING THE OPTIONS

Following a rigorous review of all the available information, the main inputs to the assessment process were identified as the outcomes of the health review, exposure assessment, the examination of the air quality management or ‘control’ options and their associated costs for achieving any proposed standards, and consideration of the benefits, typically in terms of avoided health costs, associated with each of the standards.

A preferred set of standards was determined from the range of options by using these other inputs and by considering the pollutants in three separate groups (see Table 3.2) based on the nature of their health effects thresholds.

Table 3.2

Availability of agreed thresholds

Health effects threshold	Pollutant
Identified threshold	Sulfur dioxide Carbon monoxide
Apparent threshold	Nitrogen dioxide Lead
No identified threshold	Ozone Particles

The following process was followed. For those pollutants with identified or apparent thresholds, the option which related to the lowest (or no) observed effect level (ie the LOEL or NOEL) was preferentially selected for further assessment. Careful consideration was given to ensuring that the research data supporting the identification of this level was robust and generally supported by other researchers in the area. For pollutants with no identified threshold the lowest option, which would minimise the likelihood of adverse impacts, was preferentially selected for further assessment.

3.6 UNCERTAINTY FACTORS

As a general principle uncertainty (or safety) factors were not used in the development of the standards except where there was uncertainty about the existence of a health effects threshold (ie the 'apparent threshold' group of pollutants). Uncertainty factors were subsequently used in the standards put forward for carbon monoxide (which has an identified threshold) and nitrogen dioxide (which has an apparent threshold).

3.7 COSTS AND BENEFITS

As the responsibility for achieving the NEPM goal lies with the participating jurisdictions, and as the management strategies adopted by jurisdictions differ due to the diverse nature of their particular air quality issues, the identification of the costs associated with implementation posed a challenge. It was therefore determined that for the purposes of this exercise, the most useful information which could be presented to the reader would be that on generic costs identified with respect to a range of possible management options. By their very nature, these costs would be relative, would present a 'worst-case' scenario, and would be most useful, as in the case of monetising the benefits, as an indication of the possible scale of associated costs.

To this end, a review was commissioned to identify the range of indicative air quality management options which jurisdictions could use to achieve the proposed standards for each of the pollutants, and to determine generic costings (for instance $/tonne) for the different options. Management options were considered in terms of three broad categories - emissions reductions, economic instruments, and planning strategies.

The benefits of implementing the preferred options were also investigated. In general, benefits were identified in terms of avoided health costs. It was recognised that it was not possible or appropriate to both identify and monetise all the benefits arising from the introduction of the proposed standards. A useful set of estimates of the value of avoided health costs was available from the recently completed multi-million dollar review on the costs and benefits of the United States 1970 Clean Air Act after it had been in place for twenty years. The approach adopted was to provide sufficient information to allow the reader to make an assessment on the relative scale of the associated benefits, for consideration together with the identified costs of implementing the proposed standard.

3.8 ACHIEVING THE GOAL OF THE MEASURE

Jurisdiction are presently in the process of determining how the goal of the NEPM would be achieved, and what mix of management options should be selected to assist in reaching the goals set in the proposed NEPM. As an ambient air quality measure has not yet been adopted, no jurisdiction has yet finalised exactly how it will be complied with. It is expected each jurisdiction will work closely with their industry and community groups in determining the appropriate mix of strategies to implement the NEPM. Many jurisdictions are in the process of revising, refining or re-visiting their air quality management strategies. An outline of the management approached currently used by jurisdictions, together with future management options under consideration, is presented in Appendix 1 to assist the reader.

3.9 SELECTION OF THE STANDARDS

The available health, economic, social, technological and environmental data were examined to determine the preferred standards for each pollutant. Following public comment these were then reviewed and amended where appropriate. The standards represent a high degree of consensus among leading health professionals, varied to reflect what is realistically achievable in Australia over the next ten years (see relevant chapters on pollutants).

3.10 MONITORING AND REPORTING PROTOCOLS

The difficulties encountered in identifying current population exposure levels to the pollutants under consideration reinforced the understanding that the monitoring and reporting protocol was an integral part of the proposed measure, as it had a significant role to play in interpreting compliance with the standards. It was recognised that the number and siting of monitors would be critical in ensuring that the subsequent data were representative of exposed populations and ambient concentrations of pollutants, and that reporting against the standards would actually be a way of measuring progress towards the attainment of the goal of the measure.

A consultancy was let to develop the protocols, and jurisdictions, with their expertise in monitoring, jurisdictions formed a ‘technical review group’ for the outcomes of the consultancy, and the resultant protocol reflects both the work of the consultant and the jurisdictions. Monitoring and reporting are discussed further in chapter 7.

CHAPTER 4
ALTERNATIVES TO THE MEASURE

4.1 INTRODUCTION

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 alternatives to a Measure can be broken down into three main types:

- alternative standards for each pollutant;
- alternative to NEPM air quality standards; and
- alternatives to a National Environment Protection Measure.

4.2 ALTERNATIVE STANDARDS FOR EACH POLLUTANT

In developing the standards a number of potential standards for each pollutant (where appropriate) were considered in the form of a range of pollutant concentrations (or ambient levels) which would provide suitable health protection for susceptible sub-groups in the population. The starting point for the ambient levels development in all cases was the lowest observed effect level, where health effect 'thresholds' could be determined. The range of possible ambient levels were developed through reference to a Technical Review Panel of experts and the health review consultant. Consideration was then given to pre-existing standards/guidelines (such as the NHMRC and World Health Organisation (WHO) Guidelines) which are generally accepted as being relevant to the Australian context. Ambient levels were then furthered considered in light of their general applicability to the achievement of the desired environmental outcome. These levels were further refined through the application of a benefits and costs analysis. More detail is available under the relevant pollutant chapters.

4.3 ALTERNATIVE TO NEPM AIR QUALITY STANDARDS

The draft NEPM included a set of draft ambient air quality standards. These standards consisted of quantifiable characteristics of the environment against which environmental quality can be assessed. The standards would provide a means of assessing air quality. The NEPM imposes a responsibility on jurisdictions to report progress towards meeting the standard but does not require compliance, except for the agreed monitoring and reporting requirements.

A standard is a benchmark for comparison with existing ambient air quality. No other mechanism is available to ensure that all jurisdictions adopt the same benchmark. Experience with NHMRC goals and ANZECC guidelines has not delivered consistency throughout the country. Thus the commitment to developing NEPC air quality standards by all jurisdictions is seen as recognition that the existing situation, whereby NHMRC goals are employed in a number of different ways by jurisdictions, are unlikely to bring about the desired environmental outcomes or the level of certainty which this NEPM seeks to develop.

4.4 ALTERNATIVES TO A NEPM

There are four main alternatives to a NEPM which must be considered in the light of their ability to deliver the desired environmental outcomes to be achieved through a draft Measure.

These are:

- the Commonwealth enacts legislation to give effect to national air quality standards;
- rely on NHMRC/ANZECC guidelines;
- develop uniform national objectives through an inter-Governmental agreement or memorandum of understanding; and
- maintain the status quo.

4.4.1 Commonwealth enacts legislation to give effect to ambient air quality standards

Legal advice indicates that it may not be possible for the Commonwealth to introduce legislation which could deliver the majority of the desired environmental outcomes being pursued through the development of a NEPM, given its powers under the Constitution. The Commonwealth would need to take account of the significant resources already dedicated to the establishment of an all-jurisdictional Ministerial Council (NEPC) to develop measures for the protection of the environment and its commitments under the IGAE before attempting to introduce its own legislation on this matter. In addition, the Commonwealth would not be likely to pursue a unilateral approach, given the cooperative approach being taken at present in relation to environmental issues, particularly through the NEPC. It is recognised that unilateral Commonwealth action could alienate State and Territory environment agencies. Another key issue which mitigates against adopting this alternative method of achieving the desired environmental outcomes is that the Commonwealth is not well placed to take on a hands-on role in data collection, analysis and reporting of air quality data. The Commonwealth would also need to invest significant resources to duplicate systems already in place at State and Territory level, in order to administer such a program. Parliaments have specifically legislated for National Environment Protection Measures to overcome the inherent difficulties of any Commonwealth legislated approach in developing ambient air standards.

4.4.2 Rely on NHMRC goals

NHMRC has determined a set of air quality goals for some of the major air pollutants based on their human health effects. These goals are employed by a number of jurisdictions and provide guidance in the development of air quality programs. The NEPC was established and the ability to develop NEPMs for ambient air quality included in the

NEPC legislation at a time when the NHMRC goals were in use. The clear intention was that the standards would replace the existing arrangements. This again recognises that there are a number of different approaches in the application of the NHMRC goals between jurisdictions, which significantly reduces the level of certainty envisaged by the IGAE.

As already discussed a disadvantage in relying on the NHMRC or ANZECC goals is that they make no reference to standardising monitoring or reporting requirements which differ significantly between jurisdictions, making cross-jurisdictional comparisons difficult and possibly creating compliance difficulties for industries with operations in more than one jurisdiction.

Similarly, further difficulty arises in relying on NHMRC or ANZECC goals as an alternative method of achieving the desired environmental outcomes rather than establishing NEPC standards in that the NHMRC/ANZECC air quality goals do not have any legislative basis within jurisdictions (although some jurisdictions use them as the basis for their specific legislative requirements). At present there is no uniformity in the way jurisdictions use the NHMRC/ANZECC goals, making it difficult to achieve the desired environmental outcomes sought in this NEPM at a national level.

4.4.3 All jurisdictions enter into an agreement to adopt ambient air standards

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

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 roughly in line with the NEPC process or by each jurisdiction agreeing to handle this issue within their jurisdiction in some way. In the latter case, a number of jurisdictions would need to establish mechanisms of the type currently envisaged under the draft air quality Measure. 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.

Similar to the NHMRC goals option discussed above (section 4.3.2), the standards and monitoring and reporting requirements agreed would not necessarily have any legislative basis, making withdrawal from any air quality standards agreement relatively easy compared to that of repealing or amending legislation.

This offers no obvious advantage over NEPMs as a similar process would be required and no legal obligations would fall on jurisdictions.

4.4.4 Maintaining the status quo

Arguments to maintain the *status quo* imply that the present approach to the development of air quality standards, whereby individual jurisdictions develop their own guidelines and or standards (or adopt/modify already developed guidelines/standards) is the most efficient. It also assumes that any ‘natural evolution’ of air quality standards/guidelines would address issues such as equivalent protection and variations in jurisdictional approaches.

The *status quo* has the potential to create, or may have already created, market distortions or pollution havens, and may not be in keeping with National Competition Policy.

The *status quo* needs to take into account systems as they would naturally evolve and does not necessarily mean that ambient air quality standards would not develop at some point. It is recognised that there are a number of developments in jurisdictions which will result in substantial improvements in air quality. Some improvements are the result of national strategies eg the strategy to reduce the use of leaded petrol. Other strategies have been developed by individual jurisdictions aimed at improving particular aspects of that jurisdiction’s air quality.

Under the *status quo* it is likely that some jurisdictions will continue to institute different air quality standards, despite the reasonably wide acceptance of the NHMRC ambient air quality goals. At present, 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 community input to air quality standards development is piecemeal and irregular from jurisdiction to jurisdiction. It is also unclear whether the development or revision of air quality standards which would evolve under these circumstances would provide industry and the general community with the level of access and input into air standards development as under 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 would be less likely to emerge.

Community surveys show that there is a clear demand for national standards for environment protection. This has been reflected in the development of the NEPC. The ‘status quo’ option does not deliver any improved national uniformity. Consequently, the development of a NEPM is the preferred option.

4.5 CONSEQUENCES OF NOT MAKING A MEASURE

One intent in making an ambient air quality NEPM is to achieve a harmonised national framework for ambient air quality. Nationally adopted ambient air quality standards for the most common pollutants are intended to achieve the goal of providing equivalent protection everywhere from the adverse health effects associated with these pollutants, and, in addition, provide a well defined framework for management to ensure achievement of this goal, ie national certainty.

If an ambient air quality NEPM which includes standards is not made, it is likely that the current regimes for air quality management, monitoring and reporting delivered by the jurisdictions will continue in their current form. There will continue to be only an advisory national framework with regard to ambient air quality goals and it is likely that significant differences between jurisdictions in the requirements for environmental performance will continue. Some will adopt standards, but it is expected that even these will vary between the jurisdictions which take this step. Differing environmental performance requirements between jurisdictions would be expected to lead to an incapacity to deliver the objectives of the IGAE, in particular 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 established to overcome the problems associated with those voluntary attempts in a manner consistent with the federal nature of Australian government.

Not making the NEPM would also remove an essential stimulus for a harmonised national air monitoring and reporting system. The current situation whereby jurisdictions collect data using different monitoring regimes, store the data in varying formats using incompatible hardware and software systems, and report data in different formats would be likely to continue indefinitely in the absence of any encouragement towards a national system.

In summary, not making the NEPM would hamper, if not actually prevent, the harmonisation of the key aspects of air quality measurement and management, and contribute to a failure to realise the goals of the IGAE and may also have implications for the success of the National Competition Policy.

4.6 REGIONAL ENVIRONMENTAL DIFFERENCES

In making any Measure, 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 Act 1994* (Commonwealth) and the equivalent provisions in the corresponding Acts of other participating jurisdictions). In addition, section 17(b)(v) of the Act requires that the Impact Statement to be prepared with the draft Measure to 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 NEPC Acts do not provide any explicit definition of the term "regional environmental differences", its meaning is nonetheless made clear. The legislation, and sections 15 and 17 in particular, provide a clear indication that the term is not intended to encompass regional economic and social differences.

The term "regional environmental differences" is included in the provisions identified above in recognition of the fact that fundamental environmental characteristics of different regions may be very different, and that to apply simplistic uniform standards would not 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 a 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 the country, from hot-humid Florida, hot-dry Utah, to arctic/sub-arctic Alaska. They do not make allowances for regional climatic differences and neither does the European Union in determining its air quality objectives from Mediterranean Italy to subarctic Sweden.

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 ensuing from application of health based air quality standards. Such visibility is not required to be addressed in the NEPM and the issue of protection of ‘areas of special significance' does not arise.

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.

CHAPTER 5
DERIVATION OF THE STANDARDS

The methodology used in determining the proposed standards has been discussed in chapter 3. Key considerations in the derivation of the standards for each pollutant are summarised below and explained in detail in the following chapters.

5.1 CARBON MONOXIDE

The range of standards considered for CO from the various inputs was as follows:

- Health Review Study................. 8 hour standard, 9 to 10 ppm
- Technical Review Panel............ 8 hour standard, 9 to 10 ppm
- NHMRC (1984) .... 8 hour goal, 9 ppm

The range recommended is quite small for CO with a majority support for a 8 hour standard of 9 ppm. The standard was derived from the health data and the recommendations of the Technical Review Panel and the Health Consultant.

It is expected that the standard will be met at all performance monitoring stations through current control strategies. Most of the CO (70-90%) emitted in urban airsheds comes from mobile sources such as motor vehicles. The introduction of ADR 37/01 over 1997-99 has the potential over time to significantly reduce motor vehicle emissions of CO.

The standard for carbon monoxide as measured at each performance monitoring station is:

- 9.0 ppm measured over an eight hour period.

5.2 NITROGEN DIOXIDE

The range of standards considered for NO_2 from the various inputs was as follows:

- Health Review Study................. 1 hour standard, 0.10-0.15, annual average 0.03 ppm
- Technical Review Panel............ 1 hour standard, 0.12, annual average 0.03 ppm
- NHMRC (1981) .... 1 hour standard, 0.16 ppm

The range recommended for NO_2 is from 0.10 ppm to 0.15 ppm one hour average (except for the existing NHMRC goal) with a majority support for a standard of 0.12 to 0.12 ppm one hour and 0.03 ppm for annual. The standard was derived from the health data and the recommendations of the Technical Review Panel and the Health Consultant.

At present ambient NO_2 concentrations rarely exceed the existing NHMRC 1 hour guideline of 0.16 ppm in most urban centres. In Sydney and Melbourne there have generally been no exceedences of the guideline since 1991 and 1987 respectively. Recent data indicates the 1 hour averages are below 0.12 ppm and the annual averages are below 0.03 ppm in most years at performance monitoring stations.

A number of recent studies and reviews indicate that the current NHMRC goal for NO_2 of 0.16 ppm averaged over 1 hour may not be sufficient to protect asthmatics and people with lung diseases and a lower goal is desirable.

Current motor vehicle emission management programs may be sufficient to deliver most of the reductions needed to maintain the standards in the 10 year timeframe.

The standards for nitrogen dioxide as measured at each performance monitoring station are:

- 0.12 ppm (parts per million) averaged over a one hour period; and
- 0.03 ppm averaged over a one year period

5.3 OZONE

The range of standards considered for O_3 from the various inputs was as follows:

- Health Review Study................ 1 hour standard, 0.09 ppm; 8 hour 0.05 ppm
- Technical Review Panel........... 1 hour standard, 0.08 ppm; 8 hour 0.06 ppm
- NHMRC (1995) .... 1 hour standard, 0.10 ppm; 4 hour 0.08 ppm

The range recommended for O_3 is from 0.08 ppm to 0.09 ppm one hour average (except for the existing NHMRC goal) with an 8 hour standard ranging from 0.05 to 0.06 ppm. Based on current information, these objectives would be very difficult to achieve in Melbourne and Sydney, and possibly Brisbane and Perth in the ten year time frame, which is the NEPM goal.

Hence the standard was derived from the health data and the recommendations of the Technical Review Panel and the Health Consultant but taking note of the impracticability on meeting these recommendations in the ten year timescale it was concluded that the NHMRC's current goals be adopted.

The standards for ozone as measured at each performance monitoring station are:

- 0.10 ppm measured over a one hour period; and
- 0.08 ppm measured over a four hour period.

5.4 SULFUR DIOXIDE

The range of standards considered for SO_2 from the various inputs was as follows:

Health Review Study .... 10 min, 0.175 ppm; 24 hour, 0.04 ppm;
.... annual 0.02 ppm
Technical Review Panel .... 10 min, 0.12 ppm; 24 hour, 0.04 ppm;

.... annual 0.02 ppm
NHMRC (1995) .... 10 min goal 0.25 ppm; 1 hour, 0.20 ppm;
.... annual 0.02 ppm

The range recommended for SO_2 is from 0.12 ppm to 0.175 ppm ten minute average (except for the existing NHMRC goal), no one hour standard was recommended and 0.04 ppm 24 hour average and 0.02 ppm as an annual.

Relevant exposure periods were considered in evaluating each set of standards for the protection of the susceptible sub-population viz, short term (of the order of 10 - 15 minutes), medium term (24 hours) and long term (annual). The consultant recommended a set of standards covering the three exposure periods. The current NHMRC goals for SO_2 provide guidance for human health protection at two levels of exposure, short term (10 minutes and one hour) and long term (annual). The Technical Review Panel for the Health Review Consultancy recommendation of three exposure periods is the third option.

Given the significant costs required to control SO_2 emissions from some point sources, the more stringent objectives recommended by the Health Review were not seen to be achievable in all locations in the 10 year timeframe. It was concluded that the NHMRC's current goals be adopted except for the 10 minute goal. A 10 minute standard was not set because of the inconsistency that would be evident in the monitoring and reporting protocols for SO_2 compared to the other pollutants. It would require a monitoring network around each significant point source to be designed and approved by NEPC. This was outside the scope of the NEPM.

The SO_2 one hour standard is being met throughout Australia except close to some point sources, notably Mount Isa and Kalgoorlie which are the subject of specific jurisdictional legislation. In most areas, SO_2 levels will also be below the objectives recommended by the Health Review. Compliance with the one hour standard is expected to continue to ensure compliance with the one day standard of 0.08 ppm and the annual standard of 0.02 ppm.

Hence the standards for sulfur dioxide as measured at each performance monitoring station are:

- 0.20 ppm averaged over a one hour period;
- 0.08 ppm averaged over a one day period; and
- 0.02 ppm averaged over a one year period.

5.5 LEAD

The range of standards considered for lead from the various inputs was as follows:

- Health Review Study................. 0.3 - 0.5µg/m^3, 3 month / annual average
- Technical Review Panel............ 0.5µg/m^3, 3 month average
- Intermediate value………… . .1.0 µg/m^3, 3 month average
- NHMRC (1979) .... 1.5µg /m^3, 3 month average

In view of the:

- small increase in indicative averted health impact costs between 0.5μg/m^3 and 0.3μg/m^3,
- debate regarding the blood lead IQ loss threshold,
- blood lead correlation with lead in air,
- declining lead in air levels,

It was concluded that the recommendations of the Technical Review Panel and Health Consultant for an ambient air quality standard of 0.5 μg/m^3, but averaged over a one year period, was appropriate for lead, if we are to ensure lead levels do not deteriorate in the future.

Hence the standard for lead, as measured at each performance monitoring station is:

- 0.5 μg/m^3 averaged over a one year period, reported as a fraction of TSP (total suspended particles).

5.6 PARTICLES

The range of standards considered for particles from the various inputs was as follows:

- Health Review Study................. PM_{10}: 50 μg/m^3, 1 day average.
  .... $PM_{2.5}$: 20 to 25 μg/m^3,1 day average.
- Technical Review Panel............ PM_{10}: 50 μg/m^3, 1 day average.
  .... $PM_{2.5}$: 25 μg/m^3, 1 day average.
- NHMRC.................................... No goal.

The range recommended is quite small for particles with a majority support for a 1 day standard of 50 μg/m^3 for PM_{10} and a 25 μg/m^3 standard for $PM_{2.5}$. The Technical Review Panel recommended that this be reviewed in five years time.

Available data indicates that the PM_{10} 50 μg/m^3, 1 day average is only occasionally exceeded in major airsheds in most years. Little emission inventory data are currently available on $PM_{2.5}$ and it was judged that a single PM_{10} standard would be complementary and most easily monitored at this stage. The PM_{10} standard would be the equivalent in some air sheds to a 20 to 30 μg/m^3 standard for $PM_{2.5}$.

Hence the standard for particles (PM_{10}), as measured at each performance monitoring station, is:

- 50 μg/m^3 averaged over a one day period.

CHAPTER 6
IMPLICATIONS OF THE STANDARDS

6.1 INTRODUCTION

This chapter discusses a range of possible strategies which may be adopted by jurisdictions to achieve the standards. This is intended to assist readers to put the discussion of the standards contained in chapters 8-13 in context by discussing current and possible future strategies which may assist in achieving and maintaining the ambient air quality standards. As already stated the NEPM does not place any requirements 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.

Strategies for the management of particular substances which affect air quality (eg. sulfur dioxide, carbon monoxide and ozone) are often very closely inter-related. A management strategy to tackle sources of one pollutant will often have beneficial impacts in terms of reducing emissions of other pollutants. Reducing the direct discharge of pollutants can also lead to reductions in other pollutants which are produced in the air environment by chemical reactions, particularly ozone and some particulates. Strategies for reducing particles in some regions may need to focus on reductions in nitrates and sulfates (which are secondary particles) and/or lead emissions which are in the form of fine particles.

There are some cases where air quality management strategies will focus on a single source of a single pollutant. This will occur in areas (usually non-metropolitan) where a particular industrial process is the source of significant quantities of a particular substance (eg. sulfur dioxide from ore smelting). In situations such as this, the management strategies available will need to be examined closely by the firms in question and the relevant government in order to develop an appropriate management approach which minimises costs and maximises benefits.

In urban areas, air-shed management programs already in place involve a diverse range of strategies to manage the discharge of polluting substances. These programs, and possible avenues for future programs are discussed below.

Where the standards are currently not being met, strategies to improve air quality may be developed. The goal of the measure is to achieve compliance with the standards within 10 years except for a small number of specified exceedences to allow for rare meteorological events and unpredictable circumstances. This fairly long time-frame is appropriate in order to take into account a range of factors including:

- the period required for the development of agreed air-shed management strategies;
- the length of time changes to motor vehicle design rules take to have a substantial impact because of the slow turnover of Australia's motor vehicle fleet;

- the long investment cycles of industry where over a ten year period we might expect one or two minor and perhaps one major investment in major capital equipment or process technologies which will have a substantial impact on the environmental performance of companies; and

- the long period of time required to effectively influence and change community behaviour patterns which have an adverse effect on air quality.

6.2 MOTOR VEHICLE SOURCES

Motor vehicles are the major source of a number of air pollutants in urban areas. They are key sources of lead, carbon monoxide and nitrogen dioxide in many urban centres. In urban areas, motor vehicles contribute around 10% of SO_2 emissions. They are also the major source of photochemical smog precursors. Diesel fuelled vehicles are also a significant source of NO_x and particles in urban centres, contributing up to 80% of vehicle produced particles in major cities. A new Australian Design Rule (ADR 70/00) for diesels was introduced in 1995 which sets limits on gaseous and particle emissions. This ADR is currently under review to determine standards for the early part of the next century.

Unleaded fuel was introduced in Australia in July 1985, coupled with the requirement for its use in all post-1985 cars. All post 1985 cars were also required to be fitted with exhaust catalytic converters in order to meet the emission requirements of Australian Design Rule 37/00. The key reason for this change was to reduce the vehicle contribution to urban air pollution, particularly carbon monoxide and photochemical smog. It also had the added benefit of progressively removing motor vehicles as a source of airborne lead. The turnover of Australia's motor vehicle fleet has meant that lead from motor vehicle sources has progressively reduced over the last decade, and in the near future lead will no longer be an urban air quality issue except where other sources exist.

Table 6.1

Regulated lead levels in Australian petrol (g/L)

State/Territory	1993	1994	1995	1996
NSW (ACT)	0.4	0.3	0.2 [0.14]	0.2 [0.15]
Victoria	0.3	0.25	0.2 [0.11]	0.2 [0.14]
Queensland	0.4	0.3	0.3 [0.23]	0.2 [0.18]
South Australia	0.55	0.45	0.3 [0.26]	0.3* [0.25]
Western Australia	0.5	0.4	0.3 [0.28]	0.2 [0.17]
Tasmania	0.45	0.3	0.3	0.2
Northern Territory	0.5	0.4	0.3	0.2

** Compliance with the nationally agreed level of 0.2g/L was achieved in mid-1996.*

[ ] Actual average levels as identified by the Australian Institute of Petroleum.

Strategies have also been developed to reduce lead emissions from vehicles using leaded petrol. The progressive reduction in the lead content of leaded fuel (Table 6.1), has resulted in a significant decline in lead emissions from motor vehicles (Table 6.2). Also, in 1994 a price differential of 2 cents per litre (which is still maintained) was introduced as an added incentive for drivers to 'switch' fuels. To date the use of leaded petrol has declined to about 40% of national petrol sales, with sales of unleaded petrol exceeding that of leaded petrol in all Australian states. It is predicted that by 2005 leaded petrol will probably no longer be widely available.

Table 6.2

Leaded petrol sales and emissions from lead-fuelled motor vehicles

	Sales of leaded petrol (megalitres)			Estimated lead emissions from vehicles (tonnes)		
State	**1980**	**1990**	**1995**	**1980**	**1990**	**1995**
NSW/ACT	4988	3668	2220	NE	NE	NE
Victoria	4131	3 328	1 989	1 431	769	306
Queensland	2 382	2 212	1 498	NE	1 431	769
South Australia	1 320	1 071	652	854	536	151
Western Australia	1 471	1 193	772	NE	NE	178
Tasmania	425	357	256	147	124	59
Northern Territory	110	101	66	NE	NE	15
Australia	14 772	11 930	7 542	-	-	-

NE not estimated

Source: Australian Bureau of Statistics, 1996.

The introduction of catalytic converters from 1986 also reduced the emissions of carbon monoxide and nitrogen dioxide as well as a number of other pollutants not dealt with by this ambient air Measure. They also indirectly led to reduced levels of secondary particles sourced from the formation of nitrates. The on-going turn over of the vehicle fleet means that an increasing proportion of the Australian vehicle fleet will operate with catalytic converters, and this will reduce the emissions of these pollutants further.

A number of other strategies are in place which are progressively reducing the environmental impacts of new motor vehicles. The introduction of new Australian Design Rules and initiatives by motor vehicle manufacturers have led to the development of motor vehicles which are more fuel efficient and which have more effective emissions management systems.

Costs for motor vehicles for a variety of control methods are also given by Pacific Air and Environment (1997). All parties (government and industry) have agreed to the introduction of a revised ADR (ADR 37/01) over 1997-99 which adopts US 1981 emission standards. A comparison of emissions limits for different standards are given in Table 6.3. The introduction of these standards implies the use of three way catalyst controls, ie the control of both NO_x and ROC emissions. Based on the Pacific Air and Environment data, and previous estimates by the Victorian EPA (1994), the cost per vehicle, assuming three-way catalyst is approximately $70 to $85. This represents a minor marginal addition to the cost of a new motor vehicle

Annual new vehicle sales Australia wide are approximately 600,000 per annum. The total annual cost to the consumer is therefore approximately $42 to $51 million. These costs will result from the adoption of the US 1981 emission standards. They will help to deliver the NO_2, particles and ozone standards, but will be incurred irrespective of whether the ozone standards are adopted or not. Many new vehicles are already fitted with three-way catalysts so the figures are considered an overestimate.

Table 6.3

Motor Vehicle Emission Standards

Standard	Emission Limit (g/km)		
	Hydrocarbons	NO_x	**CO**
ADR 27 (introduced 1976)	2.1	1.9	24.2
ADR 37/00 (introduced 1986)	0.93	1.93	9.3
ADR 37/01 (introduction 1997-1999)	0.26	0.63	2.1

As can be seen from the table, potential reductions from ADR 37/01 over ADR 37/00 would decrease NO_x by 67% and VOC by 77%. Even given that a large number of current vehicles were already complying with the new standard before 1997, the potential for achieving significant reductions over time is large, provided vehicle fleet turnover can be increased, and increases in vehicle kilometres travelled (VKT) contained and/or differently distributed.

Programs which encourage regular servicing and tuning of vehicles can also lead to substantial improvements in levels of emissions from motor 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. Improved maintenance practices may be an important management option for particles sourced from diesel vehicles.

The use of alternative fuels 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. These technologies are not expected to be available for some time, however, and the benefits to be gained from their introduction are not able to be estimated. Some scope may exist for emissions improvements to be achieved through measures to improve fuel quality in the medium term.

6.3 URBAN FORM ISSUES

Transport and land planning is particularly significant to air quality in relation to the level of motor vehicle use, and how cities are planned to accommodate the need for mobility and the provision of goods and services. The demand for travel in motor vehicles can be reduced by the provision of services, employment, educational and other facilities close to where people live, or close to public transport facilities.

The ‘urban villages’ concept encourages development which minimises the need for travel by motor vehicle and encourages the use of alternative travel methods including walking and cycling. This is achieved by encouraging ‘mixed use’ development with residential, commercial and other facilities located in fairly close proximity. The integration of public transport facilities in urban design will also reduce the demand for motor vehicle use. Encouraging car pooling to reduce the number of vehicles on the roads is another strategy which could be adopted.

6.4 INDUSTRIAL SOURCES

A range of strategies are used by, or available to, governments and other interested parties to influence the management of (and thus the environmental impacts of) industrial activities. These include the development of codes of best practice, business licensing, industry accreditation schemes, and the use of a range of incentive systems. Governments also use a range of educational and other mechanisms to encourage firms to identify and adopt opportunities for cleaner production and best practice environmental management.

It is also important to note that companies will undertake emission reduction activity for a range of reasons. For example, a recent survey of EPA licensees in Victoria (EPA Victoria, 1996) found that companies were motivated to improve their environmental performance by a variety of factors including:

- a corporate commitment to environmental excellence;
- a desire to maintain good relations with their local community;
- a need to comply with environmental law; and
- a desire to gain the benefits of waste minimisation and cleaner production.

Systems to manage the environmental impacts of major industrial sources have been developed by jurisdictions across Australia. In most cases, these systems, including environmental licensing, and planning instruments, require the development and use of environment protection approaches. Where there is a need to manage. a particular industrial source of a pollutant, the relevant government agency will work with the firms to negotiate an appropriate strategy for managing the emissions of pollutants to the air. In many cases where capital intensive approaches to pollution reduction are required, the costs of such strategies can be minimised by integrating them with the firm’s normal capital replacement or refurbishment cycle. For new industrial developments, environmental impact assessment processes have the ability to deliver best practice approaches to pollution prevention.

Estimates of costs for achieving emission reductions for some pollutants from stationary sources (sources other than mobile sources) are provided in the air quality management option report, Pacific Air and Environment (1997). Both technological and non technological options have been assessed. Table 6.4 summarises the costs for stationary sources based on technological end of pipe controls. These costs are based on the Sydney mix of pollutant source categories. These can be used to provide an approximation for other capital cities in Australia. As previously indicated, Sydney, Melbourne, Brisbane, Perth and possibly Adelaide, and their surrounding regions, are the only regions likely to require smog control programs in the medium term. The distribution in emission source categories is not likely to be vastly different for these cities.

Table 6.4

Estimated Control Costs $/tonne Stationary Sources

ROC		NO_x	
High	**Low**	**High**	**Low**
15,000	3,500	1,780	1,220

Where particular industrial sources have been identified in the process of developing the standards, these are discussed in the context of the particular pollutant of concern (see Chapters 8 to 13).

6.5 DOMESTIC AND OTHER SOURCES

There is a range of other sources of pollutants, including domestic solid fuel heaters (including open fire places), the use of natural gas in heating and cooking, backyard incineration of domestic waste, and fuel reduction burning-off (often called hazard reduction burns or prescribed burns in some states) to minimise fire risk in parks and bush land. These activities can be major sources of carbon monoxide, nitrogen dioxide and particles in some situations, and can contribute to the generation of ozone.

Strategies to manage these sources of air pollutants include public education to raise awareness of the environmental impacts of activities such as the use of open fire places and backyard incineration. Public education can and has led to shifts in behaviour away from these activities to the use of other forms of heating or waste disposal.

Fire risk management is a more complicated issue because of the need to balance the conflicting health impacts from particles with the potential loss of human life and injuries from bush fires that might result if hazard reduction burning was to be restricted. Strategies have been developed in many states to change the timing of activities so that, for example, prescribed burning for fuel reduction is not conducted on days when there is a high risk of ozone production or when particle levels are expected to be high (assuming the burn-off can be rescheduled safely).

A major fine particulate source which comprises most of the area based sources and that lends itself to control is domestic wood burning. Todd (1996) has estimated that the benefits of implementation of AS4013 and a national education program would far outweigh the relatively minor costs involved in such a strategy. A national education programme for example, could be run for $150,000 per annum and provide a 20% to 50% reduction in heaters currently not operated properly and an 80% reduction from old wood heaters being replaced by new ones meeting AS4013. In some cases, domestic wood burning is also a key source of NO_x. By focussing such an education programme on areas where this source is significant, the cost could be substantially reduced.

Some systems which lead to such changes in behaviour are already in place, often primarily for other reasons. For example, incineration is restricted or prohibited in many urban centres to reduce the direct impact of smoke and odour on neighbouring properties.

CHAPTER 7
MONITORING AND REPORTING PROTOCOL

7.1 BASIS FOR THE PROTOCOL

The National Environment Protection Council decision to prepare a National Environment Protection Measure included not only ambient air quality standards for six pollutants, but also monitoring and reporting protocols for the purpose of assessing progress towards the achievement of the goal.

A standard refers to a quantifiable characteristic of the environment against which environmental quality can be assessed. It is a surrogate measure of the environmental values that are to be protected, in this case, air quality, that will adequately protect human health and well-being.

A numerical standard has little significance in isolation and must be accompanied with standard procedures for measurement and assessment of compliance. The procedures need to cover a range of technical issues including sampling, measurement and quality control and validation, as well as the indirect influences which form the underlying basis for the standard, particularly where the indicators are only an indirect measure of the effect to be assessed (as is the case for ambient air quality standards).

These influences include the distribution of pollution and the potential exposure of the population. The primary objective of monitoring should therefore be to provide data for each pollutant that are as representative as possible of the exposure of the general population.

Thus for example, a single measurement of ozone and carbon monoxide on the edge of a freeway would not represent the exposure of residents several kilometres away, or vice versa. For ozone, the measured levels would underestimate the levels to which the population is exposed because fresh car emissions react with, and reduce ozone levels. On the other hand, measured carbon monoxide levels would overestimate exposure levels because of rapid dispersion and dilution of emissions with distance from the roadside.

The coverage of the air quality network, and the distribution of air quality monitors in the region are also of critical importance in making comparisons between regions. Thus monitoring data from a network designed to only measure peak values would paint a different picture of air quality, even for the same region, than one designed to measure representative pollutant levels. In a similar fashion, comparisons of data between networks which are of different spatial densities are likely to be misleading.

Network density is only one parameter of relevance for providing comparable networks. Topography, meteorology, emission source density and distribution, and population density and distribution can all influence the overall picture of air quality in a region. Clearly, unless these factors are considered in analysing data from different networks, comparisons can be misleading or of dubious value.

7.2 PROTOCOL DEVELOPMENT

Consultants were appointed to develop ambient air monitoring and reporting protocols to form part of a draft National Environment Protection Measure. Since ambient monitoring experience is largely found in the member government's jurisdictions it was not practicable to establish an external technical review panel. Jurisdictions were therefore asked to review the draft protocol.

Jurisdictional comments and advice were considered in finalising the draft protocol prepared by the consultants.

7.3 CONSIDERATION OF EXCEEDENCES

Ambient air quality standards establish the quality of the air required to avoid undesirable environmental consequences such as impaired human health. The ambient air standards refer to the ambient concentrations of the pollutants below which human health and well-being are generally protected. However, some susceptible individuals may be affected.

Actual levels of pollutants in ambient air are dependent on the quantities of pollutants emitted within a given air shed (pollutant loadings), the distribution and density of emission sources, and atmospheric processes which determine how the pollutants are formed, mix, interact and are removed from the atmosphere.

Numerous options for achieving and maintaining agreed ambient air quality standards are available to jurisdictions. Jurisdictional ambient air quality management plans specify the mix of control measures required to achieve the ambient standards. For any region, since meteorology is not a controllable variable, the potential for high air quality readings to occur on a few rare occasions is therefore related to the extreme meteorological conditions considered in developing the air quality management plan.

In setting ambient standards, it is normal practice to make some allowance for the influence of extreme meteorological events by specifying an allowable frequency of exceedence. This does not mean to imply that there are no potential health effects from exposure to such levels during these events. It is a recognition that for large complex airsheds involving a mix of pollutant sources, required control programs for meeting the standards during extreme meteorological conditions can be prohibitively expensive or technically unachievable. During these occasions, management of the impacts can be achieved by appropriate forecasting and providing a public advisory service on preventative measures such as limiting personal exposure and the use of preventative medication.

The shorter averaging time standards (24 hr average or less) in the draft NEPM allow 1 exceedence day per compliance monitoring station except for particles. This is considered to make sufficient allowance for extreme meteorological conditions. For particles, 5 exceedences per station per year have been set. This makes allowance for extreme events, and also recognises the need to reduce the potential for bushfire through control burning. Bushfire prevention in well managed programs relies on forecasting the optimum weather conditions.

Monitoring of ambient air quality therefore measures how effective implementation programs are in achieving the goal, rather than meteorological variability or forecasting accuracy. The standards and the allowable exceedences are in effect performance targets for each region, and the monitoring and reporting protocols specify how performance is to be measured.

7.4 PERFORMANCE MONITORING

Ambient air quality standards for the protection of human health, rely on data on toxicology, controlled exposure studies, and epidemiology. Epidemiology relates observed effects to air quality monitoring data. Air quality data are normally based on monitoring stations sited to give an average representation of general air quality and of population exposure. These stations are normally sited away from the influence of specific sources such as major roads and other major sources.

However, to provide a representative assessment of exposure, monitoring networks would include regions of generally high or low air quality levels excluding localised source-related peaks. Understanding the implications of ambient air monitoring data measured in this way requires an understanding of the studies on which the standards are based.

In line with the above discussion, programs aimed at achieving protection for the population in a region are usually designed to address regional air quality, and their success is therefore measured against a monitoring network that provides regional data. They are also pollutant specific. Clearly within a region there will be a range of locations with high and low pollution levels to which individuals are exposed. The general level of protection provided for that region is therefore for the population on average.

Assessment of performance against the ambient standards can be viewed as a measure of the success of implementation strategies. To provide comparable assessment of performance between regions and jurisdictions, monitoring networks need to reflect this approach, and this is the overall basis for the protocol.

Assessing performance according to the protocol is not intended to address monitoring needs associated with source impact management programs. Responsibility for developing such programs remain the responsibility of jurisdictions. There will clearly need to be other management programs to deal with specific source impact issues in different regions. The significance of these issues needs to be assessed in relation to providing an average level of protection within that region. This becomes particularly important when a relatively large proportion of the population in a region is potentially exposed to elevated ambient levels, or specific large sources dominate. .

The NEPM is intended to apply to general ambient air, allowing for the protection of the overwhelming majority of Australians wherever they live in Australia. In the case of ozone, the highest concentrations generally occur many kilometres from the source of primary emissions, often over populated areas. Accordingly, the NEPM standard for ozone will represent a level which jurisdictions will work to achieve in accordance with the monitoring protocol for this NEPM.

7.5 CONTENT OF PROTOCOL

Technical monitoring issues are discussed in the HRL Research and Technology Report, 1997. The issues are addressed in the protocol by proposing adherence to Australian standards and requiring NATA (or equivalent) accreditation. These are essential to provide technically comparable data. For this reason, alternatives to physical monitoring which are allowed in the protocol, and new or developing methods for which no Australian standards exist, are also required to be validated before use for reporting against NEPM standards. Obviously the other factors discussed above need also to be considered in assessing the data.

There is no ideal way of addressing all the issues fully in a monitoring protocol. They are addressed formally in the protocol as far as possible largely by reference to network size and siting criteria. The protocol requires the size of the network to be based principally on population, and performance monitoring stations to be sited according to Australian Standard siting criteria. This provides a minimum basis for comparison of performance. Fewer performance monitoring stations may be needed in regions where the pollution levels are consistently lower than the standards. Additional performance monitoring stations may be needed where pollutant levels are influenced by local characteristics such as topography, meteorology or emission sources.

There is a requirement to develop an NEPC approved airshed monitoring plan. The protocol requires assessment and reporting of the spatial and population representativeness of each station.

Assessment of performance is on a station by station basis at performance monitoring stations. Since the performance stations are required to be representative of a significant population and area, direct comparisons between areas and regions are simplified. The protocol also requires assessment of performance on a regional or airshed basis. For this purpose, meteorological and airshed modelling and additional measurement of air quality and meteorology are all relevant and can assist in the assessment. To ensure consistency, approval by the NEPC of the procedure to be used is required.

The protocol also permits the use of alternatives to physical monitoring which provide a surrogate for measurements which would otherwise occur at a performance monitoring station. Standard procedures approved by the NEPC are required, and include an appropriate mix of emissions inventories, modelling, campaign monitoring, and comparisons with similar regions.

7.6 AIR NEPM PEER REVIEW COMMITTEE

As already discussed, it is essential that performance in complying with the standard be measured and reported in the same way in all jurisdictions, or where alternative measurements are used, they are referenced to the approved methods. This is to ensure comparisons and interpretation of data are valid and made on the same basis.

In addition to the essential technical reasons for standardisation, there are other practical reasons. These include maximising exchange of data, providing a stronger technical base nationally, and simplifying meeting obligations (national and international) on reporting on the state of the environment. It also helps the general public in drawing valid conclusions about the quality of air in different locations and the performance of jurisdictions in implementing the standards.

The Measure therefore requires each participating jurisdiction to submit monitoring plans for approval. This provides a mechanism to take topography, demographics and other parameters into account and still produce data that are comparable between different airsheds. This approach has been adopted because of the complexity of producing a "one size fits all " formula for ambient monitoring.

To give effect to this requirement a peer review committee (PRC) will be established to advise on the adequacy of jurisdictional monitoring plans and to devise a consistent reporting format. The PRC will comprise an expert representative from each jurisdiction together with two community representatives, two industry representatives and a representative from local government.

In addition to assessing jurisdictional plans the PRC would devise a consistent reporting format, advise NEPC Committee on changes to monitoring policy, the acceptability of new measurement methods, the application of modelling techniques, exposure assessment, and the data collection needs for future NEPM development and review.

7.7 IMPACTS OF THE MONITORING PROTOCOL

7.7.1 Benefits

Significant benefits will flow from the application of the monitoring protocol by all jurisdictions.

The most obvious direct benefit will be the production of consistent and comparable reporting against the six standards. This public reporting will take place annually and will provide a basis for measuring progress toward the attainment of the goal of the NEPM. In doing so, it will place Australians in a better position to assess the quality of the air they breathe and to compare their air quality with other cities.

In the absence of the protocol, it would be impossible to accurately compare air quality data from the different states and territories. Similarly, it would be impossible to accurately judge the extent to which the various governments are making progress toward achieving the goal of the NEPM. For these reasons the adoption and application of the protocol is of fundamental importance to the successful implementation of the NEPM.

However, the benefits of applying the protocol go well beyond providing a consistent basis for reporting performance against the six standards. One of the other advantages of the protocol will be that, over time, it will lead to the development of nationally consistent databases for the major airsheds.

This set of databases will assist governments to improve air quality in a number of ways. For example, it will put governments in a better position to assess the extent of the problems in their major airsheds. In this way, governments will have an improved basis for setting air quality management priorities and assessing the effectiveness of air quality management programs. Similarly, it will provide a sound data base for future studies on the health impacts of air pollution.

These benefits will be enhanced when the data generated by the application of the protocol is combined with data generated by the National Pollutant Inventory (NPI). The NPI will generate consistent information across Australia on point and non-point air pollutant emission sources while the Air NEPM will generate consistent information on ambient air quality across Australia. The complementarity of this information will provide governments with a much improved information base for the purposes outlined above such as setting air quality management priorities and assessing the effectiveness of air quality management programs. It is also anticipated that many jurisdictions will add their Air NEPM monitoring data to the NPI public database, thus improving the NPI's value as a community information tool.

Finally, the consistent air quality data generated by the application of the protocol will also be of assistance to Australian industry. Industry will benefit as governments make more informed and better targeted air quality management decisions. In particular, governments will have a better information base to work with industry on identifying the most cost-effective means for reducing air pollution. Industry will also have a better basis for making informed investment decisions.

7.7.2 Costs of monitoring

As has been described, each jurisdiction will, in order to apply the protocol, submit a monitoring plan to the Peer Review Committee for approval by NEPC. The protocol has been drafted so that monitoring systems will be consistent across Australia, while allowing for the characteristics of the different airsheds and different monitoring approaches. The emphasis is on ensuring that jurisdictions produce monitoring results that are meaningful, consistent and comparable, not on dictating that each jurisdiction blindly uses identical monitoring approaches.

Given this flexibility and the fact that jurisdictions will have three years in which to develop their monitoring plans, it is difficult to estimate the costs of applying the monitoring protocol.

To begin with, most jurisdictions already conduct monitoring programs. These are mostly for capital city areas, but some jurisdictions also conduct monitoring programs in a number of regional centres. In preparing its monitoring plan, each jurisdiction will assess its current monitoring programs against protocol requirements. Some of the factors that jurisdictions will take into account include:

- the siting of its existing monitoring network;
- the priority and methods for performance monitoring in regional centres; and
- the applicability of combining different air quality assessment methods such as physical monitoring, modelling and emission inventories

Once a jurisdiction has taken these factors into account, it can work out the extent to which it needs to make any adjustments to its current air monitoring programs. It would then prepare its air monitoring plan and submit it to the Peer Review Committee. The costs of the plan can only be assessed by jurisdictions themselves, and hence cannot be readily assessed in the absence of approved monitoring plans.

The following table does, however, provide an approximate summary of typical monitoring costs for the six pollutants.

Table 7.1

Indicative estimates of the costs of monitoring equipment

Parameter	Capital Costs ($ per monitor)
Nitrogen Dioxide	18,000
Sulfur Dioxide	18,000
Ozone	12,000
Carbon Monoxide	18,000
Particles- lead (Hi Vol)	10,000
Particles (continuous)	35,000

Increasingly around the world including Australia, the Tapered Element Oscillating Microbalance (TEOM) is replacing the High Volume Sampler (Hi Vol) method for the measurement of particles. The advantage of the TEOM over the Hi Vol method is that the TEOM method provides for continuous measurement of particles in real time similar to a continuous measuring gas analyser; whereas the Hi Vol method is restricted to a 24 hour sampling period followed by gravimetric analysis in a laboratory. There is no Australian Standards method available yet for the TEOM method, however there are a number of countries that have accepted the TEOM method as a standard or equivalent method for PM_{10} (US EPA has designated the TEOM as an equivalent PM_{10} method).

More recent monitors include the multi parameter differential optical absorption spectrometer (DOAS) and the Airtrak. Prices depend on options and are around $100,000 for a DOAS system capable of measuring ozone, sulfur dioxide and nitrogen dioxide and $100,000 for an Airtrak. The DOAS system is also capable of measuring some of the air toxics such as benzene.

Instrumental monitoring of photochemical oxidants has, in the last couple of decades, been based on ozone. With the successful development, in Australia, of the Airtrak 2100 instrument there is now a powerful tool for developing strategies for the control of photochemical oxidants. Airtrak provides information about photochemical oxidants formation and precursor conditions (See chapter 11).

Other costs will depend on the system and locations, and include air conditioned huts, security fencing, calibration equipment, validation processes, data acquisition and telemetry costs, and analysis costs for lead. Likewise operating costs will vary depending on monitoring arrangements. Quality assurance costs may be significant additional cost for some jurisdictions. As a general guide, capital costs for a fully equipped conventional multi-parameter monitoring station are around $180,000. Annual operating costs are around 10 - 20% of capital for a relatively large mature network, but could be higher in smaller networks.

While precise total cost estimates cannot be produced prior to the preparation of each jurisdiction's monitoring plans, the above information can be used to provide an indicative estimate of applying the protocol across all jurisdictions. The context for these estimates is that for the whole of Australia there is approximately $20 million invested in ambient air monitoring equipment and infrastructure.

Some jurisdictions have indicated that monitoring and reporting requirements for the NEPM could be met through existing monitoring budgets by utilising and/or adjusting the priorities of current programs. Additional costs for jurisdictions have been estimated to be in the order of $2M for the capital costs of additional monitoring equipment required in the first three years and, $0.6M for annual recurring costs which include monitoring equipment operating costs, costs of reporting and conducting alternatives to physical monitoring including emission inventories, and modelling.

CHAPTER 8
CARBON MONOXIDE

The standard for carbon monoxide as measured at each performance monitoring station is:

- 9.0 ppm measured over an eight hour period. [The Goal being to meet the standard with one allowed exceedence day per year within a 10 year timeframe.]

8.1 NATURE OF CARBON MONOXIDE

Carbon monoxide (CO) is a colourless, odourless and tasteless gas that, in high concentrations, is poisonous to humans. Carbon monoxide is a trace constituent of the atmosphere, with background levels normally ranging between 0.01 to 0.2 parts per million (ppm). It is produced both by natural processes (such as volcanoes and bush fires) and by human activities (such as the incomplete combustion of carbon-containing fuels, especially from motor vehicles). Industrial processes such as steel making may also produce significant amounts.

When inhaled, CO combines with haemoglobin, the blood's oxygen-carrying molecule, to form carboxyhaemoglobin. Once in this state, the haemoglobin is unable to carry oxygen. It takes about 4 to 12 hours for CO concentrations in the blood to reach equilibrium with the CO concentration in air, and so any fluctuations in the ambient CO concentrations are only slowly reflected in the carboxyhaemoglobin levels in humans unless very high CO levels are experienced. For this reason environmental concentrations are generally reported in terms of an 8-hour average concentration.

8.2 SOURCES OF CARBON MONOXIDE

8.2.1 Anthropogenic Sources

Table 8.1

Anthropogenic CO Emissions from Mobile Sources

Airshed	CO Emissions (kt)	Mobile Sources (%)
Sydney	801	91
MAQS	1278	69
Melbourne Region	784	79
SEQ	398	83
Perth-Kwinana	271	81
Port Pirie	2	96
Launceston	8	78
Canberra	67	72
Adelaide	276	82

Table 8.1 shows that most of the CO emitted in urban airsheds comes from mobile sources such as motor vehicles. This has prompted requirements to ensure that new motor vehicles are fitted with catalytic converters which emit very low levels of CO.

8.2.2 Biogenic or Natural Sources

There are few significant biogenic sources of CO that impact urban centres except for natural disasters such as bushfires and volcanoes.

8.3 HEALTH EFFECTS OF CARBON MONOXIDE

Several major reviews of the health effects of carbon monoxide (CO) have been published in recent years (CONCAWE 1997, Bascom et al 1996, WHO 1996, DoE 1996, DoE 1994, Health Canada 1995, US EPA 1992, US EPA 1991, Streeton 1990, WHO 1987, Environment Canada 1987, US EPA 1979, WHO 1979). In addition, both WHO 1979 and WHO 1987 have recently been revised, but are not yet published, and can not yet therefore be cited. There have been no significant variations in the approaches adopted by the various jurisdictions to the adverse health effects of CO over this time, namely that to achieve adequate protection of the more susceptible population sub-groups (those with ischaemic heart disease, other forms of cardiac disease including cyanotic heart disease, hypoxaemic lung disease, cerebrovascular disease, peripheral vascular disease, those with anaemias and haemoglobin abnormalities, children, and developing foetuses), a carboxyhaemoglobin level of 2.5% should not be exceeded whilst either at rest or during active physical exercise.

CO affects human health by reducing the amount of oxygen which can be carried in the blood to the body tissues. When CO is inhaled into the lungs, it combines selectively with haemoglobin (the oxygen-transport protein contained in the red blood cells) to form carboxyhaemoglobin (COHb). Haemoglobin which has been thus transformed is no longer available for oxygen transport, and as a result the brain, nervous tissues, heart muscle and some other specialised tissues which require large amounts of oxygen may not receive sufficient oxygen to function optimally, and may suffer temporary or permanent ischaemic damage as a result. High levels of exposure can cause acute poisoning, leading to coma and death at COHb levels of greater than 40%. These high exposures are fortunately rare, and occur either accidentally in poorly ventilated situations with malfunctioning combustion devices, deliberately as with suicide, or in the occupational setting as with fire-fighters, etc.

At between 2.5% and 5.0% COHb content, there is evidence of an increasing incidence of angina pectoris, especially during exercise, in those with significant coronary artery disease which limits the supply of blood to the heart muscle. Such people may also develop chest pain when exerting themselves and are at increased risk of heart attacks. Above 3.0% COHb, there is also increasing psychometric dysfunction (a measurable increase in normal response time). COHb levels in average smokers (around 1 pack per day) far exceed these levels, ranging from 5% to 15% of total haemoglobin content, depending on their individual patterns of tobacco consumption.

In healthy people, CO can affect exercise capacity; the higher the COHb level, the greater the reduction. These effects have been observed at levels of COHb as low as 2.3 to 4.3 %. However, this effect is small and is unlikely to interfere with normal daily living activities.

Maternal smoking is a significant cause of reduced birth weight and delays in foetal and neonatal development and would appear to be reasonably attributed to CO exposure at levels of COHb between 2 and 7%. Table 8.2 summarises the various adverse health effects and the lowest observed adverse effect levels (LOAELs), and no observed adverse effect levels (NOAELs).

Table 8.2

Adverse health effects from exposure to carbon monoxide

	LOAEL (% COHb)	**NOAEL (% COHb)**
CARDIOVASCULAR EFFECTS - Healthy Adults:		
Decreased O_2 Uptake Decreased Work Capacity (Maximal Exercise)	5.0 - 5.5%	< 5.0%
Significant Decrease in Work Time	3.3 - 4.2%	< 3.0%
Strenuous Exercise – Maximal O_2 Consumption	7 - 20%	
CARDIOVASCULAR EFFECTS - People with Ischaemic Heart Disease:		
Decreased Exercise Capacity at Onset of Angina, Increased Duration of Angina	2.9 - 4.5%	2.5%
NEUROBEHAVIOURAL EFFECTS - Healthy Adults:		
Statistically Significant Vigilance Decrements	5.0 - 7.6%	<5.0%
Statistically Significant Diminution of Visual Perception, Manual Dexterity, Ability to Learn, Performance of Complex Sensorimotor Tasks	5.0 - 17%	<5.0%
FOETAL EFFECTS		
Reduced Birth Weight (Non Smoking Mothers)	2.0 - 7.0%	<2.0%

8.3.1 Dose response relationships

There is a linear dose response relationship between CO and Carboxyhaemoglobin (COHb) that allows predictable levels of COHb for a given ambient concentration of CO, for a given duration of exposure, and at a given level of rest or exercise. Although the relationship between ambient levels of CO and the resultant COHb levels is approximately linear in the region of ambient air concentrations, it is quite complex.

There are dilution effects in the body tissues, and it can take 10 - 12 hours following continuous exposure to CO for the blood COHb levels to achieve a steady-state equilibrium. Under conditions of increasing exercise, equilibrium is achieved more rapidly because of increased alveolar ventilation rates, increased gas exchange (diffusing capacity), and increased cardiac output. Even mild exercise increases the body's demand for oxygen, and thus can enhance the effect of exposure to a given concentration of ambient CO.

Reduced birth weight and delays in foetal and neonatal development at exposure levels of COHb between 2 and 7% provide a NOAEL below 2%.

8.4 CURRENT AMBIENT AIR QUALITY OBJECTIVES FOR CARBON MONOXIDE

8.4.1 Current Australian Ambient Objectives

Table 8.3 shows the current health-related objectives for CO in Australia. Although the NHMRC goals have no regulatory status, they may be referenced by States and Territories for appropriate health guidance. NHMRC goals do not apply in Victoria or Tasmania. Although there is some lack of uniformity for the 1-hour objectives, there is little variation in the 8-hour objectives.

Table 8.3

Australian objectives for CO

State/Authority	Averaging Period	
	1 Hour	8 Hour
NHMRC	-	9 ppm
Victoria - Acceptable level Detrimental level	30 ppm 60 ppm	10 ppm 20 ppm
New South Wales *	25 ppm	9 ppm
Queensland #	-	9 ppm
South Australia	-	9 ppm
Tasmania **	30 ppm	10 ppm
Northern Territory	-	9 ppm
Australian Capital Territory	35 ppm	9 ppm
Western Australia	25 ppm	9 ppm

**A short term goal of 87 ppm (15 mins average) applies in road tunnels*

***Maximum acceptable levels*

 # NHMRC goals are matters for consideration in making a decision about an environmentally relevant activity.

8.4.2 Current international objectives

Table 8.4 shows the current health-related objectives for CO in New Zealand, the European Union, USA, the World Health Organization, Japan and Hong Kong. As with the objectives used in Australia, there is some lack of uniformity for the 1-hour objectives, but little variation in the 8-hour objective. Air quality objectives usually contain safety factors and this is often the reason behind the variation in the levels specified in goals or guidelines.

Table 8.4

Current International objectives

Country/State/Authority	Averaging Period	
	1 Hour	8 Hour
New Zealand	30 ppm	10 ppm
European Union	25 ppm	10 ppm
United States of America	35 ppm	9 ppm
California	20 ppm	9 ppm
World Health Organization**	25 ppm	10 ppm
Japan	-	10 ppm (24 hr)
Hong Kong	25 ppm	9 ppm

*** Short term objectives of 87 ppm (15 mins average) and 50 ppm (30 mins average) also established*

8.5 CURRENT AMBIENT AIR LEVELS FOR CARBON MONOXIDE

Ambient levels of CO in major urban centres in Australia generally do not exceed the 1-hour WHO goal of 25 ppm (section 8.4 discusses this and other goals). The 8-hour NHMRC goal of 9 ppm is occasionally exceeded at some peak monitoring sites in some Australian cities. In Sydney it is often exceeded with some 70 exceedences each year at the peak monitoring site in the city centre. Maximum urban concentrations usually coincide with morning and evening rush hours and may also be influenced by the local topography, including the presence of structures such as large, tall buildings and tunnels, as well as meteorology. Elevated CO levels are associated with major urban airsheds and in particular with proximity to major arterial roads and highways.

Monitoring data for CO at sites near roads with heavy traffic are critically dependent on instrument siting, since concentration gradients are generally large near road sources. The monitoring data from roadside sites do not always provide useful data on general population exposure to ambient CO levels.

8.6 AUSTRALIAN EXPOSURE LEVELS FOR CARBON MONOXIDE

Attempts were made using available data to estimate population exposure to concentrations of carbon monoxide for major cities where CO monitoring takes place (Beer and Walsh 1997).

Limitation in the available data constrained the application of the exposure assessment methodology. However, it provided useful indications of potential exposure patterns and also identified data gaps which the NEPM could usefully fill for future studies.

The major difficulties with the information arose from the location of existing monitoring stations. Lack of consistency in monitoring locations between or even within air sheds led to lack of comparability between data and exposure estimates which were biased by the monitoring data.

These difficulties were highlighted and explained in the draft Impact Statement and the use of the data was heavily qualified. Despite these caveats and explanations covering the use of the exposure assessment data the public submissions on the draft Impact Statement have demonstrated that these data were still open to misinterpretation.

In response to widespread stakeholder concern, the exposure assessment has been accepted by NEPC as indicative only and did not influence the final choice of standards.

Future monitoring under the protocol combined with jurisdictional peak monitoring, will provide a more robust basis for future exposure studies should they be required.

8.7 CURRENT MANAGEMENT PRACTICES FOR CARBON MONOXIDE

Current management approaches have focussed on controls on combustion sources. Ensuring high combustion efficiency by proper design, as for example with woodheaters meeting AS 4013, dispersion from elevated chimneys, or add-on controls such as afterburners has been the main approach. The introduction of catalyst equipped petrol fuelled vehicles in the mid 1980s significantly reduced CO emissions progressively from this source.

8.8 RANGE OF STANDARDS CONSIDERED FOR CARBON MONOXIDE

The recommended range of standards for CO from the various inputs to the Project Team was as follows:

- Health Review Study8 hour standard, 9 to 10 ppm
- Technical Review Panel8 hour standard, 9 to 10 ppm
- NHMRC8 hour goal, 9 ppm

The range recommended is quite small for CO with a majority support for a 8 hour standard of 9 ppm. The Technical Review Panel recommended that this be reviewed in ten years time.

A number of stakeholders have indicated that consideration should be given to a shorter averaging time standard of one hour or less. The exposure data for a one hour standard of 25 ppm (the equivalent of an 8 hour standard set at 9 ppm using the Coburn-Forster-Kane Exponential equation), indicates, except for Adelaide, compliance for the years selected. A one hour goal, such as the WHO goal of 25 ppm, may be useful to jurisdictions in developing control strategies for CO in congested street canyons where there is a potential for significant public exposure to short term levels of CO. However, it is not proposed as a NEPM standard.

The standard for carbon monoxide as measured at each performance monitoring station is 9.0 ppm measured over an eight hour period. [The Goal being to meet the standard with one allowed exceedence day per year within a 10 year timeframe.]

8.9 IMPACTS OF STANDARDS FOR CARBON MONOXIDE

8.9.1 Health impacts

The number of individuals exposed to levels above 9 ppm generally occurs close to major sources such as major roads. Available monitoring data indicate that there would be little exposure above 9 ppm away from such sources and the standard would therefore be met at all future NEPM performance monitoring stations.

However, near major sources there may be some 10% of the population estimate exposed to levels above 9 ppm. As an illustrative example, using cost data from US EPA (1996) if 1% of the 5 million (the 10% noted above) person events resulted in a loss of a day's earnings, the cost to the community, neglecting health treatment, would be, in terms of total loss of productivity per year, some 6 million dollars. These $ figures are not intended to be representative of the actual Australian incurred or avoided costs but are provided to assist the reader in assessing the relative significance of these possible impacts.

It is expected that in protecting the sensitive population from adverse health effects, benefits for other populations may also result from required pollution reductions. The general population may begin to experience a slight reduction in central nervous system effects such as impaired vigilance, visual function, manual dexterity and ability to learn. This implies a decrease in risks of accidents and improved productivity or activity.

Associated benefits include increased community confidence that air quality is protected such that health impacts will be avoided, particularly ensuring protection for the elderly, foetal development and other sensitive individuals.

8.9.2 Management options

The principal focus for management action where carbon monoxide levels are considered excessive will continue to be on motor vehicle emissions. The following options would form part of a possible jurisdictional response not associated with the NEPM.

Chapter 6 provides a discussion of the range of strategies which are currently in place or could be developed to reduce the impact of motor vehicle emissions on the air environment. In brief, with the introduction of ADR 37/01 over the next few years, CO emissions from new cars will be restricted to 2.1 g/km from the current ADR 37/00 (introduced in 1986) of 9.3 g/km, a 4 to 5 fold reduction.

Regional strategies to reduce motor vehicle use (or improve local traffic management), and reducing other sources such as back-yard burning, domestic solid-fuel heating and industrial emissions will also need to be considered. As the major areas impacted are in major urban CBDs with heavy traffic flow especially in road tunnels and street canyons and in close proximity to major roads, the costs of controls (as motor vehicles are the major source in these areas) are expected to be contained in existing programs such ADR 37/01 or in improved local traffic management.

8.9.3 Other impacts

Carbon monoxide also has a range of adverse environmental effects. Carbon monoxide is an indicator of poor combustion. Actions taken to reduce CO will also generally improve fuel efficiency and reduce emissions of particles, and as a consequence, improve visibility.

Other environmental impacts will also be reduced. Other products of incomplete combustion (PAHs) would also be reduced and as many of these products are carcinogens, some reductions of this impact might be expected.

8.10 SUMMARY OF COSTS AND BENEFITS FOR THE CARBON MONOXIDE STANDARD

Because the NEPM deals only with the assessment of air quality by governments the only direct costs associated with the introduction of the standard for CO are the monitoring and reporting costs, required by the NEPM protocol, which will be incurred by governments when assessing ambient air quality. There is no other requirement placed upon governments. In most cases some changes to existing monitoring and reporting programs for assessing air quality will be required. Until detailed jurisdictional monitoring plans have been developed the costs associated with monitoring CO for the purposes of this NEPM cannot be definitively identified.

Most jurisdictions have active air quality management programs for CO which they continuously monitor, revise and refine over time. The NEPM will provide a sound basis for assessing the extent of any CO problems in the major airsheds and, therefore, assist governments in determining the priority to be given to the management of the effects of CO on ambient air quality in the context of overall government programs. Voluntary programs will continue to play an increasing and effective role in those air quality management strategies. These include both industry emission reduction programs (not expected for CO) and behaviour change programs by motorists often sponsored by motoring organisations. It is expected each jurisdiction will continue to work closely with the community (including industry where necessary) in determining the appropriate mix of strategies to maintain or achieve the NEPM goal set for CO.

8.10.1 Benefits

As it is estimated that the standards will be met at all performance monitoring stations through current control strategies then no costs and benefits can be directly attributed to the introduction of the standard. However, it is expected that the adoption of the standard will contribute to a range of ongoing benefits from maintaining low CO levels.

Existing motor vehicle strategies to reduce CO should lead to a progressive reduction in any health impacts and perhaps direct savings in terms of avoided treatment costs. Other indirect savings will consequently accrue in terms of improved productivity and a reduction in the occurrence of sick-leave, and a range of intangible benefits in terms of improved well-being (including improved vigilance, visual function, manual dexterity and ability to learn).

8.10.2 Costs

As previously indicated there are no expected costs associated with the introduction of the standard for CO. Any costs associated with existing emission control strategies will continue to be incurred. The major source of CO emissions in Australia is from motor vehicles. Table 8.1 shows mobile source emissions ranged from 72% to 96% depending on the airshed. Hence, in the urban areas currently impacted by CO emissions, any costs attributed to CO control, would need to focus on mobile sources. As outlined above, it is expected that existing programs such as ADR 37/01 would be the main mechanism of control. However, as there are specific impacts in some airsheds that are currently being monitored, but nevertheless indicative of a significant population exposure of some millions of person events, it may be that improved local traffic management would offer the most cost effective control option.

8.11 ISSUES RAISED DURING PUBLIC CONSULTATION ON CARBON MONOXIDE STANDARDS

For a detailed summary of issues and responses refer to the Summary and Response Document.

Carbon monoxide did not draw significant comment from public submissions. Those comments received were largely supportive of an eight hour standard of 9 ppm. Several submission requested consideration of a shorter averaging period, for example, one hour. This is addressed under Section 8.3.

8.12 CONCLUSIONS - CARBON MONOXIDE

Having considered the comments made during the public consultation phase, including written submissions, and the available scientific, social and economic data the following conclusions have been reached:

It is estimated that the standard will be met at all performance monitoring stations through current control strategies. The principal benefits of implementation of this standard will be its contribution to setting a benchmark to protect the gains already made and to identify areas where local meteorology may cause problems, and also to a range of ongoing benefits from maintaining low CO levels including:

- reduced adverse health impacts particularly for those suffering from clinical angina
- improved aesthetics and amenity within the urban setting, reduction in combustion odours resulting from improved combustion or declining motor vehicle emissions;
- improved visibility; and
- a number of other less tangible effects such as the removal of involuntary risk and any increased general sense of well-being.

Accordingly the standard for carbon monoxide as measured at each performance monitoring station is:

- 9.0 ppm measured over an eight hour period. [The Goal being to meet the standard with one allowed exceedence day per year within a 10 year timeframe.]

CHAPTER 9
NITROGEN DIOXIDE

The standards for nitrogen dioxide as measured at each performance monitoring station are:

- 0.12 ppm (parts per million) averaged over a one hour period; and
- 0.03 ppm averaged over a one year period.

[The Goal being to meet both standards within a 10 year timeframe. The goal allows one exceedence day per year for the 1 hour standard.]

9.1 NATURE OF NITROGEN DIOXIDE

Nitrogen dioxide (NO_2) is a pungent acidic gas. It is corrosive and strongly oxidising. It is one of several oxides of nitrogen (NO_x) which can be produced as a result of human activity mainly by combustion processes. Combustion of fossil fuels converts atmospheric nitrogen and any nitrogen in the fuel into its oxides, mainly to nitric oxide (NO). The nitric oxide slowly oxidises to nitrogen dioxide in the atmosphere. This reaction is speeded up greatly in the presence of ozone. In the presence of sunlight, oxides of nitrogen including nitrogen dioxide, react with photochemically reactive volatile organic compounds to form photochemical smog (See Ozone Chapter 10).

9.2 SOURCES OF NITROGEN DIOXIDE

9.2.1 Anthropogenic sources

The main source of NO_2 resulting from human activities is the combustion of fossil fuels (coal, gas, oil). In cities, about 80% of ambient NO_2 comes from motor vehicles. Other sources include the refining of petrol and metals, commercial manufacturing and food manufacturing. Electricity generation using fossil fuels also produces significant amounts of NO_2. The estimated NO_x emissions from regions for which information is available are summarised in Table 9.1.

The proportion of NO_x emissions from various source types differs from place to place. Most NO_x in Australian Cities comes from motor vehicles and industry point sources (See also Ozone, Table 10.1).

9.2.2 Biogenic sources

NO_2 is formed naturally by lightning and the oxidation of ammonia. In urban areas, natural sources of NO_2 are very small, in the order of 1% of the total emissions (NSW EPA MAQS Report 1996).

Table 9.1

Estimated Annual NO_x Emissions

Location	NO_x (kt)	Data Source	Year of estimation
Sydney	102	NSW SOE Report 1995: 19	1992
MAQS Region	239	NSW SOE Report 1995: 19	1992
Melbourne Region	83	Carnovale et al.(1990: 100-102)	1990
Brisbane Region	74	Morgan (1996) 2000 Then What: 90	1993
Perth-Kwinana	46	Weir (1996) 2000 Then What: 304	1993
Adelaide	34	ARC (1989: 21,22)	1985
Canberra	5	AEC (1989: 21,22)	1985
Hobart	5	AEC (1989: 21,22)	1985
Darwin	3	AEC (1989: 21,22)	1985
Latrobe Valley	52	LVASSC (1986: 20)	1984
Launceston	0.6	EPAV (1996. Vol. 2, 9-6)	1994
Port Pirie	0.4	EPAV (1996. Vol. 2, 9-6)	1994

Source: Pacific Air and Environment (1996)

9.3 HEALTH EFFECTS OF NITROGEN DIOXIDE

The health effects of NO_2 have been extensively reviewed by a number of jurisdictions over the last several years, (WHO 1997; Bascom et al, 1996; CONCAWE 1995; US EPA 1995; US EPA 1993; Department of Health 1993; Berglund et al 1993). In addition, reviews of the health effects of NO_2 have been conducted for the updating of the WHO/EURO *"Air Quality Guidelines for Europe, 1986"*.

Nitrogen dioxide has been demonstrated to potentiate the effects of exposure to other known irritants such as ozone (Hazucha et al 1994), sulfur dioxide (Devalia et al 1994) and respirable particles (Department of Health 1995).

Nitrogen dioxide appears to exert its effect on the human organism both directly, leading to an inflammatory reaction on epithelial surfaces in the human lung; and indirectly by the induction of relative impairment of immune defence mechanisms in the lung. Epidemiological studies would suggest that young children are especially susceptible to these indirect effects, resulting in potentiation of respiratory infections following disturbances in immune defence mechanisms. The direct effects are thought to be due to an oxidative reaction on unsaturated fatty acids in cell membranes and in various soluble and structural proteins, resulting in the production of inflammatory mediators.

9.3.1 Long Term Impacts

Studies undertaken worldwide have repeatedly shown robust epidemiological associations between chronic NO_2 exposure, measured either directly, or by inference due to the associated presence of unvented gas stoves and gas heaters, and the incidence of coughing, wheezing, and respiratory infections in exposed children (Neas et al 1991, Pilotto 1994, Pilotto et al 1997), especially those of a young age. Long term exposure in a chronic indoor environment appears to have more direct effects on the patterns of respiratory infection in young children presumably due to disturbances in pulmonary airway immune defence mechanisms. Indoor exposures to NO_2 have, in many studies, been shown to greatly exceed the comparable measured outdoor or ambient exposures to the same population, and frequently for much extended periods. Animal studies have demonstrated that extended exposure over several months have been required to demonstrate changes in lung structure, lung metabolism, and lung defences against bacterial and viral infections.

The effects of NO_2 in the younger human population appear to be limited to children from infancy through to late childhood. The major effects have been demonstrated in children ages 5 to 12 who have been exposed to long term background increases in NO_2. Increases as high as 20% in risk of respiratory symptoms and disease have been observed for each increase of 0.015 ppm of NO_2, where the weekly average concentrations for NO_2 were in the approximate range of 0.008 to 0.065 ppm, or possibly higher (WHO 1997). This effect is not seen in adults with similar exposures.

9.3.2 Short Term Impacts

There would appear to be separate patterns of responses in susceptible populations to short term acute ambient exposures, compared to the response patterns observed after longer term chronic exposures to mildly increased background concentrations in the indoor environment. With acute ambient exposures, generally to a mixture of pollutants including NO_2, photochemical oxidants (ozone), and respirable particles, immediate effects within one to two days can be demonstrated in the form of increased bronchial hyper-responsiveness in asthmatics and in those with chronic inflammatory lung disease. This leads to an increased frequency of wheezing, cough, sputum production, which may lead to an increased frequency of respiratory infections (Department of Health (DoH), 1995). For practical purposes however, it has not been possible in the majority of epidemiological studies to satisfactorily separate the effects of indoor and outdoor (ambient) exposures.

At present, the meta-analysis undertaken by Folinsbee (1992) remains the most reliable basis for determining a LOAEL for NO_2 at between 0.20 and 0.30 ppm exposure over one hour. A current review by CONCAWE (1995, 1996a, 1996b) confirms this LOAEL on the basis of reversible changes in respiratory function (greater than 5% reduction in $FEV_{1.0}$), and increased airway responsiveness in mild asthmatics following 30 minute exposures.

Nitrogen dioxide appears to contribute both to morbidity and to mortality, especially susceptible subgroups such as young children, asthmatics, and in individuals with chronic inflammatory airway disease (chronic bronchitis and related conditions). Some epidemiological studies have found significant effects of NO_2 on hospital admissions (Pünkä, 1991) emergency room visits and respiratory illness and mortality. The relative risk of death is weak, ranging from 1.0 (no effect) to 1.9 for mean NO_2 levels between 35 and 88 $\mu g/m^3$ (Sunyer et al, 1996; Boback and Leon, 1992).

Similar associations have also been found in studies carried out in Australia. Studies carried out in Sydney as part of the Health and Air Research Program (Morgan et al., 1996) have shown an association between hospital admissions for respiratory and cardiac conditions and ambient NO_2 levels for the years 1990 - 1994. An increase in NO_2 levels from the 10^{th} to the 90^{th} percentile resulted in a 7% increase (95% CI: 1.97 - 12.76) in hospital admissions for childhood asthma, and a 7% increase (95% CI: 4.25 - 10.24) in admissions for heart disease. Morgan et al (1996) also found that when multiple pollutant models were examined, increases in NO_2 were found to be primarily responsible for the increases in admissions for childhood asthma and for heart disease in the elderly.

The risk of respiratory illness observed from epidemiological studies ranges from 1.2 (0.083 ppm, Shy et al, 1970) to 1.8 (for NO_2 levels of 49 to 502 $\mu g/m^3$, Von Mutius et al, 1995). The effects upon lung function are modest with 40 litres/minute reduction in peak expiratory flow rates for every 20 $\mu g/m^3$ increase in NO_2 (Quackenboss et al, 1991) and a 5% reduction in $FEV_{1.0}$ / FVC for every 10 $\mu g/m^3$ increase in NO_2 above 40 $\mu g/m^3$ (Moseler et al 1994).

The experimental (controlled chamber exposure) studies have been able to control for many of the confounders which affect the epidemiological studies. However they still yield inconsistent findings, even in subjects such as young asthmatics who would be expected to be most sensitive to the effects of NO_2. There are some studies suggesting a reduction in lung function in patients with chronic obstructive pulmonary disease (COPD) and potentiation of exercise-induced asthma following exposure to 0.3 ppm NO_2 (Morrow et al, 1992). With the use of an uncertainty factor to ensure adequate protection of the most vulnerable sub groups of the population the guideline range of 0.1-0.15 should be used.

9.4 CURRENT AMBIENT AIR QUALITY OBJECTIVES FOR NITROGEN DIOXIDE

Table 9.2 shows the current health-related objectives for NO_2 in Australia and internationally. Although the NHMRC goal has no regulatory status, it may be referenced by States and Territories for appropriate health guidance. Comparisons are not straight forward since the status (eg. goal versus standard), allowable exceedences, and monitoring protocols, where they exist, are different and need to be considered. The numerical values provide a guide only.

Table 9.2

Australian and International objectives for nitrogen dioxide

State/Country/Authority	Averaging Period		
	1 hour (ppm)	24 hours (ppm)	Annual (ppm)
Australia (NHMRC)	0.16	-	-
Victoria ... acceptable ... detrimental	0.15 0.25	0.06 0.15	-
New South Wales**	0.16	-	-
Queensland #	0.16	-	-
South Australia	0.16	-	-
Tasmania *	0.15	0.06	-
Northern Territory	0.16	-	-
Australian Capital Territory	0.16	-	-
Western Australia	0.16	-	-
New Zealand	0.15	0.05	-
European Union	0.071 (98th percentile)	-	0.026 (50th percentile)
United States of America California	- 0.25	- -	0.053 -
World Health Organisation	0.11	-	0.021- 0.026
Hong Kong	0.16	0.08	0.04
Japan	0.06	-	-

** Maximum acceptable levels*
 # NHMRC goals are a matter for consideration in making a decision about an environmentally relevant activity
*** NSW "Action For Air" (1998) has new interim goals of 0.125 ppm one hour and 0.03 ppm annual*

9.5 CURRENT AMBIENT AIR LEVELS FOR NITROGEN DIOXIDE

Elevated ambient levels of NO_2 can occur in Australian urban areas particularly during autumn or winter. Some cities, such as Sydney and Adelaide, occasionally exceed the NHMRC 1-hour goal (0.16 ppm). However, the peak 1-hour values appear to be decreasing in Melbourne (most years less than 0.10 ppm), with Brisbane, Sydney and Adelaide remaining relatively static. Recent data shows that peak 1 hour NO_2 values are below 0.12 ppm in these cities in most years. For smaller cities and towns NO_2 levels are low.

9.6 AUSTRALIAN EXPOSURE LEVELS FOR NITROGEN DIOXIDE

Attempts were made using available data to estimate population exposure to concentrations of NO_2 for major cities and towns where NO_2 monitoring takes place (Beer and Walsh 1997).

Limitation in the available data constrained the application of the exposure assessment methodology. However, it provided useful indications of potential exposure patterns and also identified data gaps which the NEPM could usefully fill for future studies.

The major difficulties with the information arose from the location of existing monitoring stations. Lack of consistency in monitoring locations between or even within air sheds led to lack of comparability between data and exposure estimates which were biased by the monitoring data.

These difficulties were highlighted and explained in the draft Impact Statement and the use of the data was heavily qualified. Despite these caveats and explanations covering the use of the exposure assessment data the public submissions on the draft Impact Statement have demonstrated that these data were still open to misinterpretation.

In response to widespread stakeholder concern, the exposure assessment has been accepted by NEPC as indicative only and did not influence the final choice of standards.

Future monitoring under the protocol combined with jurisdictional peak monitoring, will provide a more robust basis for future exposure studies should they be required.

9.7 CURRENT MANAGEMENT PRACTICES FOR NITROGEN DIOXIDE

The principal focus for management in urban regions where mobile sources are an important source of NO_x has been and will continue to be motor vehicle emissions. In most airsheds, current motor vehicle management strategies are expected to deliver lower ambient NO_2 levels.

9.8 RANGE OF STANDARDS CONSIDERED FOR NITROGEN DIOXIDE

The recommended range of standards for NO_2 from the various inputs to the project team was as follows:

- Health Review Study...............1 hr standard 0.10-0.15 ppm; annual average 0.03 ppm
- Technical Review Panel...........1 hr standard 0.12 ppm; annual average of 0.03 ppm
- NHMRC..................................1 hr standard 0.16 ppm

The range recommended for NO_2 is from 0.10 ppm to 0.15 ppm one hour average (except for the existing NHMRC goal) with a majority support for a standard of 0.12 to 0.12 ppm one hour and 0.03 ppm for annual. The standard was derived from the health data and the recommendations of the Technical Review Panel and the Health Consultant.

At present ambient NO_2 concentrations rarely exceed the existing NHMRC 1 hour guideline of 0.16 ppm in most urban centres. In Sydney and Melbourne there have generally been no exceedences of the guideline since 1991 and 1987 respectively. Recent data indicates the 1 hour averages are below 0.12 ppm and the annual averages are below 0.03 ppm in most years at performance monitoring stations. Under current ambient levels, and spatial distribution, exposure to ambient NO_2 levels only becomes significant at concentrations around 0.10 - 0.12 ppm.

A number of recent studies and reviews indicate that the current NHMRC goal for NO_2 of 0.16 ppm averaged over 1 hour may not be sufficient to protect asthmatics and people with lung diseases and a lower goal is desirable. Current motor vehicle emission management programs may be sufficient to deliver most of the reductions needed to maintain the standards in a 10 year timeframe.

Hence the standards for nitrogen dioxide as measured at each performance monitoring station are:

- 0.12 ppm (parts per million) averaged over a one hour period; and
- 0.03 ppm averaged over a one year period.

[The Goal being to meet both standards within a 10 year timeframe. The goal allows one exceedence day per year for the 1 hour standard.]

9.9 IMPACTS OF STANDARDS CONSIDERED FOR NITROGEN DIOXIDE

9.9.1 Health Impacts

The exposure assessment indicates lowering NO_2 levels to achieve a standard of 0.12 ppm might reduce exposure by 1.8 million person events. A consultancy has estimated the most likely quantifiable health benefits as some $5 million based on 10-15% of the population being affected and costs of $27 per patient for acute respiratory symptoms.

Other environmental benefits such as reductions in visibility impairment due to formation of secondary aerosols cannot be reliably estimated but would result in increased community amenity. Benefits of potential reductions in photochemical smog are expected to be large and are discussed and evaluated in Chapter 10 (Ozone).

9.9.2 Management options and costs

The principal focus for management in urban regions where mobile sources are an important source of NO_x has been and will continue to be motor vehicle emissions.

In most airsheds, current motor vehicle management strategies are expected to deliver lower ambient NO_2 levels. However, some reductions from industrial sources may also be required to achieve the standard in large urban airsheds such as the MAQS region of NSW, particularly if extensive cogeneration occurs. NSW's Action For Air (1998) indicates that the EPA will implement its NO_x policy by capping total emissions at 1998 levels and set up a scheme for trading within the cap.

Costs have been estimated by source to enable identification of sectors for which mitigation strategies might be applied to achieve potential benefits in moving to new standards. Control strategies to reduce NO_x emissions needs to target both mobile (transport) and large point source emitters. Control of motor vehicle emissions has been the introduction of Australian Design Rules (ADRs) to limit NO_x and other exhaust emissions from new vehicles. (See also Chapter 6).

Approximate abatement costs ($ per tonne) have been developed for each reduction option/strategy where possible. The cost estimations are applied in a generic fashion and do not imply a preferred option for abatement strategies. Each airshed will need to be evaluated by jurisdictions to enable them to choose the relevant options that are suitable for their purposes.

Note that the presented cost estimates are subject to considerable uncertainty and there may be large variations in costs based on different information sources. For example, the NO_x values used in this report (extracted from Ramsay, 1996; CARB, 1997) are much lower than costs prepared by the California Energy Commission (1993).

Much effort has gone into the research of controlling NO_x emissions. The technology associated with NO_x reduction involves both process modification (ie. cleaner production, as well as end of pipe control techniques). Evidence indicates that many of these practices and technologies are economically viable and have attractive payback periods. New technologies are also expected to become available during the 10 year timeframe of the Measure.

Options such as low NO_x burners (have been in use in NSW power stations for many years) and trim control should be explored as a priority as they have the potential to reduce NO_x emissions by 30 to 55% in coal burning power stations. They could result in cost savings due to coincidental increases in fuel efficiency. Furnaces in petroleum refineries and steel works could be converted from natural to forced draft combustion, or fitted with low NO_x burners. Reductions in NO_x emissions of 40 to 50% could be achieved at a cost of between $155 and $2,500 per tonne NO_x reduced per year. Selective catalytic reduction of NO_x could be implemented at power stations, steel works, petroleum refineries and co-generation facilities for around $1,500 per tonne NO_x reduced per year (Ramsay, 1996).

Existing management strategies for vehicle emission are likely to deliver most the reductions needed to achieve the standard and individual jurisdiction's air quality management plans (such as NSW's "Action for Air") would develop cost effective strategies to control the remainder.

9.9.3 Other impacts

Reductions in oxides of nitrogen (NO_x) in major population centres would reduce the ambient levels of nitrogen dioxide. However, the impact of NO_x reductions on ozone levels in some regions of major cities will need to be assessed, and ROC reductions may be necessary to avoid potential increases in ozone. This is because nitric oxide is initially a sink for ozone in areas where NO_x emissions occur, but can later lead to increased ozone levels in outlying areas if the air parcel or plume is NO_x limited.

The presence of NO_2 in association with fine particles is the primary factor leading to the formation of atmospheric haze and subsequent visibility impairment.

The contribution of ambient NO_2 at levels presently recorded in our major urban centres to impacts upon buildings and materials, commercial crops and other ecosystem components are likely to be marginal in comparison with the effects of other priority pollutants.

Note that the Air NEPM does not cover indoor air quality. Reducing indoor NO_2 from poorly vented heaters and stoves is an area where health benefits may be significant.

9.10 SUMMARY OF COSTS AND BENEFITS FOR THE NITROGEN DIOXIDE STANDARD

Because the NEPM deals only with the assessment of air quality by governments the only direct costs associated with the introduction of the standard for NO_2 are the monitoring and reporting costs, required by the NEPM protocol, which will be incurred by governments when assessing ambient air quality. There is no other requirement placed upon governments. In most cases some changes to existing monitoring and reporting programs for assessing air quality will be required. Until detailed jurisdictional monitoring plans have been developed the costs associated with monitoring NO_2 for the purposes of this NEPM cannot be definitively identified.

Most jurisdictions have active air quality management programs for NO_2 which they continuously monitor, revise and refine over time. The NEPM will provide a sound basis for assessing the extent of any NO_2 problems in the major airsheds and, therefore, assist governments in determining the priority to be given to the management of the effects of NO_2 on ambient air quality in the context of overall government programs. Voluntary programs will continue to play an increasing and effective role in those air quality management strategies. These include both industry emission reduction programs and behaviour change programs by motorists often sponsored by motoring organisations. It is expected each jurisdiction will continue to work closely with the community (including industry where necessary) in determining the appropriate mix of strategies to maintain or achieve the NEPM goal set for NO_2.

9.10.1 Benefits

The current NHMRC goal for NO_2 of 0.16 ppm averaged over 1 hour may not be sufficient to protect asthmatics and people with lung diseases. Lowering NO_2 levels to achieve a standard of 0.12 ppm is estimated to reduce exposure by around 1.8 million person events and provide a benefit of some $5 million by reducing respiratory symptoms in up to 15 percent of the population .

9.10.2 Costs

Existing management strategies for vehicle emission are likely to deliver most the reductions needed to achieve the standard and individual jurisdiction's air quality management plans would develop cost effective strategies to control the remainder. Evidence indicates that many of the NO_x control technologies are economically viable and have attractive payback periods due to improved fuel efficiency.

9.11 ISSUES RAISED DURING PUBLIC CONSULTATION ON NITROGEN DIOXIDE STANDARDS

For a detailed summary of issues and responses refer to the Summary and Response document. Some of the points raised during public consultation were:

- Generally a nitrogen dioxide standard of 0.12 ppm one hour average was accepted.

- Some industry groups suggested that there was insufficient justification for a one hour standard more stringent than the current Australian objectives for nitrogen dioxide of 0.15 to 0.16 ppm.
- Some community groups suggested a tighter one hour standard for nitrogen dioxide of 0.10 ppm based on the World Health Organization objective.
- Some industry groups suggested the costs in the impact statement were overestimates as they are based on end of pipe technologies rather than cleaner production options.
- Few submissions addressed the annual average standard.

9.12 CONCLUSIONS - NITROGEN DIOXIDE

Having considered the comments made during the public consultation phase, including written submissions, and the available scientific, social and economic data the following conclusions have been reached:

- Achieving the standard for NO_2 of 0.12 ppm averaged over a one hour period should provide a high level of protection for asthmatics and people with lung diseases. The standard is consistent with the recommendations of the Health Technical Review Panel. It is tighter than the current NHMRC goal for NO_2 of 0.16 ppm averaged over a one hour period which a number of recent studies and reviews indicate may not be sufficient;
- Achieving the standard for NO_2 of 0.03 ppm annual average should provide a high level of protection to children from increased risk of respiratory illness;
- The standards are currently being met throughout Australia, except for Sydney in some years. Current motor vehicle emission management programs should be sufficient to deliver most of the reductions needed to meet and maintain the NO_2 standards in the 10 year timeframe. Any major new sources of nitrogen oxides (eg. power stations) in cities are likely to need low NO_x technology and careful siting; and
- A range of other benefits will accrue to the community as a result of a successful program to achieve and maintain ambient levels of NO_2 at or below the standards. These include a reduction in the production of photochemical smog, and associated visible haze.

The standards for nitrogen dioxide as measured at each performance monitoring station are:

- 0.12 ppm (parts per million) averaged over a one hour period; and
- 0.03 ppm averaged over a one year period.

[The Goal being to meet both standards within a 10 year timeframe. The goal allows one exceedence day per year for the 1 hour standard.]

CHAPTER 10
PHOTOCHEMICAL OXIDANTS (AS OZONE)

The standards for ozone as measured at each performance monitoring station are:

- 0.10 ppm measured over a one hour period; and
- 0.08 ppm measured over a four hour period.

[The Goal being to meet both the standards with one allowed exceedence day per year within a 10 year timeframe.]

10.1 NATURE OF OZONE

Photochemical oxidants is a term used to describe a complex mixture of chemicals produced in the atmosphere by the action of sunlight. It is commonly known as photochemical smog. The principal component of photochemical oxidants is ozone: also present are formaldehyde, other aldehydes, and peroxyacetyl nitrate (PAN). Measurements of photochemical oxidants (and standards relating to it) are usually referenced to ozone ie, although measurements are of ozone, they are taken to be a surrogate for photochemical oxidants, and ozone will generally be used in the discussion.

Ozone (O_3) is a relatively insoluble gas with a characteristic sharp odour. It is a strong oxidising agent capable of reacting with a variety of substances. It is a highly irritating substance at high concentrations with significant effects on various parts of the respiratory tract and mucous membranes. The range and severity of the effects on health are dependent on the pollutant concentration, exposure duration, and individual sensitivity.

The natural background concentrations of ozone of 0.04 ppm have been recorded. Ozone and photochemical oxidants which form near ground level should not be confused with ozone in the stratospheric ozone layer, some 15 to 50 km above ground level.

10.2 SOURCES OF OZONE

Ozone is a secondary pollutant, ie. it is not emitted directly but is formed in the atmosphere by the reaction of various precursor compounds. These include oxides of nitrogen (NO_x) and photochemically reactive organic compounds, commonly referred to as reactive hydrocarbons, or reactive organic compounds (ROCs), or non methane hydrocarbons (NMHCs), or hydrocarbons. Many chemical reactions and intermediate products are involved, and the reactions are driven by energy in the form of ultraviolet light.

The control of ozone therefore requires management strategies that target reductions in either or both NO_x and ROCs. In general, high levels of ozone are only a problem for major cities where emissions from concentrated urban activities can accumulate to high levels if the meteorology is favourable for pollution build up and for smog formation. Melbourne, Sydney, Perth, Brisbane and Adelaide, are the main Australian cities of sufficiently large size and favourable meteorology for significant ozone formation. Most rural areas and other cities have either populations which are too small and dispersed and/or meteorology that does not favour ozone production.

Most (70% to 80%) of the NO_x emissions in Australian cities come from motor vehicles. Domestic, commercial and industrial combustion processes account for the rest. Sources of ROCs are many and varied, including motor vehicles, oil refining, printing, petrochemicals, lawn mowing, aviation, surface coatings, bush fires and burning off. Generally, motor vehicles account for about 40% to 50% of ROCs emissions.

Natural emissions from vegetation (biogenic emissions) are also an important source of ROCs. Their importance and significance for smog formation and control varies greatly between cities. The relative contributions of various source categories to NO_x and ROCs emissions in different airsheds are shown in Tables 10.1 and 10.2, adapted from Pacific Air and Environment, 1997. Annual average emissions are shown as an indication only. The contributions are seasonally dependent, rising in summer.

Table 10.1

NO_x and ROC Anthropogenic Emission Source Contributions in Various Airsheds

Location & Inventory Year	**Mobile Sources (%)**		**Industrial Point Sources (%)**		**Area-based Sources (%)**		**Data Source**
	NO_x	**ROC**	**NO_x**	**ROC**	**NO_x**	**ROC**	
Sydney 92	82	49	13	10	5	41	NSW SOE Report 1995: 19
MAQS Region 92	45	49	52	10	3	41	NSW SOE Report 1995: 19
Melbourne Region 90	75	45	17	18	8	37	EPAV SRS91/101 (1991)
Brisbane - SEQ 93	74	51	23	17	3	32	Morgan et al (1996)
Perth - Kwinana 93	51	44	44	19	5	37	Perth Photochemical Smog Study 1996 Wier 1996
Latrobe Valley 84	3	62	97	2	<1	36	LVASSC (1986: 20)
Port Pirie 94	65	43	33	9	2	48	EPAV (1996: Vol.2, 9-9)
Launceston 94	72	15	8	1	20	83	EPAV (1996: Vol.2, 9-8)

Table 10.2

Biogenic ROC emissions as a % of total ROC emissions in various airsheds

Brisbane Region	**Sydney Region**	**MAQS Region (NSW)**	**Perth Region**	**Melbourne Region**
~64	~21	~36	~26	~20

** Based on total ROC being ~ 4 times summer isoprene emissions and annual/summer ratio of 0.5.*

The data in the above tables for Melbourne, Sydney, Brisbane, and Perth are based on detailed inventories carried out for each region, for different inventory years.

NO_x emissions are predicted to remain essentially constant in Melbourne (EPA report SRS 91/001) 1991, but increase in Sydney and Perth (The Perth Photochemical Smog Study, May 1996). By contrast, motor vehicles contribute approximately the same proportion of anthropogenic ROCs in all regions. They are predicted to decrease in all regions although at different rates because of the predicted differential growth in new motor vehicles which have better emission performance. Both NO_x and ROC emissions are predicted to increase in the long term under current emission control regimes as gains from cleaner cars are outstripped by increase in cars and car use.

The corresponding emission rates for anthropogenic NO_x and ROCs in different airsheds with detailed inventories are given in Table 10.3.

Table 10.3

Emission Rates for ROCs and NO_x in Australian Airsheds

Airshed	ROC kt/a	NO_x kt/a
Sydney Region 92	~165	102
MAQS Region 92	209	239
Melbourne Region 90	~ 153	83
Brisbane - SEQ 93	84	74
Perth - Kwinana 93	61	46

10.3 HEALTH EFFECTS OF OZONE

The effects on human health from exposure to ambient ozone are reviewed and summarised in Streeton (1997).

Ozone is a highly irritant substance which has significant effects in various parts of the respiratory tract.

There is strong supportive evidence from clinical, epidemiological and controlled exposure studies, of health effect associations at ambient ozone levels normally encountered in Australian cities. Health effects associated with exposure to ozone include minor changes in lung function, increased symptoms consistent with airway irritation, leading to increased requirement for additional medication and medical and hospital services. There is also evidence of a slight but clearly present increase in mortality, chiefly from cardiovascular causes, especially in the elderly. Exercise enhances the effects of ozone on lung function. Table 10.4 adapted from Streeton (1997), summarises these health effects.

Table 10.4

Summary of Health Response to Ambient Ozone Exposure

Health Effect	Ambient Ozone Concentration (ppm)	Exposure Duration
Epidemiological Studies		
Reduced lung function in farm workers	> 0.085	summer months whole day
Mortality (2.5% increase per 0.01 ppm)	0.10 - 0.16	summer months
Reduced lung function in children, adolescents, and adults Exacerbations of asthma Respiratory symptoms	> 0.12 (daily 1 hour maximum)	days - weeks
Controlled Exposure Studies		
Reduced lung function	≥ 0.08	6.6 hours
Increased airways responsiveness	>0.1	1 - 3 hours
Airway inflammation	>0.1	1 - 3 hours

Most of the evidence comes from studies and observations in North American and European cities. Recent studies in Sydney (Morgan et al., 1998) assessing various health outcomes including mortality and morbidity confirm the reproducibility of overseas health responses to ozone exposure in Australia. A mortality study conducted in Brisbane for the period 1987 to 1993, (Simpson et al., 1997) found significant associations for daily mortality and fine particles (measured by nephelometry) and ozone. The associations were only significant for the elderly.

Epidemiological studies have shown that O_3 levels are associated with hospital admissions and emergency room visits for respiratory disease (including asthma) and with increases in respiratory symptoms, airway responsiveness and decreases in lung function. These effects are correlated with both daily 1 hr maximum and 8 hr maximum O_3 levels with the strongest effects observed with a 1 day lag. There is also some evidence that O_3 may be associated with an increase in daily mortality.

The effects on lung function and airway responsiveness have also been observed in controlled exposure studies in both human and animal studies. Results of bronchoalveolar lavage (BAL) have shown that the observed response may be due to an inflammatory process. No association between spirometric responses, eg FEV_1, and BAL inflammatory end points has been observed. The observed effects appear to be greater on asthmatics than on healthy subjects. Ozone has also been found to increase bronchial allergen responsiveness in sensitive groups.

There is consistent evidence to suggest that there are specific subgroups in the population, in particular asthmatics, which are more susceptible to the adverse health effects from ozone exposure, and individual susceptibility is wide. There is also an increasing body of literature which details the interaction of ozone with other pollutants, in particular, the enhancement of the effects of ozone as a result of prior or concurrent exposure to particles, nitrogen dioxide, airborne allergens, and sulfur dioxide, and conversely, for people with asthma, sensitisation to other agents by exposure to ozone. Controlled chamber studies support the findings of the community based epidemiological studies.

No threshold exposure level can be identified for ozone, There is a monotonic relationship between increasing ozone concentration and adverse health effects. Therefore it is not possible to define either a No Observable Adverse Effect Level (NOAEL) or a Lowest Observed Adverse Effect Level (LOAEL) at this time.

The significance or severity of effects at the lower ozone concentrations are difficult to assess. Multiple occurrences of relatively minor symptoms can be very significant for affected people. The evidence for chronic effects from multiple exposures is not clear. Cumulative effects from relatively low level exposures (0.04 ppm average daily maximum over a summer season) have recently been observed. These appear to be reversible, but further work is required to verify whether this is so.

WHO has classified the overall effect of exposure to 1 hour ozone concentrations of between 0.05 and 0.10 ppm as 'mild'. In this range of exposures, eye, nose and throat irritation would probably occur in a sensitive minority, an average FEV_1 decrement in the whole population, and a 10% decrement in FEV_1 in the most sensitive 10%. Other effects include some chest pains and cough, and slight reductions in peak athletic performance.

In summary, exposure to O_3 at ambient levels has been associated with increases in hospital admissions for respiratory disease and asthma, exacerbation of asthma symptoms, reductions in lung function, chest pain and cough. There is some evidence of increased mortality. Asthmatics form a particularly susceptible subgroup of the population.

10.4 CURRENT AMBIENT AIR QUALITY OBJECTIVES FOR OZONE

Current Australian objectives are given in Table 10.5. It should be noted that most States use the NHMRC goals as appropriate within their own jurisdiction. In Victoria, ambient objectives for ozone, as for other environmental objectives, are formally adopted by the Government and included in State Environment Protection Policies.

Table 10.5

Current Australian Objectives for Ozone

State/Authority	Averaging Period		
	1-hour, ppm	4-hour, ppm	8-hour, ppm
(NHMRC)	0.10	0.08	-
Victoria• acceptable detrimental	0.12 0.15	- -	0.05 0.08
New South Wales *	0.10	0.08	-
Queensland #	0.10	0.08	-
South Australia	0.10	0.08	-
Tasmania	0.10	0.10	-
Northern Territory	0.10	-	-
Australian Capital Territory	0.10	0.08	-
Western Australia	0.08	-	-

** NSW has announced a reporting 1 hour goal of 0.08 ppm in addition to the 0.10ppm interim goal*

 # NHMRC goals are matters for consideration in making a decision about an environmentally relevant activity

● 8 hr Victorian objective is for vegetation protection

Current international objectives are listed in Table 10.6. Comparisons both nationally and internationally are not straight forward since the status (goal versus standard), allowable exceedences, and monitoring protocols, where these exist, are different and need to be considered. The numerical values provide a guide only.

Table 10.6

Current International Objectives for Ozone

Country/Authority	1 hr ppm	4 hr ppm	8 hr ppm
New Zealand	0.08	-	0.05
European Union	0.08	-	0.05
United States America	0.12*	-	0.08
California	0.09	-	-
Japan	0.06	-	-
Hong Kong	0.12	-	-
World Health Organization	0.08	-	0.06#

** Existing standard to be phased out, # Proposed goal*

10.5 CURRENT AMBIENT AIR LEVELS FOR OZONE

Current oxidant levels and trends are available from several sources including Beer and Walsh (1997), EPA Victoria (1995), and the National Environmental Health Forum Monograph on Ozone (1997). Beer and Walsh in particular provide frequency distributions for the Capital City Regions for which data were available for analysis in suitable form. Table 10.7 provides a summary of the top of the frequency distribution for the 1993, 1994, and the 1995 years of monitoring in these Regions. The highest levels recorded in the Latrobe Valley in these years were below potential standards, and therefore no further analysis for the Latrobe Valley is included.

Table 10.7

Frequency Distribution of Ozone Monitoring Data 1993 - 1995

Averaging Time	Percentile	Concentration (ppm)					
		Adelaide	Perth	Brisbane	Melbourne	Sydney	Canberra
1 hour	99.0	<0.040	0.040	0.045	0.045	0.045	<0.040
1 hour	99.5	<0.040	0.047	0.050	0.050	0.050	<0.040
1 hour	99.9	0.050	0.065	0.065	0.075	0.070	0.055
1 hour	99.95	0.058	0.071	0.070	0.080	0.080	0.050
1 hour	3 yr highest	0.083	0.111	0.127	0.172	0.155	0.085
4 hour	99.0	0.045	0.055	0.060	0.070	0.060	0.040
4 hour	99.5	0.045	0.062	0.065	0.075	0.070	0.045
4 hour	99.9	0.060	0.078	0.080	0.100	0.090	0.055
4 hour	99.95	0.070	0.082	0.085	0.110	0.100	0.055
4 hour	3 yr highest	0.077	0.092	0.101	0.146	0.132	0.072
8 hour	99.0	0.040	0.047	0.050	0.055	0.050	0.040
8 hour	99.5	0.040	0.051	0.055	0.065	0.055	0.040
8 hour	99.9	0.055	0.062	0.065	0.080	0.075	0.050
8 hour	99.95	0.060	0.065	0.065	0.085	0.085	0.050
8 hour	3 yr highest	0.075	0.074	0.082	0.113	0.101	0.068

*note 99.9% 1hr – 9hrs/year

It is clear from these data, that although extreme ozone events are rare, relatively high ozone levels are quite common, particularly in Melbourne, Sydney, and to a lesser extent Brisbane and Perth.

The above monograph contains trend data on ozone for all the capital cities. Care needs to be taken in interpreting these data, particularly in relation to trends, and intercity comparisons. The networks differ in length of record, number of monitors, siting, and overall network design. Without consistent protocols for network design, operation, and reporting, trends and comparisons are only indicative.

Within these limitations, it appears that since the early 1980s to the present, ozone peak levels and number of hours above the NHMRC goal of 0.10 ppm (100 ppb) have trended downwards for Sydney, Melbourne, and Adelaide. This is consistent with the ROC control programs, particularly for motor vehicles. For Brisbane, there do not appear to be any trends. Since biogenic emissions are approximately 60% of total ROC emissions in Brisbane, then ROCs controls are expected to be less effective than for other Australian cities where biogenic ROCs are a much smaller fraction of total ROCs. For Perth and Canberra, the data records are shorter and ascribing trends to the data is even more problematical.

Photochemical models for predicting the impact of air management strategies have been developed and applied in Melbourne, Perth, Sydney and Brisbane (See the Perth Airshed Study Report 1996, a Report to the NHMRC on Air Quality Goals for Ozone May 1994 (appendix to NHMRC Report 1994) and the MAQS report (1997). A number of jurisdictions are extending this work as part of their development of air quality management plans, and for guiding implementation of National Standards.

10.6 AUSTRALIAN EXPOSURE LEVELS FOR OZONE

It is clear from the data that only the populations of Perth, Brisbane, Sydney and Melbourne would be exposed to ozone levels greater than the standards.

Attempts were made using available data to estimate population exposure to concentrations of ozone for major cities where ozone monitoring takes place (Beer and Walsh 1997).

Limitation in the available data constrained the application of the exposure assessment methodology. However, it provided useful indications of potential exposure patterns and also identified data gaps which the NEPM could usefully fill for future studies.

The major difficulties with the information arose from the location of existing monitoring stations. Lack of consistency in monitoring locations between or even within air sheds led to lack of comparability between data and exposure estimates which were biased by the monitoring data.

These difficulties were highlighted and explained in the draft Impact Statement and the use of the data was heavily qualified. Despite these caveats and explanations covering the use of the exposure assessment data the public submissions on the draft Impact Statement have demonstrated that these data were still open to misinterpretation.

In response to widespread stakeholder concern, the exposure assessment has been accepted by NEPC as indicative only and did not influence the final choice of standards.

Future monitoring under the protocol combined with jurisdictional peak monitoring, will provide a more robust basis for future exposure studies should they be required.

10.7 CURRENT MANAGEMENT PRACTICES FOR OZONE

Current management approaches for the control of ozone rely largely on the control of ROCs from various sources, as this has been considered the most cost effective approach. A national approach was adopted and implemented in the 1970s with the main target for control being motor vehicles. National emission limits were incorporated in the Australian Design Rules (ADRs) for motor vehicles. The most recent revision of these, ADR 37/01, is being introduced over 1997-99 and has tighter emission standards for both NO_x and hydrocarbon. Programs for reducing ROC emissions from commercial and industrial activities were also adopted by different jurisdictions. These included end-of-pipe controls, hydrocarbon loss control programs, solvent reformulation, and other cleaner production methods.

10.7.1 Monitoring Methodology

Instrumental monitoring of photochemical oxidants has, in the last couple of decades, almost solely been based on ozone. With the successful development in Australia, of the Airtrak 2100 instrument there is no reason why that should continue. The instrument measures the smog-producing reactivity (Rsmog) and the concentrations of ozone, nitric oxide, nitrogen dioxide, “nitrates” (NO_y), reactive organic compounds (ROC) and “smog”. NOy denotes the sum of NO and the more highly oxidised gas phase nitrogenous species (NO_2+HNO_3+PAN+gaseous organic nitrates etc) and is distinguished here from NO_x, which is used to denote NO+NO_2 only.) Smog is defined as the sum of nitrogen dioxide and ozone at any moment in time.

The Airtrak continuously measures the photochemical smog-producing characteristics of the air. From these data and taking into account the sunlight intensity and temperature, the system can determine the chemical history of the air and predict downwind photochemical smog production. Airtrak provides information about photochemical oxidants formation and precursor conditions, in a form that would assist a review of the standards for photochemical oxidants. The concept is particularly useful to the development of effective control strategies to minimise the formation of photochemical oxidants.

10.8 RANGE OF STANDARDS CONSIDERED FOR OZONE

Table 10.8 provides the exposure for a range of standards. The list includes the current NHMRC goals, the Technical Review Panel (TRP) recommended standards, and the alternative in the range proposed by the consultant. The project team has selected the current national goals, and the TRP recommended standards as an appropriate basis for comparison and further analysis.

Table 10.8

Current Exposure to Various Potential Ozone Standards

Standard (ppm)	Source	Exposure (million person events per year)
1 hour 0.10	NHMRC goal	9
4 hour 0.08	NHMRC goal	9
1 hour 0.08	TRP	40
8 hour 0.06	TRP	18
1 hour 0.09	Consultant’s alternative	20
8 hour 0.05	Consultant’s alternative	50

The data can be used to indicate the level of stringency and the level of protection provided to the Australian population. The stringency of the goal and the level of protection are inversely related to the number of person events occurring with current exposure, assuming the population and pollution distributions do not change. Current exposures to each NHMRC goal level are similar, indicating that the two goals are probably equivalent in terms of stringency and level of protection of the Australian population. An 8 hour standard of 0.06 ppm as recommended by the TRP would be more stringent than current NHMRC goals. The 4 hour 0.08 ppm NHMRC goal is more stringent than 8 hour 0.08

ppm and 0.07 ppm goals, hence is closer to the TRP recommended goal of 0.06 ppm 8 hour average.

The current NHMRC goal is recommended as the standard. A number of stakeholders have pointed out that there will be demonstrable effects at the standard, and this is acknowledged. On this basis Health Departments and health professionals support the standards recommended by the health review TRP(1 hr = 0.08 ppm, 8 hour = 0.06 ppm). Where there appears to be no threshold of effects, (or one close to background level based on more recent evidence as is the case for ozone), as low a standard as is practicable should be aimed at.

However, as briefly discussed in section 10.9.2, based on current information, these tighter standards would be very difficult to achieve in Melbourne and Sydney, and possibly Brisbane and Perth. It seems clear that the TRP recommended standards, particularly the 8 hour average of 0.06 ppm, are unlikely to be practicably achievable within a 10 year attainment program.

Hence, the standards for ozone as measured at each performance monitoring station are:

- 0.10 ppm measured over a one hour period; and
- 0.08 ppm measured over a four hour period.

[The Goal being to meet both the standards with one allowed exceedence day per year within a 10 year timeframe.]

10.9 IMPACTS OF STANDARDS FOR OZONE

10.9.1 Health impacts

Current effects of air pollution for various health end points have been estimated by Simpson and London (1996) for the Brisbane City Council area. The estimates are based on various sources including the Victorian Transport Externalities Study. Table 10.9 adapted from Simpson and London (1996) summarises the estimates of the direct impacts on health resulting from exposure to ozone. The estimates for the Brisbane City Council area (BCC) for each health indicator, as well as extrapolations to the Australian population are given in this table.

Table 10.9

Health Effects of ozone for the Brisbane City Council area and Australia

Health Indicator for Ozone	Number of Cases (BCC)	Number of cases (Australia)
mortality	0	Unknown (possibly 5 - 10)
asthma attack -AA	67 - 202	1500 - 4500
acute respiratory symptoms -ARS	0 - 1381	0 - 31,000
minor restricted activity days -MRAD	0 - 1423	0 - 32 000
total of minor symptoms (sore throat, cough, headache, chest discomfort, eye irritation)	267,384 - 802,155	6,000 ,000 - 18,000,000

The above estimates of health impacts can be combined with unit cost estimates of these impacts to provide an aggregate estimate for Australia. The unit cost values, derived from US EPA are as follows:

Health Indicator for Ozone	Unit Cost (1997 Australian Dollars)
asthma attack (AA)	47 per case
acute respiratory symptoms(ARS)	27 per case
restricted activity days (assume same as work days lost)	123 per case
MRAD	56 per case
minor symptoms (sore throat, cough, headache, chest discomfort, eye irritation)	15 per case

On this basis, the health damage costs from current exposure to ozone nationally are estimated to be in the range (90 - 270) million dollars, and this would represent the potential benefit of achieving the standard. By way of comparison, the Victorian EPA estimated health benefits of the order of $20 million for achieving an ozone objective of 0.08 ppm 4 hour average for Victoria alone, EPA publication No. 405, 1994.

Since both the mortality unit costs and the excess mortality are highly uncertain the above health damage costs have not included these possible costs. Hence the potential benefits do not include reduced mortality benefits resulting from cleaner air.

In addition to direct impacts of ozone on specific health indicators, there are indirect effects due to secondary particles, ie particles which are formed in the atmosphere by chemical reactions. Secondary particles in Australia comprise 20% to 30% of fine particles. A large proportion of these are formed from precursor ROC and NO_x emissions, ie ozone precursors, and involve photochemical activity.

For various reasons, these are likely to be underestimates. Not all health points have costing data. For example the significance of a 10% decrease in FEV_1 on health damage costs cannot be estimated. Likewise, no deaths have been ascribed, although the health study indicates a small but clear relationship with ozone, and indirect effects on particle deaths. There has been no estimate of the potential effects and long term costs of lung ageing, and none to other distinct but subtle structural and biochemical changes. The assumed threshold of effects has been 0.08 ppm although the medical data suggests a zero threshold. Finally there are the various problems with costing health impacts, as previously indicated. A factor of 2 - 5 (say 3) applied to the direct costs for ozone equates to a total cost plausibly in the range $270 to $810 million to correct for the underestimate.

This analysis demonstrates the complexities involved in separating and attributing costs and benefits associated with controls for individual pollutants. It is further complicated by the fact that indirect costs are largely attributable to secondary particles and potentially double counted. The potential co-occurrence of symptoms from multiple causes makes the unravelling and attribution of costs to a single pollutant extremely challenging.

It also needs to be remembered that the costings, however crude, are for current ozone damage to health. Avoided health damage costs resulting from cleaner air effected by current air pollution control programs controls are not included.

One of the other key points to consider is the large number of minor symptoms estimated for ozone exposure. The combined incidence of one or more of sore throat, cough, headache, chest discomfort, and eye irritation is estimated at between 6 and 20 million dollars per annum. Irrespective of any economic costs, there are clearly very large impacts of irritating symptoms potentially affecting productivity.

10.9.2 Management options and costs

As discussed earlier, to achieve reductions in ambient ozone requires control on the precursor emissions, NO_x and or ROCs. This can be achieved by reductions in ROCs alone, in NO_x alone, or in both these pollutants. The chemistry of ozone production in the atmosphere is complex, and resulting reductions in ozone do not occur in a one to one relation with reductions in either or both NO_x or ROCs. Current control strategies in place in Australia have relied mainly on the control of ROCs from various sources, with a major emphasis on motor vehicles.

These strategies have been effective in reducing or maintaining ozone levels in all airsheds despite growth in emissions, as indicated by the monitoring and inventory data. It is clear that the increase in emissions generating activities (more cars, travel and industry) in all airsheds will, in the long term, over take gains from current control approaches which will need to be reviewed. Further, because of the different patterns of development, meteorology, and relative contributions from different source categories, airshed specific approaches are required. As a major example, natural ROCs emissions account for over 60% of total ROCs in the Brisbane airshed, so that ROCs controls on anthropogenic emissions needs to be much higher to have the same impact on ozone in Brisbane than in say Melbourne. The matter is complicated by the fact that the reactivities of different categories of ROCs vary, ie they reduce ozone by different amounts per unit of ROCs reduction.

Sophisticated models for predicting the effect of different strategies have been developed and tested in Australian airsheds, including the Perth, Sydney, Brisbane and Melbourne airsheds. The models rely on accurate information on emission sources, and high quality data on the detailed meteorology of the relevant airshed. Detailed inventories have been developed for Perth, Sydney, Brisbane and Melbourne and monitoring and meteorological networks are in place, and long term air quality management strategies are being developed.

This sophisticated methodology is necessary to test various scenarios to determine the best and most cost effective strategies for achieving compliance with air quality standards for ozone. The appropriate balance is likely to be different for each airshed, but some common elements and national approaches, eg controls for motor vehicle will emerge.

Preliminary modelling projections in the Melbourne Region in Victoria examined different scenarios for ozone control from a 1985 base year to the year 2005 (NHMRC Report, 1994). The report indicated that ambient ozone levels in this period due to current motor vehicle controls would continue to improve. A “business as usual” scenario for industrial emissions with no significant changes in ROCs and NO_x was assumed. The report also indicated that further industry controls as well as planned motor vehicle controls would be likely to be required to achieve tighter 1 hr ozone goals of 0.08 ppm and 0.10 ppm. NO_x control options were not explored.

Modelling in NSW for the Sydney region indicates that NO_x controls in some areas may be required to achieve the NHMRC ozone goal. However, the situation may be different for different regions of the airshed, reinforcing the need for detailed airshed management plans. The situation for Perth, Brisbane, and Adelaide is not clear, but model sensitivity studies indicates similar complexity. Any large scale shift in power production through the widespread introduction of cogeneration facilities in large urban areas has the potential to increase ambient ozone and NO_2 levels unless tight controls and/or emission offsets are used in conjunction with appropriate siting.

Table 10.10 presents the required degree of reductions in ozone levels to meet different formulations of the standard, based on the monitoring data analysis. These reductions are based on simply scaling the current measurements to the relevant proposed formulation.

Table 10.10

Reductions in Current Ozone Levels (%) to Meet the Potential Standard

Potential Standard	**Reduction in Current Ozone Levels (%) to Meet the Standard**					
	Adelaide	**Brisbane**	**Melbourne**	**Sydney**	**Canberra**	**Perth**
1 hour = 0.10 (not to be exceeded	complies	22%	42%	36 %	complies	10%
1 hour = 0.10 (99.95% of all hours)	complies	complies	complies	complies	complies	complies
4 hour = 0.08 (not to be exceeded)	complies	20%	45%	40 %	complies	10%
4 hour = 0.08 (99.95 % of daily maximum)	complies	6%	27 %	20 %	complies	2%

* complies means achieved in most years.

For the standards listed, Adelaide and Canberra are in compliance, although the data base is not extensive for the former. The data indicate that large percentage reductions in current Ozone levels are required if the peak measurements are to be below the standard at all times. These are between 35% and 45% for Melbourne and Sydney, around 20% for Brisbane and around 10% for Perth. To achieve this, similar reductions in NO_x, ROCs or both may be required.

The available monitoring data indicate that all cities are in compliance with the 1 hour standard but require reductions of between 6% and 27% in current ambient levels to comply with the proposed 4 hour standard. This is assessed as being practicably achievable within a ten year timeframe.

Clearly, the method for achieving ozone reductions will differ in each airshed, and the percentage reductions may not be linearly related to precursor emission reductions. However, in order to estimate costings, some assessment of precursor reductions is required and a linear relationship has been used as a first order approximation eg 10% reduction in NO_x or ROCs is assumed to result in 10% reduction in ozone. It is acknowledged that this is a highly simplifying assumption, but is expected to be directionally correct. As discussed earlier, complex modelling involving detailed consideration of source categories and distribution, inter-regional transport, and relative potential source reductions would be necessary in developing implementation plans. The estimates for each airshed are as given in Table 10.11.

Table 10.11

Estimated NO_x and ROC Reductions

Airshed	Reduction %	ROC kt/a	ROC\` reductions kt/a	NO_x kt/a	NO_x reductions kt/a
Sydney (MAQS Region) 1992	20	210	40	240	50
Melbourne (Port Phillip Region)1990	30	~150	45	80	25
Brisbane - SEQ 1993	10	80	10	70	8
Perth - Kwinana 93	5	80	5	50	3

A discussion of the costs of motor vehicle management programs is provided in Chapter 6. These costs will occur regardless of any NEPM standards since the relevant National Motor Vehicle regulations (ADR 37/01) are already in place. No costs have been assumed by the Project Team for these programs.

In order to estimate an upper bound for the costs of compliance with the standards only industry costs have been considered as motor vehicle controls are assumed to be already paid for. It is further assumed that Perth and Melbourne airsheds will target ROCs controls, while Brisbane and Sydney may adopt a mix of NO_x and ROCs controls. These assumptions are for analysis purposes only, and do not imply any preference or priority. It is acknowledged that detailed airshed management plans may well result in a different and probably more cost effective mix.

On this basis, and based on information provided by Pacific Air and Environment (1997), Table 10.12 provides a range of estimates of the costs of implementing a range of different NO_x or ROCs reduction for industry within each airshed, excluding motor vehicle control costs associated with ADR 37/01. These cost estimates are based on the estimated control costs shown in Table 6.4 in chapter 6.

Table 10.12

Upper Bound Estimates of Control Costs for Ozone Reduction

Region	Approach	Reductions (kt/a)	high ($m/a)	low ($m/a)
Sydney (MAQS)	NO_x control + ADRs	50	90	60
Melbourne (Port Phillip)	ROC control + ADRs	45	668	160
Brisbane - SEQ	NO_x control + ADRs	8	15	10
Perth - Kwinana	ROC control + ADRs	3	90	10
Total			820	240

For various reasons the high estimate provided by the consultants is unrealistic, with an upper bound being provided by the low estimate. These cost estimates are based on end of pipe technological methods of control. They assume uniform reductions across industry, and to some unknown extent, application of further controls to already controlled sources.

The costs are based on retrofitting equipment, and make no provision for cleaner production mechanisms, either as providing a lower cost per unit of reduction, or credits for recovered materials. A number of examples of net profits to industry rather than net cost from emission reductions exist. Furthermore, as indicated above, the cost estimates have assumed that all emission reductions will come from industry, and no allowance has been made for potential reductions from motor vehicle control strategies including a range of non technical options.

In addition, the unit reduction costs will vary depending on the maturity of the airshed management programs on which they are based, ie the law of diminishing returns applies. In this respect, it has already been identified that current programs in NSW, and most probably Australia fall short of international best practice, Pacific Air and Environment, (1997), so the unit reduction costs are likely overestimates.

A detailed strategy on an airshed by airshed basis would achieve substantially lower costs from targeting the most cost effective mix of industry categories, using plant upgrades for introducing controls, promoting cleaner production, recovering valuable materials, thereby reducing waste disposal costs. In addition, at least a substantial proportion of plant upgrade costs ascribed to emission reductions are introduced for production efficiency and other reasons.

In global markets, as is the case for motor vehicles, international standards force the introduction of emission control technologies. Hence, although a cost can be ascribed to the technology, a cost penalty would apply in many instances if less stringent standards without the technology were required.

Reductions in ROCs and NO_x associated with ozone also yield reductions for particles, CO and NO_2, as well as a range of air toxics. The costs should be apportioned to each pollutant but this cannot be readily done.

Finally, alternative management approaches including integrated transport planning, urban village concepts, various approaches to reducing vehicle travel, and approaches involving incentives and disincentives for reducing emissions from existing emissions may be cheaper alternatives. A detailed discussion of these approaches is provided by Pacific Air and Environment (1997), and is not reproduced here. They clearly provide the potential for realising real long term gains in ambient air quality at minimal cost but require the acceptance and adoption of social change.

Clearly, these are all implementation approaches. The costs depend on optimising the implementation timetable in a way that recognises the natural time cycles for different management methods.

As indicated above, the most appropriate management strategy for achieving the proposed ozone standard will need to be developed on an airshed by airshed basis. Air quality management plans are currently being developed for Melbourne, Sydney, Brisbane, and Perth. These plans will obviously form the basis for assessing and implementing the most cost effective method for complying with standards and achievable timeframes. A realistic upper bound estimate of the cost of achieving the proposed draft ozone standard is some $250 million annually, with this cost subsumed into the various air quality management plans of the jurisdictions.

10.9.3 Social impacts

The social impacts from exposure to ozone, and the benefits to be derived from better standards cannot be separated from those of other air pollutants.

Ozone is an urban pollution problem, and as such is an issue for a major proportion of the Australian population residing in urban centres. Sydney, Melbourne, Brisbane, and Perth all have problems to varying degrees. Improvements in air quality will therefore be of major benefit to urban residents, and peripheral direct benefit to non urban dwellers, but the costs of mitigation measures will accrue to all consumers. On the other hand, the benefits of industrial production are enjoyed by all Australians, but the pollution cost externalities such as health impacts are born by urban residents since manufacturing is generally located in cities.

Asthmatics and other susceptible sub groups will reap the largest benefit of reductions in ozone. These benefits include fewer hospitalisations and doctors' visits, increased mobility, less use of medication, and fewer days of restricted activity and absence from work. The lower utilisation of medical and hospital infrastructure has benefits for the whole community. Exercising athletes will derive performance benefits. More generally, a whole range of minor but irritating symptoms will be avoided. The social well-being associated with potentially 6 and 20 million fewer irritating symptoms annually cannot be reliably quantified, but at a $1 a symptom, it adds up to an appreciable amount.

An optimum balance of measures for reducing ozone may have employment benefits from expenditures in abatement technology and methods. There may of course be distributional effects across different industries.

10.9.4 Environmental impacts

The environmental impacts of ozone other than health, and hence the benefits of reduction, occur in a number of areas, including:

- **Vegetation damage** - Ozone is a phytotoxicant which affects a large number of species. Because higher ozone levels are an urban issue, significant economic damage to commercial crops are unlikely. However, a large number of market gardens occur in areas of potentially high ozone, and domestic vegetables and ornamentals which are usual in temperate Australian climates may be affected.

- **Built environment** - Some damage to materials and structures can occur. Some rubber products are particularly vulnerable.

- **Natural Environment** - Damage could occur to native vegetation. Deposition of nutrients such as nitrates from the air environment to water bodies can be significant and aggravate algal blooms and potentially eutrophication. Ozone control strategies targeting NO_x reductions should minimise this impact.

- **Aesthetics -** Ozone and smog can reduce visibility through the formation of fine aerosol particles including sulfates and nitrates. In addition to health impacts, they reduce visibility, and can result in the white haze common during pollution episodes.

10.10 SUMMARY OF COSTS AND BENEFITS FOR THE OZONE STANDARD

Because the NEPM deals only with the assessment of air quality by governments the only direct costs associated with the introduction of the standard for photochemical oxidant (measured as ozone) are the monitoring and reporting costs, required by the NEPM protocol, which will be incurred by governments when assessing ambient air quality. There is no other requirement placed upon governments. In most cases some changes to existing monitoring and reporting programs for assessing air quality will be required. Until detailed jurisdictional monitoring plans have been developed the costs associated with monitoring ozone for the purposes of this NEPM cannot be definitively identified.

Most jurisdictions have active air quality management programs for ozone which they continuously monitor, revise and refine over time. The NEPM will provide a sound basis for assessing the extent of any ozone problems in the major airsheds and, therefore, assist governments in determining the priority to be given to the management of the effects of ozone on ambient air quality in the context of overall government programs. Voluntary programs will continue to play an increasing and effective role in those air quality management strategies. These include both industry emission reduction programs and behaviour change programs by motorists often sponsored by motoring organisations. It is expected each jurisdiction will continue to work closely with the community (including industry where necessary) in determining the appropriate mix of strategies to maintain or achieve the NEPM goal set for photochemical oxidant measured as ozone.

10.10.1 Benefits

The benefits from the ozone standards are reduction in the incidences of respiratory problems and exacerbation of asthma symptoms. Actions to reduce ozone levels also lower levels of particles and nitrogen dioxide, and lead to indirect benefits from these lower levels.

10.10.1 Costs

The method for achieving ozone reductions will differ in each airshed. Current management strategies for motor vehicle emissions will continue to reduce or maintain ozone levels. Further industry controls as well as the newly introduced ADR 37/01 would be likely to be required to achieve the standards.

10.11 ISSUES RAISED DURING PUBLIC CONSULTATION ON OZONE STANDARDS

For a detailed summary of issues and responses refer to the Summary and Response Document. Some of the points raised during public consultation included:

- Ozone standards should not differ from those recommended by health experts.
- Ozone standards set too high/too low.
- Four hour standard is not justified, the evidence supports an eight hour standard.

10.12 CONCLUSIONS - OZONE

Having considered the comments made during the public consultation phase, including written submissions, and the available scientific, social and economic data the following conclusions have been reached:

- The ozone standards have been selected on the basis of: providing health protection for the majority of the population including susceptible groups, being technically achievable, and providing comparable costs and benefits within the limitations of the analysis. The standards are consistent with the NHMRC guidelines currently being used by most jurisdictions.
- The health effects of ozone are; increases in hospital admissions and emergency room visits for respiratory and cardiovascular disease, decreases in lung function, increases in respiratory symptoms such as cough and chest pain on inspiration and increased mortality. Sensitive subgroups of the population include the elderly and asthmatics.
- The allowable exceedence recognises that catering for meteorologically rare events may be technically and economically unachievable. This compliance frequency recognises the high degree of conservative management which would need to be adopted in order to ensure compliance with the standards in times of extreme meteorological conditions.
- Melbourne, Sydney, Perth, Brisbane and Adelaide, are the main Australian cities of sufficiently large size and favourable meteorology for significant ozone formation.
- Tighter standards as recommended by the Health Technical Review Panel (0.08 ppm 1 hour average and 0.06 ppm 8 hour average), and supported by Health departments and health professionals are recommended to jurisdictions as a long term goal were assessed as not being practicably achievable within the ten year timeframe for attainment. This is mainly due to motor vehicle replacement rates which are estimated at 17 years for full turnover.

- The selection of a 4 hour standard as opposed to an 8 hour standard is based on providing a standard that is as close in stringency to the TRP recommendation as is technically achievable, and is also statistically compatible with the 1 hour standard. As already stated the NEPC has made a commitment to review the ozone standards in 5 years.
- Current control strategies in place in Australia have relied mainly on the control of ROCs from various sources, with a major emphasis on motor vehicles.
- A realistic upper bound estimate of the cost of achieving the ozone standard is of the same order, or less, than the anticipated benefits
- Since actions and expenditure for ozone control also result in the control of fine particles (which forms the major component of the indirect cost benefit estimate), carbon monoxide, and nitrogen dioxide, these indirect costs are noted but not included to avoid double counting. Other benefits include improved aesthetics, lower damage to buildings and structures, avoided vegetation damage, lower environmental impacts, and improved aesthetics such as visual amenity.

Accordingly the standards for ozone as measured at each performance monitoring station are:

- 0.10 ppm measured over a one hour period; and
- 0.08 ppm measured over a four hour period.

[The Goal being to meet both the standards with one allowed exceedence day per year within a 10 year timeframe.]

CHAPTER 11
SULFUR DIOXIDE

The standards for sulfur dioxide as measured at each performance monitoring station are:

- 0.20 ppm (parts per million) averaged over a one hour period;
- 0.08 ppm averaged over a 24 hour period; and
- 0.02 ppm averaged over a one year period.

[The Goal being to meet all standards within a 10 year timeframe. The goal allows one exceedence day per year for both the 1 and 24 hour standards.]

11.1 NATURE OF SULFUR DIOXIDE

Sulfur dioxide (SO_2) is a colourless, pungent, irritating and reactive gas which is soluble in water. SO_2 and its reaction products (sulfurous and sulfuric acids and sulfate particles) are removed from the atmosphere by wet (ie. rain) and dry deposition (ie. by direct uptake at soil, plant and water surfaces).

11.2 SOURCES OF SULFUR DIOXIDE

11.2.1 Anthropogenic sources

The main human activities which are sources of SO_2 are power generation from the combustion of coal, oil or gas containing significant amounts of sulfur, the roasting or smelting of mineral ores containing sulfur, oil refining, and industrial plants which burn large quantities of fuels with a significant sulfur content, and in urban areas, motor vehicles.

Table 11.1 (based on Pacific Air & Environment, 1997) summarises the emissions data and source types. Even in the major urban centres, emissions from point sources of SO_2 dominate.

Table 11.1

Estimated annual emissions of SO_2

Location	SO_2 Emissions, (kt/year)	Source Type
Mount Isa	500	Copper smelting
Kalgoorlie	372	Nickel and gold processing
Hunter Valley	105	Power generation and aluminium smelting
Gladstone	80	Power generation and aluminium smelting
Port Pirie	53	Lead smelting
Latrobe Valley	47	Power generation
Anglesea	40	Power generation
Collie	36	Power generation
Nhulunbuy	31	Alumina refining
Brisbane	20	Power generation and oil refining
Sydney	20	Oil refining and mineral processing
Perth – Kwinana	18	Power generation and oil refining
Melbourne Region	15	Oil refining, chemical and metal processing
Portland	8	Aluminium Smelting
Adelaide Region	6	Oil refining and power generation
Total	1,303	

11.2.2 Biogenic sources

Natural sources of SO_2 are volcanic and geothermal activity. As well, bacterial and algal processes can produce organic sulfur compounds which are readily converted to SO_2. Natural sources typically contribute less than one percent of total ambient SO_2 in urban areas.

11.3 HEALTH EFFECTS OF SULFUR DIOXIDE

The health effects of SO_2 are summarised by WHO (1996) and Streeton (1997). The only route of exposure of interest with regard to the health effects of SO_2 is by inhalation. SO_2 acts directly on the upper airways (ie nose, throat, trachea and major bronchi) initially, producing rapid responses in minutes. It achieves maximum effect in 10 to 15 minutes, particularly in those individuals with significant airway reactivity such as asthmatics and those suffering similar bronchospastic conditions.

The responses may be manifest by symptoms such as wheezing, chest tightness, shortness of breath or coughing, and functionally as reductions in ventilatory capacity (for example, reduction in FEV_1, increased specific airway resistance). If exposure occurs during exercise the observed responses may be accentuated because of increased ventilation associated with the exercise and the fact that soluble gases like SO_2 tend to be carried further down the respiratory tract before coming into contact with the mucous layer lining the airways (the bronchial mucosa) resulting in production of an irritant acidic solution which stimulates the nerve endings, leading to coughing and subsequent wheezing. A wide range of sensitivity is evident in both normals and susceptibles such as asthmatics, the latter being the most sensitive to irritants.

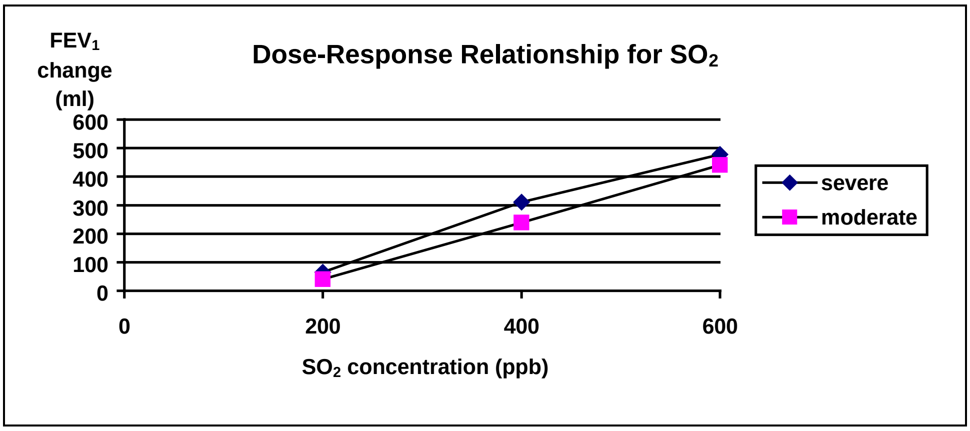
The results of community based epidemiological studies have shown associations between increases in SO_2 levels and increases in mortality, hospital admissions for asthma and respiratory disease, and increases in respiratory symptoms. In many instances it is difficult to separate the adverse effects resulting from exposure to SO_2 from those resulting from concurrent exposure to mixtures including other known irritant pollutants such as NO_2, ozone and, in particular, respirable particles. Results of controlled exposure studies support the epidemiological findings with respect to exacerbation of asthma, increases in respiratory symptoms and decreases in lung function. Data from a wide range of studies are reported by Streeton (1997).

A pattern of continuous dose-response relationships for asthmatics can be demonstrated. The dose-response relationships with respect to change in FEV_1 in asthmatics are presented in Figure 11.1. The graph indicates that small changes in FEV_1 were observed at 0.2 ppm. However, changes regarded as of greater clinical significance (ie of the order of 10% reduction in baseline FEV_1) were observed at about 0.4 ppm over a 15-minute averaging period.

In developing protective ranges as part of guidelines or standards both epidemiological and chamber studies have relevance. The former provide details of the effects of “real world” response, while the latter are the source of data on the minimum dose which produces an adverse effect particularly in susceptible subjects.

Figure 11.1

Change in mean FEV_1 with increasing concentrations of SO_2



(15 minute duration) with exercise (after subtracting the effect of exercise alone) in patients with moderate and severe asthma (reproduced from WHO 1996)

The literature cited in the Health Effects Review (Streeton, 1997) indicates that exercising asthmatics are sensitive to short term exposures of SO_2. Bronchospasm has been observed in some subjects exposed briefly (ie 10 to 15 minutes) at 0.25 ppm, and in 50% of subjects at 0.75 ppm. No similar effects are observed in healthy subjects below concentrations of 1.0 ppm.

The dose-response relationship for short term (15 minute) exposure to SO_2 shown in Figure 11.1 indicates a possible threshold for adverse effects at 0.2 ppm for both moderate and severe asthmatics and a 10% reduction in FEV_1 at 0.4 ppm. In addition the results of exposure appear to be largely independent of the severity of the asthma. The evidence indicates that there is little significant difference in observed responses to SO_2 exposure, for exposure duration of the order of 15 minutes and exposure duration of up to several hours. The response occurs quickly and appears to alter little with recurrent exposure, even after more than one hour. As indicated earlier, different positions on the risks associated to short term exposure to SO_2 have been taken by the US EPA and the WHO.

While acknowledging that there are clear adverse health effects from short term (1 hour or less) exposure to SO_2 in susceptible subjects, the US EPA concluded that there was insufficient evidence of a widespread risk (ie to the population across the country) of adverse health effects to justify a short term standard. This conclusion was made on the basis that the effects are reversible, can be ameliorated and prevented by medication, affect only the most sensitive significantly, and, except in 10% to 20% of asthmatics, do not result in lung function variations above normal diurnal variations, or above variations caused by other stimuli.

Using, in the main, the same data on associations between adverse health effects and SO_2, the WHO arrived at the contrary conclusion that there was a need for a short term guideline to provide protection against the identified health risks.

11.4 CURRENT AMBIENT AIR QUALITY OBJECTIVES FOR SULFUR DIOXIDE

Current Australian and overseas objectives for SO_2 are shown in Table 11.2. Standards have been adopted by the European Commission and the United States and have been recommended in the United Kingdom. In Australia, the NHMRC goals are used as guidance values for SO_2 in the majority of Australian jurisdictions, as the table shows. Victoria and Tasmania have set their own standards, and New South Wales has introduced guidance levels for new plant in areas of high population exposure.

11.4.1 World Health Organization objectives

In 1993 WHO Europe commenced a review of the guidelines in collaboration with the European Commission (EC) and the International Programme on Chemical Safety (IPCS). The data base used in the review included studies of very short term (up to 15 minutes), short term (up to 24 hours) and long term (1 year) exposure effects. The recommended guideline was 0.175 ppm (500 μg/m3) over 10 minutes. The previous 24-hour guideline of 0.04 ppm (125 μg/m3) and annual guideline of 0.02 ppm (50 μg/m3) were not revised on the basis that the evidence for the effects of SO_2 alone over these longer averaging periods was not yet sufficiently clear. The expectation was expressed that evidence would emerge indicating that they would have to be revised to more stringent levels in the future (WHO 1996).

Table 11.2

Current health-related guideline values or goals for SO_2 in Australia and elsewhere

(Note that although NHMRC goals have no regulatory status they may be referenced by States and Territories as appropriate health guidance.)

	Averaging period			
Country/Authority	**10 minutes (ppm)**	**1 hour (ppm)**	**24 hours (ppm)**	**1 year (ppm)**
Australia (NHMRC)	0.25	0.20	-	0.02
New South Wales:				
general	0.25	0.20	-	0.02
high population areas exposed to new or upgraded plant	0.175	0.12	-	-
Victoria *:acceptable level	-	0.17	0.06	-
detrimental level	-	0.34	0.11	-
Queensland ##	0.25	0.20	-	0.02
South Australia	0.25	0.20	-	0.02
Tasmania: maximum acceptable level	-	0.16	0.06	0.02
Northern Territory	0.25	0.20	-	0.02
Australian Capital Territory	0.25	0.20	-	0.02
Western Australia **	0.25	0.20	-	0.02
New Zealand	0.175	0.12	0.044	0.02
USA #	-	-	0.14	0.03
California	-	0.25	0.04	-
Hong Kong	-	0.30	0.13	0.03
Japan	-	-	0.04	-
WHO	0.175	-	0.044	0.02

**acceptable level has three allowed breaches per year; detrimental level not to be reached.*
***different ambient limits from the NHMRC goals are set in the Environmental Protection Policies for Kwinana and Kalgoorlie.*
#primary standard to protect public health.
##NHMRC goals are matters for consideration in making a decision about an environmentally relevant activity.

11.4.2 US EPA objectives

Standards for SO_2 were initially promulgated by the US EPA in 1971. The primary standards, set for the protection of human health, were a 24-hour average of 0.14 ppm (365 μg/m^3) not to be exceeded more than once per year, and an annual average of 0.03 ppm (80 μg/m^3). A review in 1988 resulted in a decision not to revise the standards, but, in response to public comment on the 1988 decision, a further review was initiated in 1994. In addition to proposing to retain 24-hour and annual average standards, the review proposed consideration of short term standards to deal with potential health risks associated with high 5-minute peaks of SO_2. The proposal to consider a short term standard for SO_2 provided the bulk of the comments.

The decision on the 1994 review confirmed the 24-hour and annual standards. While there was general agreement that short term exposures to high concentrations of SO_2 (ie. 0.5 to 1.0 ppm) cause some temporary adverse symptoms in some asthmatics, there was no consensus on the risk to the health of asthmatics from such exposures. Consequently opinion was sharply divided, and a short term standard was not adopted. However, the US EPA proposed that the States consider the adoption of two guidance levels for SO_2, a “concern” level of 0.60 ppm and an “intervention” level of 2 ppm, both 5-minute averages to provide a basis for assessing whether a revision of the decision with regard to a short term standard would be made.

11.5 CURRENT AMBIENT AIR LEVELS FOR SULFUR DIOXIDE

In urban areas of Australia, ambient concentrations of SO_2 tend to be quite low except in the immediate vicinity of petroleum refineries, petrochemical and other chemical manufacturing industries.

In regions where roasting of sulfur-containing mineral ores, or power generation from relatively high sulfur coal or oil occurs, average and peak ambient levels of SO_2 can be much higher. In Mt Isa, for example, the highest 1-hour average was 0.72 ppm, but the majority of maximum values were below 0.4 ppm, while, by contrast, in Gladstone the peak 1-hour maximum value was 0.06 ppm with the majority being below 0.04 ppm. However, it is noteworthy that the annual average for both these locations has remained below the NHMRC goal of 0.02 ppm. Little information is available on 10 minute SO_2 concentrations throughout Australia.

Peak 24-hour average levels of SO_2 in urban areas are quite low, generally below 0.01 ppm in areas well away from point sources, rising to about 0.04 ppm in the vicinity of these sources with some notably higher values of around 0.08 ppm.

The only population centres predicted to have more than one exceedance of the one hour standard of 0.2 ppm per year are Mt Isa and Kalgoorlie. Both these centres have populations of around 25,000. The vast majority of the Australian population have maximum exposure concentrations of less than 0.1 ppm averaged over one hour and 0.04 ppm averaged over 24 hours. In such population centres, it is recognised that it may take longer than the 10 year timescale envisaged to achieve the standards based on current management strategies.

11.6 AUSTRALIAN EXPOSURE LEVELS FOR SULFUR DIOXIDE

Attempts were made using available data to estimate population exposure to concentrations of SO_2 for major cities and towns where SO_2 monitoring takes place (Beer and Walsh 1997).

Limitation in the available data constrained the application of the exposure assessment methodology. However, it provided useful indications of potential exposure patterns and also identified data gaps which the NEPM could usefully fill for future studies.

The major difficulties with the information arose from the location of existing monitoring stations. Lack of consistency in monitoring locations between or even within air sheds led to lack of comparability between data and exposure estimates which were biased by the monitoring data.

These difficulties were highlighted and explained in the draft Impact Statement and the use of the data was heavily qualified. Despite these caveats and explanations covering the use of the exposure assessment data the public submissions on the draft Impact Statement have demonstrated that these data were still open to misinterpretation.

In response to widespread stakeholder concern, the exposure assessment has been accepted by NEPC as indicative only and did not influence the final choice of standards.

Future monitoring under the protocol combined with jurisdictional peak monitoring, will provide a more robust basis for future exposure studies should they be required.

11.7 CURRENT MANAGEMENT PRACTICES FOR SULFUR DIOXIDE

As Table 11.1 showed, major point sources of SO_2 include three main industry types: metal smelting (copper, gold, lead, aluminium etc), power generation, and oil refining. Management of SO_2 tends to be similar within each industry type.

In most metal smelting the sulfur dioxide is due to sulfide ores, which produce relatively concentrated SO_2 emissions. This makes scrubbing or acid plants a feasible way of controlling emissions. Acid plants recover the SO_2 as saleable sulfuric acid. Alumina is not a sulfide ore, the SO_2 from aluminium smelting comes from coke used in the process and emissions contain relatively high concentrations of SO_2 . Currently aluminium smelters use dispersion through tall stacks to meet ambient air objectives for SO_2. This is also the case for power stations where the SO_2 is due to sulfur in the fuel (usually coal). Oil refineries using high sulfur crude oil usually have sulfur recovery equipment that recovers much of the sulfur in elemental form before it can be emitted as SO_2.

11.8 RANGE OF STANDARDS CONSIDERED FOR SULFUR DIOXIDE

The recommended range of standards for SO_2 from the various inputs to the project team was as follows:

Health Review Study.................10 to 15 minute standard of 0.175 ppm
....24-hour standard of 0.04 ppm and
....Annual standard of 0.02 ppm

Technical Review Panel............10-minute standard of 0.12 ppm,
....24-hour standard of 0.04 ppm,
....annual standard of 0.02 ppm.

NHMRC...................................10-minute standard of 0.25 ppm,
....1 hour standard of 0.20 ppm,
....annual standard 0.02 ppm.

In the absence of sufficient 10 minute data, the following 1 hour surrogate values were used for:

- 0.25 ppm 10-minute = 0.20 ppm 1-hour
- 0.175 ppm 10-minute = 0.146 ppm 1-hour
- 0.12 ppm 10-minute = 0.09 ppm 1-hour

11.9 IMPACTS OF POTENTIAL STANDARDS FOR SULFUR DIOXIDE

11.9.1 Health Impacts

For evaluation purposes, the relevant health effect considered is the bronchospasm. It is assumed that only asthmatics and atopics (15% of the general population) are susceptible. Table 11.3 shows an illustrative example of how the impact might be calculated. These dollar values are not intended to be representative of the actual Australian incurred or avoided costs but are provided to assist the reader in assessing the relative significance of these possible impacts. Within this group, the response (see footnote on Table 11.3) would vary with exposure concentration.

The avoidable effects in numerical terms and the indicative potential dollar benefits range are calculated, from Acute Respiratory effects at Au$27 per case from US EPA (1997), to be $1.4 million per year for achieving a 0.20 ppm one hour standard to $3.5 million for achieving a 0.09 ppm one hour standard. These costs could be a substantial underestimate for actual effects if asthma attacks are triggered or hospitalisation is required.

Table 11.3

Illustrative Example of Costing Potential Health Benefits

	NHMRC 0.25 ppm (10-min)	**Consultant 0.175 ppm (10-min)**	**TRP 0.12 ppm (10-min)**
1 hour surrogate standard	***0.20 ppm***	***0.146 ppm***	***0.09 ppm***
Total population exposed (million person events per year)	1.7	3.8	9
Avoided bronchospasm* (events per year)	50,000	90,000	130,000
Potential health benefit (million dollars per year)	1.4	2.3	3.5

* *Assuming 20% of those asthmatics and atopics bronchospasm at 0.25 ppm, 15% at 0.175 ppm and 10% at 0.12ppm.*

11.9.2 Management options and costs

Jurisdictions are currently undertaking programs that include the 10-year implementation plan for the Kalgoorlie smelters, the long running Port Pirie program scheduled to run until 2004 in the current phase, the most recently announced Mt Isa Mines Limited acid plant program in Mt Isa. The range of costs used for these program are not known precisely but estimates might vary from $2,000 per tonne to $7,000 per tonne although it is recognised that these are likely to be overestimates. The net estimated capital cost of reduction (lower) is around $360m for jurisdictions for achieving a 0.20 ppm 1 hour standard. More than 90% of these costs would be at Mt Isa and Kalgoorlie. Programs are in place in both centres to reduce the impact of SO_2 emissions and would be expected to continue irrespective of any NEPM standards, the costs and benefits have been discounted accordingly to avoid double counting.

11.9.3 Other Benefits

The social gains from improved health, particularly in the susceptible sub-groups resident in point source regions are the key benefits anticipated to arise from adoption of the standards. Visual effects from plumes and characteristic acidic odour from high short term concentrations of SO_2 would be minimised, providing significant amenity improvements over the current situation near point sources with associated property value improvements.

In addition to the impacts of SO_2 on human health, other effects of this pollutant have been recognised including damage to buildings and materials, damage to crops and vegetation, and acid deposition to water and soil. Acid deposition, is regarded as minor in Australia, although most recent work expresses caution. However, compliance with the 0.02 ppm annual average everywhere should ensure that any effects of acid deposition remain minor. SO_2 damage to buildings and materials is not considered significant at the ambient SO_2 levels found in Australia.

The limited work done on Australian native vegetation and various crop species and varieties indicates that adverse effects can result from exposure to high concentrations of SO_2. For example, in some trees, growth can be affected by exposure during the growing season at SO_2 concentrations above 0.08 ppm, and for some commercial crops, yields can be affected by levels above 0.053 ppm. Minimising vegetation damage will be an additional benefit of achieving the SO_2 standards.

11.10 SUMMARY OF COSTS AND BENEFITS FOR THE SULFUR DIOXIDE STANDARD

Because the NEPM deals only with the assessment of air quality by governments the only direct costs associated with the introduction of the standard for sulfur dioxide are the monitoring and reporting costs, required by the NEPM protocol, which will be incurred by governments when assessing ambient air quality. There is no other requirement placed upon governments. In most cases some changes to existing monitoring and reporting programs for assessing air quality will be required. Until detailed jurisdictional monitoring plans have been developed the costs associated with monitoring sulfur dioxide for the purposes of this NEPM cannot be definitively identified.

Most jurisdictions have active air quality management programs for sulfur dioxide which they continuously monitor, revise and refine over time. The NEPM will provide a sound basis for assessing the extent of any sulfur dioxide problems in the major airsheds and, therefore, assist governments in determining the priority to be given to the management of the effects of sulfur dioxide on ambient air quality in the context of overall government programs. Voluntary programs will continue to play an increasing and effective role in those air quality management strategies including industry emission reduction programs. It is expected each jurisdiction will continue to work closely with the community (including industry where necessary) in determining the appropriate mix of strategies to maintain or achieve the NEPM goal set for sulfur dioxide.

11.10.1 Benefits

Compliance with the SO_2 standards would protect against bronchospasm in most sensitive individuals living near point sources.

11.10.2 Costs

The effect on ground level concentrations as a result of reductions in emissions of SO_2 that will be delivered by existing programs needs to be better quantified before an assessment of the necessity of additional controls. Since these programs would be expected to continue irrespective of any NEPM standards, the costs and benefits have been discounted accordingly to avoid double counting.

11.11 ISSUES RAISED DURING PUBLIC CONSULTATION ON SULFUR DIOXIDE STANDARDS

For a detailed summary of issues and responses refer to the Summary and Response Document. Some of the points raised during public consultation were:

- Some submissions supported the standards
- Some health professionals and community groups recommended that a very short term (10-15 minute) standard should be set and that the one day standard be tightened to the Health Review Study level
- Some industry groups suggested that the short term standard(s) (1 hour or less) should be removed and that only a one day standard should apply and that the one day standard should be relaxed to the US EPA level. Other industry groups suggested that the one hour standard should be relaxed
- Industry groups recommended that the standard should not apply around point sources.
- Some submissions recommended a five year review of SO_2 standards

11.12 CONCLUSIONS

Having considered the comments made during the public consultation phase, including written submissions, and the available scientific, social and economic data the following conclusions have been reached:

- Achieving the standard for SO_2 of 0.20 ppm averaged over a one hour period should provide protection from increased risk of breathing difficulties for the bulk of the susceptible sub-population. The standard is consistent with the current NHMRC goal. Given the significant costs required to control SO_2 emissions from some point sources, the more stringent objectives recommended by the Health Review were not seen to be achievable in all locations in the 10 year timeframe.

- The SO_2 one hour standard is being met throughout Australia except close to some point sources, notably Mount Isa and Kalgoorlie which are the subject of specific jurisdictional legislation. In most areas, SO_2 levels will also be below the objectives recommended by the Health Review. Ongoing point source and motor vehicle control programs should ensure continued compliance with the standards in the 10 year timeframe.

- Compliance with the one hour standard is expected to continue to ensure compliance with the one day standard of 0.08 ppm and the annual standard of 0.02 ppm.

- A 10 minute standard for SO_2 was not recommended in the Measure because of the difficulties in assessing compliance with such a standard on a national basis due to limited data. As already stated in chapter 1, the NEPC is committed to 10 minute SO_2 data being collected from performance monitoring stations to allow a review in five years.

- For SO_2, short term high concentrations are usually a result of plume impacts from point source emitters. An imputed ground level concentration of 0.25 ppm averaged over a 10-minute period could be used by jurisdictions as a basis for designing their control programs for these sources.

- Another benefit that would result from achieving the standard is reduced impact on vegetation around point sources.

Accordingly the standards for sulfur dioxide as measured at each performance monitoring station are:

- 0.20 ppm (parts per million) averaged over a one hour period;
- 0.08 ppm averaged over a 24 hour period; and
- 0.02 ppm averaged over a one year period.

[The Goal being to meet all standards within a 10 year timeframe. The goal allows one exceedence day per year for both the 1 and 24 hour standards.]

CHAPTER 12
LEAD

The standard for lead, as measured at each performance monitoring station is:

- 0.5 μg/m^3 (micrograms per cubic metre) averaged over a one year period, reported as a fraction of TSP (total suspended particles).

[The Goal being to meet the standard within a 10 year timeframe. No exceedences are allowed.]

12.1 NATURE OF LEAD

Lead (Pb) is a soft bluish or silvery grey metal which is naturally present in low concentrations in the earth's crust. Most of the lead in the atmosphere is in the form of fine inorganic particles with a diameter of less than 1.0 μm. Organic lead generally makes up less than 10% of the total atmospheric lead burden.

Lead is removed from the atmosphere by both wet and dry deposition, although wet deposition appears to be more important (WHO, 1995). Its residence time in the atmosphere varies according to a range of factors, including particle size, wind currents, rainfall and the height at which the particles were emitted.

Lead shares some chemical similarities with calcium and zinc and may exert at least some of its toxic effects by interfering with or substituting for these elements in key biological processes. There are no known health benefits from human exposure to lead (Streeton, 1997).

12.2 SOURCES OF LEAD

12.2.1 Anthropogenic sources of lead

Lead has been widely used for many centuries and it is believed to be the first metal to be won from its ores, and is now an ubiquitous pollutant in the ecosystem. Its distribution and concentrations rose substantially with the onset of industrialised society (EPA NSW, 1994; Streeton, 1996) and with the use of lead alkyls as antiknock agents in petrol, which began in 1923.

Today lead enters the atmosphere from the use of leaded transport fuels, from industrial operations and from a range of other human activities. In urban areas about 90% of atmospheric lead comes from emissions from motor vehicles using leaded petrol. It has been estimated that over the life of a car about 75% of the lead in fuel is emitted from the exhaust system, and that a further 2% of the lead in petrol may escape to the atmosphere as a result of evaporation from the fuel tank, carburettor or spillage during transport and refuelling (EPA Vic, 1991).

Other broad scale sources of atmospheric lead include smelters, mining operations and waste incinerators. Lead also enters the air environment through very localised sources, such as secondary lead processing (battery recycling) and manufacture of lead fishing sinkers. Sandblasting or paint-stripping in older buildings may also contribute to atmospheric lead because lead was used as a significant component of domestic paints in the past.

12.2.2 Biogenic sources of lead

Lead is a commonly occurring metal in the earth's crust. It enters the atmosphere through soil erosion, volcanic activity, Seaspray, vegetation and bushfires. Natural levels of atmospheric lead are low, generally less than 0.01 μg/m^3, and are mainly in the form of particles. The contribution of natural sources of lead to human exposure is small (WHO, 1995), although environmental lead near natural ore deposits can be an important ingestion route in certain locations.

12.3 HEALTH EFFECTS OF LEAD

12.3.1 Human exposure pathways

The total body lead burden comes from food, water, soil and air, and the general population is exposed to lead simultaneously from many sources and through multiple pathways. In addition, exposure to groups within the population varies because of physiological, behavioural and other factors. (Table 12.1 presents a summary of the lowest observed lead-induced health effects in adults and children.)

Increased exposure may result from choice, habit or unavoidable circumstances, in addition to the normal exposure through food, drinking water and air. For example, babies may be exposed to lead in breast milk, young children to lead in dusts and on non-food items such as toys. Alcohol consumption and smoking increase lead exposure, as do variations in diet. People may also be exposed through hobby or occupational activities (WHO, 1995b).

Lead is absorbed after being inhaled or ingested. Food provides the largest proportion of the daily lead intake in most adults. The most important pathway by which lead enters the food chain is thought to be direct foliar contamination of plants (WHO, 1996). In adults approximately 10% of dietary lead is absorbed. In babies and young children as much as 50% is absorbed. The average lead intake in the diet of adults has fallen from values of 100-500 μg/day in the early 1980s to a present value of less than 30 μg/day.

Lead concentrations are low in most ground and surface waters although they may increase as a result of contact with lead in the distribution system. Soil and dust may contain lead deposited from leaded petrol, lead paint and a variety of other sources. Lead compounds do not degrade and are slow to disperse, so contaminated soil is a long-term source of potential exposure unless immobilised or cleaned up.

Ingestion of lead from dust may be a major source of exposure for young children who ingest lead from it when mouthing their hands, toys or food. This will be particularly significant for children in close proximity to smelters and other major point sources and central urban areas. Although dust derived from the soil may be either ingested or inhaled, ingestion appears to contribute the major part of a child's intake (Streeton, 1997). Dust is not considered a significant source of lead in adults, but may be for workers where hygiene practices are poor (WHO, 1995b). Lead in dust can make a significant contribution to the levels of lead adsorbed by children, contributions from this route may be as high as 80% of the total (WHO, 1996).

Table 12.1

Summary of Lowest Observed Lead-Induced Health Effects

Blood lead level *(µg/dL)*	**Lowest observed health effects** *Adults*	*Children and/or foetuses*
> 100	Encephalopathic signs and symptoms	
> 80	Anaemia	Children: Encephalopathic signs and symptoms, chronic nephropathy (eg aminoaciduria)
> 70	Clinically evident peripheral neuropathy	Children: Colic and gastrointestinal symptoms
> 60	Female reproductive effects. Central nervous system symptoms (ie sleep disturbances, mood changes, memory and concentration problems, headaches)	
> 50	Decreased haemoglobin production, decreased performance on neurobehavioural tests, altered testicular function, gastrointestinal problems (ie abdominal pain, constipation, diarrhoea, nausea, anorexia)	Children: Peripheral neuropathy
> 40	Decreased peripheral nerve conduction, chronic nephropathy	Children: reduced haemoglobin synthesis and Vitamin D metabolism
> 25	Elevated erythrocyte protoporphyrin levels in males	
15 - 25	Elevated erythrocyte protoporphyrin levels in females	
> 10	Elevated blood pressure (males aged 40-59 years)	Foetus: Preterm delivery, impaired learning, reduced birthweight, impaired mental ability
≤ 10		Children: Both the level of concern and the lowest observed adverse effect level for the effects of lead on intelligence has been determined to be 10µg/dL.

Source: Streeton, 1997 (adapted from CDC, 1992).

Most of the lead in air is in the form of submicron-sized particles. In the vicinity of smelters, levels may be as high as 10 µg/m^3 (Streeton, 1997). WHO reports that the larger particles found in the vicinity of smelters settle at distances from a few hundred metres to 1-2 kilometres. At these distances the particle distribution is indistinguishable from that found in non point source urban areas (WHO, 1996).

Depending on chemical speciation, particle size and solubility in body fluids, up to 50% of inhaled lead may be absorbed. Some inhaled particulate matter (notably that larger than

7 μm) may subsequently be swallowed. The chemical form of lead is not considered an important factor for respiratory absorption, even though lead salts differ widely in terms of solubility.

12.3.2 Dose response relationships

Lead is absorbed after being inhaled or ingested. It can result in a wide range of biological effects depending on the level and duration of exposure. Its toxicity can largely be explained by its interference with different enzyme systems, which it affects in a number of ways. It is for this reason that lead exposure may result in a very wide range of adverse health effects. Effects at the subcellular level, as well as effects on the overall functioning of the body, have been noted and range from inhibition of enzymes to the production of marked morphological changes and death (WHO, 1995b).

Absorbed lead is distributed among the soft tissues (blood, liver, kidneys, brain etc) and mineralising systems such as teeth and bone. Bones form the major lead storage site in the body, and lead accumulates in the bones over a person's lifetime (WHO, 1995b). Because of retention of lead in bone, conditions associated with increased bone catabolism may lead to increased circulating blood lead even when environmental exposures have been reduced or eliminated (Streeton, 1997).

The concentration of lead in whole blood has gained almost universal acceptance as the best available surrogate for cumulative exposure, and surveys of blood lead concentration have come to be regarded as measuring community exposure (Donovan et al, 1996). The concentration of lead in blood is usually expressed in micrograms per decilitre (μg/dL). Table 12.1 presents a summary of the lowest observed lead-induced health effects in adults and children.

12.3.3 Susceptible subgroups

Children

Foetuses, babies and children (especially those below the age of 4 years) are considered to be more susceptible to the adverse effects of lead exposure than adults for a number of reasons. These include their smaller body size (children eat and drink more per unit of body weight than adults, so their relative lead intake is increased); higher rates of gastrointestinal absorption (approximately 50% compared with 10% in adults); greater prevalence of nutritional deficiencies, such as iron and Vitamin D, which enhance absorption of lead; incompletely developed nervous systems (neurological effects of lead occur at lower thresholds than in adults); and higher rates of growth (WHO, 1995b; Streeton, 1997).

Children up to the age of 4-6 years are also considered to be a group at increased risk of exposure due to a range of behavioural characteristics. These include the greater amount of time they spend outdoors playing, hand to mouth behaviours (such as thumb sucking) and possibly pica. Pica is the compulsive, habitual consumption of non-food items, and where these include dust and paint chips, lead consumption can be significantly increased. Much of the lead poisoning caused by lead based paint has been found to occur because children actively eat paint chips (US EPA, 1986).

Over the past two decades, attention has focused on children as a risk group for central nervous system (CNS) effects, at increasingly lower levels of exposure. As a global measure of CNS-functioning, intelligence quotient (IQ) has received particular attention in such studies. Analyses have consistently shown that a blood lead increase from 10 μg/dL to 20 μg/dL is likely to be associated with an IQ drop of 1-3 points (Schwartz, 1994; Pocock et al, 1994; WHO, 1995b). At blood lead levels greater than 25 μg/dL this relationship may differ (Streeton, 1997).

Existing epidemiological studies do not provide definitive evidence of a threshold (Donovan et al, 1996). The research suggests that below a blood lead level range of 10-15 μg/dL there is increasing uncertainty attached to identified effects (WHO, 1995b). It has also been suggested that while there is a definite association between lead concentration in early childhood and IQ, many observational studies have not allowed for key confounders-such as the possibility of reverse causation (IQ deficit leading to higher blood lead) and the IQ of parents (Pocock et al, 1994).

Children subject to such exposures may also show impairment of motor abilities, visual attention and spatial skills, and of their memory for sights or sounds. Greater amounts of lead in the blood correlate statistically with low levels of educational achievement in reading, spelling and mathematics (Sciarillo et al, 1992; Needleman et al, 1979). There is some evidence that these effects are persistent and may be irreversible where exposure occurs up to age seven (WHO, 1995b).

Pregnant women

Lead is foetotoxic. Since the placenta is not an effective biological barrier to lead, pregnant women represent a second group at increased risk because of exposure of the foetus to lead (WHO, 1995b). It should be noted that it is not pregnant women *per se* who are at increased risk, but rather the foetuses. Umbilical cord studies involving mother-child pairs have repeatedly shown a correlation between maternal and foetal blood lead levels (US EPA, 1986). In some studies on pregnant women, blood lead levels above 15 μg/dL have been associated with premature birth and low birthweight babies (Streeton, 1997). The adverse effects of very high lead concentrations in maternal blood on pregnancy outcome are well documented and generally undisputed (Baghurst et al, 1987).

12.4 CURRENT AMBIENT AIR QUALITY OBJECTIVES FOR LEAD

12.4.1 Australian ambient air quality objectives for lead

In 1979 the (NHMRC) recommended an ambient air quality goal for lead of 1.5 μg/m^3 based on a 3 month average; this standard has been adopted Australia wide. Recognising that this standard is almost twenty years old and the blood lead level of concern, has been reduced from 25 μg/dL to 10 μg/dL the National Environmental Health Forum noted in its submission that:

> "[the standard] is in vital need of revision in the light of current research on the health effects of lead at very low concentrations".

Table 12.2 shows the current health-related guidelines suggested for lead in ambient air in Australia and internationally.

Table 12.2

Current health related guidelines for lead in ambient air

Country/Authority	Averaging Time	
	3 months/90 days	1 year
NHMRC goal	1.5 μg/m^3	-
All Australian States and Territories	1.5 μg/m^3	-
New Zealand	0.5 to 1.0 μg/m^3	-
EC	-	0.5 μg/m^3
WHO		0.5 μg/m^3
United States of America	1.5 μg/m^3	-
Hong Kong	1.5 μg/m^3	-

12.4.2 Current international ambient air quality objectives for lead

In response to the substantial increase in knowledge concerning the effects of lead on humans at low levels of exposure, the World Health Organization (WHO) released a major revision of the lead report in 1995. The new research cited in the 1995 review included studies emphasising the effects of inorganic lead on babies and children, a high-risk population. The WHO air quality guidelines for lead were also updated and revised in 1996, and if adopted, will see the WHO guideline drop to a flat rate of 0.5 μg/m^3 (annual average). In 1997 the European Commission (EC) adopted a proposal setting limit values for lead of 0.5 μg/m^3 annual average to be met by 1 January 2005. The current US EPA standard for ambient lead 1.5 μg/m^3 averaged over 3 months was set in 1978 and has not been revised.

12.5 CURRENT AMBIENT AIR LEVELS FOR LEAD

While exceedences of the NHMRC goal (1.5 μg/m^3, three month average) were detected in heavy traffic areas in most major cities prior to the late 1980s or early 1990s, lead levels in urban areas have declined significantly in the past 5 to 10 years in line with the decrease in mobile source emissions (Pacific Air and Environment, 1997; also Section 6.2). The 1996 State of the Environment Report noted that all Australian capital cities have ambient air lead levels between 0.2 and 0.8 μg/m^3, with the highest levels recorded in Adelaide and Perth (SOE Advisory Council, 1996). Studies of lead levels in small particles (< 2.5 μm) suggest that levels decline quickly with distance away from major cities (Cohen, 1993). Monitoring indicates that levels in major urban areas continue to decline and together with declining sales of leaded petrol, levels are expected to become negligible in most parts of Australia over the next decade.

Some localised exceedences, however, continue to be recorded in areas adjacent to major point sources. Airborne lead continues to be a problem in Port Pirie, with lead levels still regularly exceeding the NHMRC goal in areas close to the smelter and the wharf stockpiles (SoE Advisory Council, 1996), and exceedences of the NHMRC goal were reported in recent years adjacent the lead smelter at Boolaroo (near Newcastle) in NSW (Pacific Air and Environment, 1997).

It is estimated that 80% of lead released into the atmosphere is deposited near the source, with the remaining 20% (often very fine particulate matter) more widely dispersed. The most affected areas in Australia lie near major point sources and along major roads.

12.5.1 Blood lead surveys

Surveys of blood lead concentration are employed as a useful surrogate for measuring community exposure to lead. In 1993 a national review of public exposure to lead in Australia was conducted to establish a comprehensive database of studies of Australian exposure to environmental lead, and to allow an assessment of the extent of lead exposures around the country. The review focussed on non-occupational exposures to inorganic lead in children under the age of 4 years. The findings of the review suggested that there might be up to 630,000 children (with a lower estimate of 310,000) in Australia under the age of 4 years with blood lead levels greater than or equal to 10 μg/dL. Children living in towns with smelters were identified as being in the highest exposure category.

In 1993 the NHMRC revised its 1979 (and 1987) blood lead level of concern, of 25 μg/dL, and recommended a blood lead goal of less than 10 μg/dL for all Australians. It recommended that the first target for achieving this goal should be a reduction of lead in all Australians to less than 15 μg/dL by the end of 1998. Because of the increasing evidence of adverse effects on children, the NHMRC identified 'a particular urgency in reaching this level in children aged one to four', and recommended that 90% of all children in this age group should have blood lead levels of below 10 μg/dL by 1998.

In 1995 the Australian Institute of Health and Welfare conducted a national random survey of lead in 1,575 Australian children on behalf of the Commonwealth Government. The survey found that 92.7% of children had blood lead levels of less than 10 μg/dL (Donovan et al, 1996). While it is commendable that the NHMRC’s first target of having 90% of children under the lead limit by 1998 is being met ahead of schedule, 7.3% of children (75,000 one to four year olds) still have blood lead levels exceeding 10 μg/dL. Given that the total population of major point source areas is unlikely to surpass 100,000 people (equivalent to approximately 0.6% of the total Australian population) it is clear, as the survey was a random sample, that high blood lead levels are not exclusively an issue for point source areas. Since the Donovan report, further surveys in areas of concern have continued to record blood lead levels which exceed the national goal.

12.6 AUSTRALIAN EXPOSURE LEVELS FOR LEAD

Attempts were made using available data to estimate population exposure to concentrations of lead for major cities where lead monitoring takes place (Beer and Walsh 1997).

Limitation in the available data constrained the application of the exposure assessment methodology. However, it provided useful indications of potential exposure patterns and also identified data gaps which the NEPM could usefully fill for future studies.

The major difficulties with the information arose from the location of existing monitoring stations. Lack of consistency in monitoring locations between or even within air sheds led to lack of comparability between data and exposure estimates which were biased by the monitoring data.

Whereas 3.5 million person events per year were calculated to occur at 0.5 μg/m^3 (monthly average, over the years 1993-1995), when analysis of the number of people exposed to those levels in each city was undertaken, it became apparent that there was some variation in the apparent exposure between cities.

Although it was concluded that this could be an artefact of the location of individual monitors it was also possible that as the indicative data was from the period 1993-1995, the variations might be because of the high rate of decline in the reported exposure estimates (but not always uniform across all cities), reflecting the significant reductions in the levels of lead emitted from motor vehicles as a consequence of the ongoing phase out of leaded petrol. These downward trends are expected to be mirrored in all jurisdictions although the extent of the reduction will be less significant in areas in close proximity to major point sources. Data for the Sydney MAQS Area for individual years 1993-1995 are provided in Table 12.3 and illustrate the dramatic decline in estimated exposed population for 1995. The decline is judged to be real and not just indicative.

Table 12.3

Estimated urban populations exposed in Sydney MAQS Area, by individual year

Year	Estimated population exposed (million person events/year)		
	0.3μg/m^3	0.5μg/m^3	1.0μg/m^3
1993	13.3	5.0	0.97
1994	14.0	4.0	0.97
1995	1.5	1.4	0.14
3 year Average [a]	9.6	3.5	0.7

[a] 3 year average as reported in Table 12.

These difficulties were highlighted and explained in the draft Impact Statement and the use of the data was heavily qualified. Despite these caveats and explanations covering the use of the exposure assessment data the public submissions on the draft Impact Statement have demonstrated that these data were still open to misinterpretation.

In response to widespread stakeholder concern, the exposure assessment has been accepted by NEPC as indicative only and did not influence the final choice of standards.

Future monitoring under the protocol combined with jurisdictional peak monitoring, will provide a more robust basis for future exposure studies should they be required.

12.7 CURRENT MANAGEMENT PRACTICES FOR LEAD

Lead emissions in Australia impacting on ambient air levels are primarily associated with motor vehicle use (the major source in urban areas) and a relatively small number of metallurgical industries, such as smelting, foundries, scrap metal recovery and lead-acid battery manufacture (Pacific Air and Environment, 1997; SoE Advisory Council, 1996). The management of lead from motor vehicles is discussed in Chapter 6 in the context of the range of strategies used to manage air pollutants from motor vehicles.

Management of point source emissions has focused on reductions in process emissions (regulatory-based particulate emission programs and improvements in handling and storage procedures to address fugitive emissions), although monitoring at a number of the main point sources indicates that in some locations lead levels still regularly exceed the NHMRC goal.

Table 12.4

Australian locations where pronounced lead emissions are anticipated

Locations		**Routine[1] monitoring**	**Monthly mean lead data obtained**
Queensland	Brisbane	√	√
	Townsville		
	Mount Isa	[√]	
	Gladstone		
ACT	Canberra	√	√
NSW	Metropolitan Air Quality Study Area	√	
	Sydney[2]	√	√
	Port Kembla (Wollongong)[2]	√	√
	Cockle Creek/Boolaroo (Newcastle)[2]	√	
	Broken Hill	√	√
Victoria	Port Phillip Control Area	√	√
South Australia	Adelaide	√	√
	Port Pirie	√	√
Western Australia	Perth	√	√
	Kalgoorlie		
	Kwinana	√	
Tasmania	Hobart	√	√
	Launceston		√

1.Quality assured data publicly available (as at June 1995) SoE Advisory Council, 1996; except where [ ] which indicates data collected in accordance with relevant State licence requirements.

2.Located within the Metropolitan Air Quality Study Area.

12.8 RANGE OF STANDARDS CONSIDERED FOR LEAD

The Technical Review Panel advised that they supported the view that the current goal (1.5 μg/m^3 three month average) was too high and should be lowered to at least 0.5 μg/m^3 but that the evidence presented in the review did not support the case for a standard of 0.3 μg/m^3.

Prior to commencing the development of the Ambient Air NEPM, both NSW and Victoria, on the basis of increased understanding of the potential adverse health effects of relatively low levels of exposure, had foreshadowed a downward revision of their current ambient air lead standards to 1.0 μg/m^3 in Victoria and 0.5 μg/m^3 in NSW, measured as a rolling quarterly mean.

The range of standards considered in the impact assessment and NEPM development process are shown in Table 12.5. The range included the recommendations made in the health review (Streeton, 1997) and by the Technical Review Panel, and an intermediate level between the existing goal and the new recommendations. In addition three different averaging periods have been considered for the standards: an annual average as proposed by the health review consultant and as used by the WHO and European Union; three month average (based on rolling 1 month averages) as currently used by all Australian jurisdictions; and the monthly average also proposed by the health review consultant.

Table 12.5

Range of potential standards for lead

Standard (μg/m^3)	as recommended by
1.5	NHMRC
1.0	intermediate value
0.5	health review consultant and Technical Review Panel
0.3	health review consultant

12.9 IMPACTS OF STANDARDS FOR LEAD

12.9.1 Health impacts

One of the best documented and increasingly well understood dose response relationships with respect to lead is that between blood lead levels and IQ decrements in children. This effect has been attributed to lead present in levels in the order of 10 μg/dL, but no specific threshold has been identified (Streeton, 1997). Work has also been undertaken on the development of monetary values for IQ decrements (US EPA, 1997). Health benefits likely to arise from the introduction of a new lead standard have therefore been assessed using this relationship.

Benefits from decreases in IQ decrements in children

The methodology (including cost estimates) that has been used to quantify the benefits is that identified in the study, *The Benefits and Costs of the Clean Air Act, 1970 to 1990*, (US EPA, 1997). In the US study, a dose response relationship for IQ decrements was estimated from the results of a meta-analysis of seven research studies (Schwartz, 1994). The agreed relationship between blood lead levels and IQ was taken to be: that for a 1 μg/dL increase in lead, a decrease of 0.25 IQ points could be expected.

The total change in the number of IQ points, for children aged 4 and under, may be represented by the following equation:

$$(\text{TOTAL LOST IQ})_k = \Delta GM_k \times 1.117 \times 0.25 \times (\text{Pop})_k / 5$$

Where ΔGM is the change in the geometric mean (average blood lead level); and $(\text{Pop})_k$ represents the total number of children in the population up to the age 4.

Estimates of the value of avoided effects (see Table 3.3) identify a value of A$4,437 for each lost IQ point. The costings derived in this manner are similar to those used in the study *Reducing Lead Exposure in Australia* (Berry et al, 1994).

The 1995 national survey, *Lead in Australian Children* (Donovan et al, 1996) provides some data , for use in the equation, namely:

M_k= 5.05 µg/dL (mean of lead in blood of Australian children under 4 years old)

Pop_k= 1, 032, 379 (1995 population of Australian children under 4 years old)

Consideration of potential standards

- **1.0 µg/m^3 standard**

  As the indicative monitoring providing guidance on actual ambient levels show they are at or below 1.0 µg/m^3 in all capital cities (ie major metropolitan areas), the benefits resulting from the establishment of a standard at this level would appear to be small, as they would effectively be experienced only in those areas where exceedences of the current (1.5 µg/m^3) standard are recorded. The exposed populations in the vicinity of major point source locations are small and unlikely to exceed 100,000 people in total.

- **0.5 µg/m^3 standard**

  The blood lead-inhalation slope for the most susceptible sub-group in the population, young children, is typically taken to be 1.92 µg/dL per µg/m^3 (of lead in air). It is assumed that reducing the indicative ambient lead level of 1.0 µg/m^3 (measured during years 93 to 95) by half to a standard of 0.5 µg/m^3 would therefore lead to a reduction in geometric mean blood levels in children by 0.96 µg/dL over a considerable period of time.

  It is further assumed over such a period of time (say ten years) that local lead in soil contamination could be cleaned up or immobilised and that the only source for re-contamination would be lead in air. The Lost IQ points at this ambient exposure (based on 1995 population numbers), can be calculated as follows:

$$(\text{TOTAL LOST IQ})_k = (0.96)_k \times 1.117 \times 0.25 \times (1,032,379)_k / 5 = 55,352$$

  When considering exposure pathways for children under the age of 4, corrections to the blood lead-inhalation slope are generally made for additional uptake of deposited airborne lead through other media. The range of estimates varies, and for the purposes of this exercise, an uncertainty factor of 2 was applied to the estimate shown above.

  Therefore the health benefits gained, in terms of saved IQ points, from establishing (and meeting) a standard of 0.5 µg/m^3 at ambient exposures of below 0.5 µg/m^3 from those lost at indicative ambient exposures of 1.0 µg/m^3, gives a range of 55,000 to 110,000 IQ points saved. At $4,437 per IQ point, health benefits range from $245 million to $490 million, assuming the loss of IQ points is a linear relationship with blood lead levels in the range of 5 to 15 µg/dL as Bellinger et al (1991) indicated in a study where 70% of the data was below 10µg/dL.

If the results of the 1995 national survey (*Lead in Australian Children)* are applied to these calculations and an assumption made that there is a threshold at 10 μg/dL blood lead, a further decrease in the potential effects of reduced IQ are seen. The survey showed that 7.3% of children exceeded the 10 μg/dL blood lead level threshold. This equates to some 4,000 to 8,000 total IQ points lost or some $18 million to $34 million in additional averted health costs. While the 1995 national survey was generally encouraging, it still equates to some 75,000 Australian children under 4 having blood lead levels in excess of 10 μg/dL. Although the calculations are based on the three years 1993 to 1995, recent indicative monitoring data shows that ambient lead levels in the capital cities are already below 0.5 μg/m^3. If the current monitoring continues to confirm this downward trend the health benefits may not be as great as those described above.

- **0.3μg/m^3 standard**

  Undertaking the same exercise for benefits resulting from the introduction of, and compliance with an ambient air quality standard of 0.3 μg/m^3, and using reductions in children's mean blood levels of 1.3 (for a blood lead inhalation slope of 1.92) and 2.6 (when introducing an uncertainty factor of 2, for 4 year olds), provides estimates of health benefits, in terms of saved IQ points of between 77,000 and 150,000. At $4,437 per IQ point, this gives health benefits in the range of $340 million and $680 million, assuming no threshold. If the threshold is considered these figures are further reduced to a range of some $25 million to $50 million.

In view of the:

- small increase in indicative averted health impact costs between 0.5μg/m^3 and 0.3μg/m^3,
- debate regarding the blood lead IQ loss threshold,
- blood lead correlation with lead in air,
- declining lead in air levels.

It was concluded that the recommendations of the Technical Review Panel and Health Consultant for an ambient air quality standard of 0.5 μg/m^3 was appropriate for lead if we are to ensure lead levels do not deteriorate in the future.

Hence the standard for lead, as measured at each performance monitoring station is:

- 0.5 μg/m^3 (micrograms per cubic metre) averaged over a one year period, reported as a fraction of TSP (total suspended particles).

[The Goal being to meet the standard within a 10 year timeframe. No exceedences are allowed.]

Other health benefits

A number of other health effects were identified in *The Benefits and Costs of the Clean Air Act, 1970 to 1990*, (US EPA, 1997). These included avoided cases of lead exposure induced hypertension and coronary heart disease, possible cancer and other cardiovascular diseases. In women they also included reproductive effects, and in children included foetal effects from maternal exposure (including diminished IQ) and other neurological and metabolic effects (US EPA, 1997).

A study by Schwartz (1994) investigated the benefits of reducing blood lead levels in the US identified health benefits included reductions in cognitive damage in children, in impacts on foetal development, hypertension, myocardial infraction and premature death in adults.

12.9.2 Management options

The majority of atmospheric lead is present in the form of fine particles. As such, the management of its emission into the atmosphere forms part of the management of the control of particulate matter in general (see discussion in Chapter 13).

Potential costs have been assessed in terms of achieving compliance with the range of potential standards over a ten year implementation period. As a result, the reductions in emissions that will be needed to bring about compliance with any of the potential standards will not be uniform in each region. This will be reflected in the resulting distribution of the costs of compliance.

Table 12.6

Global sources of airborne lead

Source		Percentage of total
Mobile sources (petroleum additives)		63
Industrial sources	Metal smelting	21
	Coal & oil combustion	4
	Refuse incineration	1
Other/domestic sources		6
Natural sources		5

Source: WHO, 1995.

Detailed information on the total volume and relative source contributions of lead emissions in Australia does not exist. However, Table 12.6 shows the relative source contributions of lead emissions on a global basis. If this is to be taken as an approximate representation of the situation in Australia, then mobile sources can be said to contribute 63%, industrial sources 26% and other/domestic sources 6% of emissions. The major industrial point sources of lead emissions in Australia are all smelters, roasters and refineries, and their locations are listed in Table 12.4.

Mobile source emissions

As the principal source of emissions in urban areas is motor vehicles, a continued reduction in the use of leaded petrol is predicted to lead to a continued decline, and then stabilisation, in ambient lead levels. Therefore it is considered that for mobile source emissions no further specific actions to reduce lead emissions need be adopted to achieve compliance with the standard within the ten year implementation period.

Stationary source emissions

Sources in this group include industrial emissions and minor emissions from domestic (and other) uses. Smelting operations, which tend to be located outside major urban areas, are the largest industrial source. Other significant industrial sources include waste incinerators and secondary lead processing (battery recycling). Sources in this group include industrial emissions and those minor emissions from domestic (and other) uses. Smelting operations, which tend to be located outside major urban areas, are the largest industrial source. Monitoring shows that exceedences of the current ambient air quality goals are restricted to a few locations immediately adjacent to major point sources (typically smelters). This suggests that in order to meet current goals in these locations, the percentage reduction in emissions will need to be significantly greater than those required with respect to other industrial sources.

Major point sources - smelting

The only major point source for which some data was available to estimate emission costs was Port Pirie. Reductions required to meet an ambient air quality objective of 1.0 $\mu g/m^3$ require a reduction in ambient levels in the order of 85%.

Annual industrial particulate emissions for Port Pirie are estimated at 130 tonnes, of which some 36 are lead (EPA Vic, 1996). Ambient lead levels in Port Pirie are not, however, proportional to industrial stack emissions. It is considered likely that a significant contribution to ambient lead levels adjacent to major point sources arises from the remobilisation of deposited lead in dust and soil (contaminated by past emissions) and fugitive emissions. This suggests that any additions to the existing control strategies would need to target a range of emission sources if it were to be both effective and economically attainable over time.

To meet a 0.5 $\mu g/m^3$ annual average would require additional reductions to those which will be achieved with the continuation of existing programs. No dollar per tonne costs were available for major point source lead emission controls. Pacific Air and Environment (1997) provided overall emission reduction cost estimates in the order of $80 to $400 million per major point source, with the variation based on the level of control achieved. Existing control measures at smelters already include fabric filter baghouses, which typically capture more than 99.95% of particulate emissions (EPA Vic, 1994; Pacific Air and Environment, 1997).

Given the significance of other sources as contributors to ambient lead levels in major point source locations, it is considered very unlikely that the increase in stack emissions capture that would be considered necessary would be more than 50% above that already achieved. The cost of an increase of this magnitude is estimated to lie at the lower end of the range identified above, ie $80 -$100 million (capital costs). It is noted, however, that there is large uncertainty in the estimates, and that substantial reductions in ambient levels may be achieved at a lower cost by concentrating on specific areas of the plant and reducing fugitive emissions.

Other industrial sources

The relative proportion of lead in industrial particulate emissions varies considerably depending upon both the nature of the industry and the nature of the fuel source. It is therefore not possible to determine a percentage decrease in emissions required across this group of sources to achieve the range of lead standards. Most industrial point sources already incorporate a range of particulate controls which in general are effective in reducing particulate (and therefore lead) emissions. Future gains in emissions reductions are likely in any event as a result of continuous improvement practices and the increased implementation of cleaner production technologies.

Domestic sources

Lead particles are included in the mix of pollutants in emissions from lawnmowers and in woodsmoke. Most lawnmowers, however, use unleaded petrol, and lead levels in woodsmoke are likely to be low, arising from trace levels in the wood itself.

Costs to government

The principal costs to government will be monitoring and reporting costs, although the choices made in relation to lead minimisation strategies may attract additional costs (e.g. for enforcement, provision of infrastructure, research etc.)

Identification of monitoring period

Monitoring for lead is undertaken by means of gravimetric monitoring for particles, as prescribed by the Australian Standard (AS 3580.9.6, 1990) which also requires that a one in 6 day sampling regime is used. In selecting the averaging period, it should be recognised that there is a potential to skew the results by placing an uneven weighting on some of monitoring days in contrast to others. On this basis, further consideration of a one month monitoring period was abandoned as it appeared to endorse the use of potentially unrepresentative data.

The current practice adopted by jurisdictions requires reporting of a 3 month average based on rolling monthly averages. This practice goes some way to levelling out the fluctuations caused by monthly reporting. Under a 3 month averaging period each day of the week is sampled at least twice (i.e. the Australian Standard requires samples be taken every 6 days, this equates to a total of 15 samples in 90 days). A rolling annual average further reduces fluctuations caused by reporting on short and long months, moreover the use of the annual averaging reporting period is entirely consistent with WHO recommendations and world's best practice. For the reasons noted above, the recommended averaging period is:

- 12 month reporting average based on 1 month averages.

12.9.3 Social and environmental impacts

Employment

There are a number of social benefits associated with decreases in IQ decrements in children. Reductions in IQ have both direct and indirect effects on employment and earning opportunities. Not only do lower IQs decrease job attainment and performance, but they also result in reduced educational attainment, which in turn affects earnings and workforce participation. Lead is also a strong correlate with attention span deficits, which also affects workforce participation (US EPA, 1997). Improvements in the capacity to participate in the workforce are likely to flow on to a community in terms of increased employment opportunities.

Well-being

Lead exposure, though declining rapidly in recent years, is a relatively emotive issue. Much of the concern is raised by parents living in the shadow of significant industrial sources or in close proximity to major highways, in relation to the health of their children. As such, a reduction in ambient lead levels is likely to have largely hidden social benefits for a family or community over and above those associated with a reduction in exposure and health risk.

Property values

Deposited airborne lead may result in significant, persistent environmental contamination, as lead compounds do not degrade and are slow to disperse. Decontamination may require replacement of soils. Costs depend on the degree of local contamination and the depth of the soil to be replaced.

Ecosystems

Atmospheric lead is deposited on the surface of soil, vegetation and water. The movement of lead within ecosystems is influenced by the chemical and physical properties of lead and by the biogeochemical properties of the ecosystem. In the appropriate chemical environment, lead may undergo transformation that affects its solubility, its bioavailability or its toxicity.

Animals

The impact of deposited lead has also been studied in relation to exposure of animals. Numerous studies were undertaken which identified elevated blood lead levels in small mammals caught within the vicinity of major urban roads. The precise health effects of such exposures were not clarified.

12.10 SUMMARY OF COSTS AND BENEFITS FOR THE LEAD STANDARD

Because the NEPM deals only with the assessment of air quality by governments the only direct costs associated with the introduction of the standard for lead are the monitoring and reporting costs, required by the NEPM protocol, which will be incurred by governments when assessing ambient air quality. There is no other requirement placed upon governments. In most cases some changes to existing monitoring and reporting programs for assessing air quality will be required. Until detailed jurisdictional monitoring plans have been developed the costs associated with monitoring lead for the purposes of this NEPM cannot be definitively identified.

Most jurisdictions have active air quality management programs for lead which they continuously monitor, revise and refine over time. The NEPM will provide a sound basis for assessing the extent of any lead problems in the major airsheds and, therefore, assist governments in determining the priority to be given to the management of the effects of lead on ambient air quality in the context of overall government programs. Voluntary programs will continue to play an increasing and effective role in those air quality management strategies. These include both industry emission reduction programs and behaviour change programs by motorists often sponsored by motoring organisations. It is expected each jurisdiction will continue to work closely with the community (including industry where necessary) in determining the appropriate mix of strategies to maintain or achieve the NEPM goal set for lead.

12.10.1 Benefits

The key benefit anticipated to arise from adoption of the lead standard is a reduction in adverse human health impacts. Meeting the standard in regions where it is currently exceeded is expected to lead to a range of reduced health impacts. The key health impact of concern which will be prevented is reduction in blood lead levels, children's learning ability and IQ levels.

The upper limits of the benefits to be derived from the reduction in IQ points resulting from a lead standard of 0.5 $\mu g/m^3$ (annual average) is estimated at $18 million to $34 million in additional averted health costs (Section 12.9.1). Although these estimates are judged to be upper limits as they are based on exposure estimates for the years 1993-1995 and significant reduction in ambient lead levels have occurred since as a result of ongoing strategies for the phase out of leaded petrol they are based on the assumption that there is a threshold at 10 µg/dL.

Other adverse health effects which have been associated with exposure to lead but which have not been costed include: premature deaths in adults, hypertension and coronary heart disease and other cardiovascular diseases, reproductive effects in women, and foetal effects from maternal exposure (including diminished IQ) and other neurological and metabolic effects.

12.10.2 Costs

The sources of lead emissions to ambient air can be subdivided into two major categories: mobile (motor vehicle emissions) and industrial. The relative contribution from each varies significantly depending on the local situation. For the majority of the population the main source of exposure is from mobile sources with leaded petrol accounting for around 90% of the total load. Other sources will include secondary lead processing (battery recycling), waste incinerators, and the renovation of older buildings. Indicative cost estimates reported in the assessment have excluded existing actions to reduce emissions. These existing strategies were considered to have zero cost.

Mobile sources: for regions dominated by mobile sources (e.g. Sydney) the continuation of existing programs for the elimination of lead from petrol will ensure that the lead standard is met with no new additional costs or actions required.

Point sources: Of the major point sources, of which there are a very limited number, Port Pirie provides the best information regarding emissions of lead. There are already significant lead amelioration programs in place at Port Pirie, and assessment suggests that their continuation may need to be intensified to meet the NHMRC goal of blood lead levels of 10 μg/dL, and therefore with the air quality objective. The time scale within which this may occur, based on current management strategies, could be longer than ten years.

No dollar per tonne costs were available for lead emission controls at major point sources. However, Pacific Air and Environment (1997) provided overall emission reduction cost estimates in the order of $80 to $400 million per major point source, with the variation based on the level of control achieved.

It was considered very unlikely that the necessary stack emission capture rates would be 50% above that already achieved. The cost of an increase of this magnitude is estimated to lie at the lower end of the range identified above, ie $80-$100 million (capital costs). Most other industrial point sources of lead already incorporate a range of controls which are effective in reducing lead particle emissions. Future gains in emissions reductions are likely to occur as a result of the increased implementation of cleaner production technologies.

12.11 ISSUES RAISED DURING PUBLIC CONSULTATION ON LEAD STANDARDS

For a detailed summary of issues and responses refer to the Summary and Response Document. Some of the points raised during public consultation included:

- Lead standard supported.
- Lead standard – too high/ standard should be zero.
- Lead standard too low, should remain at existing NHMRC goal level.
- Averaging time should be reduced.
- Insufficient justification because it is argued that Australia is already meeting NHMRC Blood Lead Level targets.
- IQ Calculation flawed because no threshold is assumed.
- Particle size should be specified for lead.

12.12 CONCLUSIONS - LEAD

Having considered the comments made during the public consultation phase, including written submissions, and the available scientific, social and economic data the following conclusions have been reached:

- Since introduction of NHMRC's goal for lead in 1979 there has been a considerable volume of new scientific research on the adverse effects of excessive lead exposure.
- Of particular note is the correlation between increased blood lead levels and decreasing IQ but other effects include effects on the kidneys, reproduction, cardiovascular and central nervous systems.
- Children are subject to increased risk from lead exposure and associated adverse health effects, in particular, impacts on the central nervous system as evidenced by reduced IQs with increased blood lead.

- In 1993, the NHMRC recommended a blood lead level of less than 10 μg/dL for all Australians, a factor of two and a half times lower than when the 1979 goal was recommended.
- The Technical Review Panel confirmed the findings of the health review that an ambient air quality standard for lead should be one which is directed towards reducing and maintaining blood lead levels below 10 μg/dL.
- The 1995 national survey showed that although we are meeting NHMRC's target for the percentage of children with blood lead levels above 10 μg/dL there are still 75,000 children under 4 that exceed that goal.
- Lead exposure is an issue in major metropolitan areas (as a result of lead from mobile sources) and in the immediate vicinity of major point sources (typically small industrial towns).
- Current monitoring indicates that with respect to metropolitan areas, ambient lead levels are generally below 1 μg/m^3 three month average and falling, and that in the capital cities they are already below 0.5 μg/m^3 (three month average).
- An assessment of the costs and benefits of implementing a standard demonstrates that in all locations other than at a few major point source sites, the establishment of a standard of 0.5 μg/m^3 annual average could be achieved in a cost neutral manner.
- This reflects the success of existing programs to reduce lead emissions from motor vehicles (introduction of unleaded petrol in 1985, the controlled phase out of lead in all petrol and the introduction of a price differential in favour of unleaded petrol in 1994).
- These existing programs will ensure that lead in air will no longer be of concern in most urban areas within the next decade and it will help in ensuring that new point sources are introduced with appropriate emission controls.
- The contribution of atmospheric lead levels to blood lead levels can not be considered in isolation from the contribution from dust particles as dust particles are deposited from the atmosphere and may be the largest source of lead exposure for children.

Accordingly the standard for lead, as measured at each performance monitoring station is:

- 0.5 μg/m^3 (micrograms per cubic metre) averaged over a one year period, reported as a fraction of TSP (total suspended particles).

[The Goal being to meet the standard within a 10 year timeframe. No exceedences are allowed.]

CHAPTER 13
PARTICLES

The standard for particles (PM_{10}), as measured at each performance monitoring station, is:

- 50 μg/m^3 (microgram per cubic metre) averaged over a one day period. [The Goal being to meet the standard within a 10 year timeframe. Five exceedence days are allowed each year.]

13.1 NATURE OF PARTICLES

Airborne particles are very diverse in their chemical composition and physical properties. The principal common feature is that they exist as discrete units ranging in size from 0.005 micrometre (μm, one-thousandth of a millimetre) to about 100 μm in diameter. Particles can be characterised by size, number, their mechanism of formation or origin, chemical composition, physical properties, or by what is measured by a particular sampling technique. In general, the composition and behaviour of airborne particles are linked with those of the gas surrounding them.

Particles can be referred to in various ways: as total suspended particles (TSP), as black smoke, or by direct or indirect descriptions of their size. Common size-related terms are the classes PM_{10} and $PM_{2.5}$ (the numbers refer to the maximum particle diameter in micrometres) and 'inhalable' or 'respirable' particles. Another way of classification is as primary particles (ie. those directly emitted, such as road dust, sea salt and fly ash) and secondary particles (ie. those condensed or formed in the atmosphere, such as photochemical aerosols and condensed acids).

Respirable particles can be inhaled deeply into the lung and have been associated with a wide range of respiratory symptoms. Long and short term exposure to such particles has been linked with increased deaths from heart and lung disease and has been observed at levels well below the current guidelines. No threshold for the effects of particles has been identified. Particles can also carry carcinogens (eg. polycyclic aromatic hydrocarbons) into the lungs. The elderly, children, and people with respiratory infections or lung or cardiovascular disease are particularly susceptible to the effects of airborne particles.

13.2 SOURCES OF PARTICLES

Particles are emitted from motor vehicles, domestic fuel burning, fuel reduction burns, power plants and industrial processes, and industrial and domestic incinerators. Secondary production can also contribute significantly to particle levels. The most important secondary particles are:

- sulfates, which derive primarily from sulfur dioxide emissions;
- nitrates, which derive primarily from nitrogen oxide emissions; and
- organic aerosols, which derive primarily from volatile organic compound emissions.

Domestic wood fires, which are a major source of particles in some places, can adversely affect the local air quality. Likewise, smoke from fuel reduction burning can have wide regional impacts and affect communities far removed from the burn site. Wood combustion and fuel reduction burning are usually confined to the autumn/winter months. Acid aerosols of particles can also be formed by the transformation of gaseous emissions, such as oxides of sulfur and nitrogen. Many natural sources such as wind blown dust, pollens, bushfires and oceans also contribute to particle levels. Particles are removed from the atmosphere by both wet and dry deposition.

Emissions of particles arise from a variety of sources which differ markedly from one location to another depending upon the presence of industry and dominant landuse. Estimates of the contribution made by various source types in major urban airsheds are presented in Table 13.1.

Table 13.1

Particles Emissions from Various Source Types Yearly Averages (% shares)

Airshed	Mobile Sources	Industrial Point Sources	Area Based Sources
Sydney	30	34	36
MAQS Region	16	67	16
Port Philip Region	16	10	74
S E Queensland	18	65	17
Perth-Kwinana	8	68	24
Port Pirie	2	94	4
Launceston	1	2	97

Source: Pacific Air and Environment, 1997

13.3 HEALTH EFFECTS OF PARTICLES

Over the past decade, evidence that human exposure to inhalable particles can result in significant increases in both morbidity and mortality has become overwhelming. Widely dispersed populations around the world have been assessed and usually show similar response patterns in every instance where appropriate statistical analyses have been undertaken. It is now possible to enumerate the health effects that have, on epidemiological, clinical and toxicological grounds been currently identified as being related to short-term increases in ambient respirable particles (PM_{10}) (see Streeton 1997). These associated adverse health effects include:

- increases in total mortality ('all causes'), as well as in mortality from respiratory or cardiovascular disease,
- increases in hospital admissions for respiratory and cardiovascular conditions,
- increases in the daily prevalence of respiratory symptoms,
- increases in hospital casualty and medical surgery visits for asthma and other respiratory conditions,

- increases in functional limitation as indicated by restricted activity days or, in the case of children by increased frequency of absence from school, and
- small decreases in the level of pulmonary function in healthy children, and in adults with existing disease.

Overseas studies have consistently shown a 1% increase in daily mortality (all causes) per 10 $\mu g/m^3$ increment in PM_{10}. For respiratory and cardiovascular mortality, the observed increases are higher with values of 3.4% and 1.4% per 10 $\mu g/m^3$ PM_{10} respectively. Recent studies in Sydney (Morgan et al, *Air Pollution and Daily Mortality in Sydney Australia 1989 - 1993*, American Journal of Public Health, May 1998) have found similar results and indicate for an increase in PM_{10} of 25 $\mu g/m^3$, an increase in daily deaths from all causes of 2.6% was found. For cardiovascular impacts it was 2.7% and from respiratory ailments, 3.4% was found.

On the basis of this study, it can be estimated that fine particle air pollution in Sydney accounts for 397 premature deaths per year out of a total of 21,500 deaths per year. A mortality study conducted in Brisbane for the period 1987 to 1993, found similar results (Simpson et al., 1997). Significant associations were found for daily mortality and fine particles (measured by nephelometry) and O_3. The associations were significant for the elderly and for mortality from cardiovascular causes.

Significant associations have also been observed between PM_{10} and hospital admissions and emergency room visits for respiratory (including asthma and COPD) and cardiovascular disease. Similar results have been observed in the Sydney studies (Morgan et al., 1996b). PM_{10} has also been associated with exacerbation of asthma in both local and overseas studies.

Table 13.2 summarises the observed health effects associated with PM_{10} and the dose response relationships:

Table 13.2

Summary of Short-Term Exposure-Response Relationships of PM_{10} with Different Health Effect Indicators

	PERCENTAGE CHANGE IN HEALTH INDICATOR PER 10 $\mu g/m^3$ INCREASE IN PM_{10}
Daily Mortality (all cause)	1.0[(a)]
Respiratory Deaths	3.4[(a)]
Cardiovascular Deaths	1.4[(a)]
Hospital Admissions	
Respiratory Disease	1.96[(b)]
COPD	3.26[(b)]
Pneumonia	1.42[(b)]
Heart Disease	0.4[(c)]
Exacerbation of Asthma	3.0[(a)]
Increase in Respiratory Symptoms	
Lower Respiratory	3.0[(a)]
Upper Respiratory	0.7[(a)]
Cough	1.2[(a)]

(a) Dockery and Pope, (1994); (b) Abt. Associates, (1996); (c) Schwartz and Morris, (1995)

There are population subgroups that are clearly more sensitive to PM_{10} exposure, in that they experience more severe adverse health effects for a given particle exposure. These subgroups include the elderly and those individuals suffering from pre-existing heart or lung disease. There is also evidence to suggest that young children may be more sensitive, leading to an increased frequency of respiratory tract infections, coughing, and wheezing.

Statistical evidence suggests that the observed adverse health effects of PM_{10} appear to occur independently of the presence of other pollutants such as ozone, nitrogen dioxide, and probably sulfur dioxide, although the reverse does not apply. There is evidence to suggest that PM_{10} can impact significantly as a major confounder on the observed responses to other pollutants, however there is no satisfactory evidence that the effects of PM_{10} are influenced by other pollutants.

Based on epidemiological data, there is no evidence that threshold concentrations can be described for PM_{10} below which it is not possible to detect any population health impacts. There is no available evidence to suggest that exposure to high particle concentrations for brief periods are more harmful than relatively constant low level concentrations. Further research is required before any useful progress can be made towards establishing air quality objectives based on short-term exposures less than 24 hours.

Currently, the evidence that particles of some size ranges ($PM_{2.5}$ or $PM_{1.0}$) detected within the PM_{10} fraction might be more deleterious to health than others size fractions is inconclusive, although there is increasing evidence to suggest that the $PM_{2.5}$ fraction may well be the major area of concern with regard to adverse health effects.

Another recent report from the UK (DoH 1995) concluded that "in terms of protecting public health it would be imprudent not to regard the demonstrated associations between daily concentrations of particles (PM_{10}) and acute effects on health as causal".

Finally, the most thorough and comprehensive report now available is the new US EPA Particle Criteria Document (US EPA 1996a). Among its numerous conclusions are.

- The evidence of PM-related effects from epidemiological studies is fairly strong, with most studies showing increases in mortality, hospital admissions, respiratory symptoms, and pulmonary function decrements associated with several PM indices.
- Within the overall PM complex, the indices that have been most consistently associated with health endpoints are fine particles, thoracic particles (PM_{10} or $PM_{2.5}$. and sulfate. Less consistent relationships have been observed for TSP, strong acidity (H^+), and coarse PM (PM_{10}- $PM_{2.5}$).

13.4 CURRENT AMBIENT AIR QUALITY OBJECTIVES FOR PARTICLES

13.4.1 Existing Australian ambient air quality objectives

There are no NHMRC goals for fine particles (PM_{10}), only totally suspended particles (TSP). However, there are visibility goals for NSW and Victoria that relate to ultra fine particles. More recently NSW released its air quality management plan "Action for Air" (1998) with a new interim goal for PM_{10}. These ambient objectives are shown in Table 13.3.

Table 13.3

Existing Australian Ambient Particle Objectives

State/Authority		Measure	Value
NHMRC)	goal	TSP	yearly average 90 µg/m^3
Victoria	standard	visibility reducing particles	20 km
New South Wales	goal	visibility reducing particles PM_{10} TSP	10 km (1 hr); $PM_{2.5}$ equiv = 60µg/m^3 50 µg/m^3 (24 hr) (Action For Air) #50 µg/m^3 (annual); 150 µg/m^3 (24 hr) 90 µg/m^3 (annual)

*Note: * Although the NHMRC goal has no regulatory status, it is referenced by States as appropriate health guidance.*

 # Previous NSW goal

13.4.2 Existing international ambient air quality objectives for particles

Table 13.4 shows the current health-related guideline objectives for PM_{10} in New Zealand, the United Kingdom, the USA the European Commission (EC) and the World Health Organization (WHO). There is a trend to uniformity for the 24-hour average goals with the United Kingdom and the EC joining California for a 50 µg/m^3 objective. Overseas goals usually contain safety factors and this is often the reason behind the variation in the levels specified in goals or guidelines. It is important to note that the WHO has decided to set no guideline for fine particles because of the absence of a threshold below which there are no effects. They recommend the use of dose response relationships which can be applied to particular areas.

Table 13.4

Existing International Ambient Particle Objectives

Country/Authority		Measure	Value
New Zealand	guideline	PM_{10}	40 µg/m^3 (annual); 120 µg/m^3 (24 hr)
USA	standard	PM_{10} $PM_{2.5}$	150 µg/m^3 (24 hr) 15 µg/m^3 (annual): 65 µg/m^3 (24 hr)
California	standard	PM_{10}	30 µg/m^3 (annual geometric mean) 50 µg/m^3 (24 hr)
UK	guideline	PM_{10}	50 µg/m^3 (24 hr running average)
EC	Limits	PM_{10}	30 µg/m^3 (annual); 50 µg/m^3 (24 hr)
WHO	guideline	PM_{10}	No guideline set due to absence of threshold
Japan	standard	PM_{10}	100 µg/m^3 (24 hr)
Hong Kong	Guideline	PM_{10}	180 µg/m^3 (24 hr), 55 µg/m^3 (annual):

13.5 CURRENT AMBIENT AIR LEVELS FOR PARTICLES

By comparison with some overseas countries, particle levels in Australia are low. Measurements of PM_{10} in urban areas indicate that levels are well below current US EPA standards, but can exceed Californian standards, with annual average levels being around 25 to 40 µg/m^3 and peak 24-hour average levels around 90 to 110 µg/m^3. Particle concentrations vary with season, the higher values occurring in the autumn/winter months. This is when wood combustion for domestic heating is at its greatest and most of the fuel reduction burns and other large scale burning takes place. In addition, the weather patterns during these months favour the build-up of pollution because of poor dispersion. In areas where wood smoke from domestic fires dominates, particle levels higher than 150 µg/m^3 (as a 24-hour average) have been recorded on occasion. Nephelometer readings in areas dominated by woodsmoke, indicate that, on still, cold nights, particle levels consistently climb to high values. Readings of β_{scat} of 5 to 10 units are common. Using the Sydney Pollution Index as a guide, readings greater than 2.1 units (daytime visibility equivalent to 10 km) are considered high.

13.6 AUSTRALIAN EXPOSURE LEVELS FOR PARTICLES

Attempts were made using available data to estimate population exposure to ambient PM_{10} concentrations for major cities where PM_{10} monitoring takes place (Beer and Walsh 1997).

Limitation in the available data constrained the application of the exposure assessment methodology. However, it provided useful indications of potential exposure patterns and also identified data gaps which the NEPM could usefully fill for future studies.

The major difficulties with the information arose from the location of existing monitoring stations. Lack of consistency in monitoring locations between or even within air sheds led to lack of comparability between data and exposure estimates which were biased by the monitoring data.

These difficulties were highlighted and explained in the draft Impact Statement and the use of the data was heavily qualified. Despite these caveats and explanations covering the use of the exposure assessment data, the public submissions on the draft Impact Statement have demonstrated that these data were still open to misinterpretation.

In response to widespread stakeholder concern, the exposure assessment has been accepted by NEPC as indicative only and did not influence the final choice of standards.

Future monitoring under the protocol combined with jurisdictional peak monitoring, will provide a more robust basis for future exposure studies should they be required.

13.7 CURRENT MANAGEMENT PRACTICES FOR PARTICLES

Current management approaches have focussed mainly on fabric filter and electrostatic precipitator controls and improving the efficiency of combustion sources as well as fugitive dust controls on mining, transfer and storage operations. Catalytic controls on vehicles in the mid 1980s significantly reduced NO_x emissions progressively from this source and as a result fine particle nitrates. Ensuring high combustion efficiency by proper design as, for example with wood heaters meeting Australian Standard 4013, reduces potential particle emissions from new wood heaters by up to 80%.

13.8 RANGE OF STANDARDS CONSIDERED FOR PARTICLES

The range of recommended standards for particles from the various inputs to the Project Team were as follows:

- Health Review Study — 24 hour standard, 50.0 $\mu g/m^3$ PM_{10}
  20 to 25 $\mu g/m^3$, for $PM_{2.5.}$
- NHMRC — No Current Goals for PM_{10} or $PM_{2.5.}$
- Technical Review Panel — 24 hour standard, 50.0 $\mu g/m^3$ PM_{10}
  25 $\mu g/m^3$ for $PM_{2.5.}$

The range recommended is quite small for particles with a majority support for a 24 hour standard of 50 $\mu g/m^3$ for PM_{10} and a 25 $\mu g/m^3$ standard for $PM_{2.5}$. The Technical Review Panel recommended that this be reviewed in five years time. Little emission inventory data are currently available on $PM_{2.5}$ and it was judged that a single PM_{10} standard would be complementary and most easily monitored at this stage.

The PM_{10} standard would be the equivalent in some air sheds to a 20 to 30 $\mu g/m^3$ standard for $PM_{2.5}$. This is based on an ANZECC study, nearing completion by officers of the Victorian EPA, comparing both size fractions in a number of airsheds in Australia. Results so far indicate that $PM_{2.5}$ as a percentage of PM_{10} concentrations vary with season being higher in Winter than Summer. The results are still being analysed and may be subject to revision, nevertheless the results are indicative and are summarised in Table 13.5 below.

Table 13.5

Comparison of Particle Size Fractions in Australian Cities

CITY	Ratio ($PM_{2.5}$ as a % of PM_{10}) Winter	Ratio ($PM_{2.5}$ as a % of PM_{10}) Summer
Brisbane	44	26
Melbourne	60	40
Sydney (a)	80	41
Sydney (b)	58	41

Because of the lack of a threshold below which no effects are expected, the philosophy that usually drives environmental authorities is to reduce emissions to the lowest extent feasible. Bench marking world's best practice in terms of goals for fine particles would include the recent European Commission Limit, and the United Kingdom and the established Californian goal for PM_{10} of 50 $\mu g/m^3$ as a 24 hour average.

The new US EPA Particle Criteria Document (US EPA 1996a) and recommendations flowing from it have concluded that, based on the same data examined by WHO and the United Kingdom that the existing US EPA PM_{10} standard (see Table 13.8) is to be relaxed by increasing the number of exceedences allowed from 1 to about 7 per year. In addition these exceedences may be averaged over a 3 year period.

In a US EPA Fact Sheet dated 17 July 1997, on monitoring requirements for particulate matter, the design of monitoring network was to include peak stations to be located in areas reflective of the highest measured values within each metropolitan area for comparison to the 24 hour standards. Hence the US $PM_{2.5}$ standard of 65 $\mu g/m^3$ (24 hr) is much more stringent than it first appears, possibly reflecting a $PM_{2.5}$ standard (using performance monitoring stations with no peak stations) of some 30 $\mu g/m^3$ (24 hr) and not greatly different from a PM_{10} 24 hour standard of 50 $\mu g/m^3$ assuming similar ratios of $PM_{2.5}$ to PM_{10}.

Possibly in recognition of this hidden stringency, the American Trucking Association in conjunction with the US Chamber of Commerce and the National Coalition of Petroleum Retailers, has filed a lawsuit against the new US Air Quality Regulations claiming that the US EPA failed to consider the impact the new rules will have on small business and that the standards are based on inadequate science and that there are serious doubts whether the standards will do any good.

There are not enough Australian data to provide control costs at this stage for a $PM_{2.5}$ standard to be analysed in the same way that the proposed PM_{10} standard was. There are also several measurement issues related to fine particle measurement that are currently receiving the attention of quality control experts, Meyer (1996). Unlike many gaseous pollutants, ambient particles are usually heterogeneous and may consist of heavy metals, inorganic compounds such as salts and volatile components such as water, secondary aerosols such as nitrates and sulfates, and PAHs. With the volatile components being more prevalent in the fine particle mode and its quantity directly influenced by temperature, relative humidity and vapour pressure, it is clear that much more effort is required in the characterisation of the measurement technique (accuracy and precision) to ensure a consistent indicator for a $PM_{2.5}$ standard.

In view of the equivocal health risk data for $PM_{2.5}$, lack of control cost data and challenges with measurement techniques, coupled with the fact that a PM_{10} standard is a surrogate for a $PM_{2.5}$ standard in most instances, it was concluded that a single PM_{10} standard be used in the interim.

Hence the standard for particles (PM_{10}), as measured at each performance monitoring station is:

- 50 $\mu g/m^3$ (microgram per cubic metre) averaged over a one day period.
- [The Goal being to meet the standard within a 10 year timeframe. Five exceedence days are allowed each year.]

The PM_{10} standard would be the equivalent in some air sheds to a 20 to 30 $\mu g/m^3$ standard for $PM_{2.5}$. It is acknowledged that a lower size fraction such as $PM_{2.5}$ or $PM_{1.0}$ may, within a short period of time, be the most appropriate indicator of public health impacts. It may also be found that the number of particles or the hydrogen ion concentration could also be a suitable indicator of public health impacts. This aspect will need to be reviewed in the near future; the Technical Review Panel has suggested a five year time frame. Commencement of the review in about three years would be appropriate.

Environmental agencies need to continue or commence studies into $PM_{2.5}$ and $PM_{1.0}$ to ensure adequate data is available for this proposed review. A review of all existing work and options for collaboration should be investigated. Detailed inventories need to be developed and developmental work on the source measurement of both $PM_{2.5}$ and $PM_{1.0}$ needs to be considered as well as a better understanding of potential agglomeration of these particles as they disperse.

13.9 IMPACTS OF STANDARDS FOR PARTICLES

13.9.1 Health impacts

Extensive studies of mortality in Australia have been conducted in Sydney (Morgan et al., 1998) and in Brisbane (Simpson et al., 1997). It is estimated in the Sydney study that, fine particle air pollution accounts for 397 premature deaths out of 21,500 deaths per annum. Using the results from (Morgan et al 1998) the number of mortality impacts associated with exposure to existing PM_{10} in Sydney (see Table 13.6) was extrapolated to an Australian context on a per capita ratio for indicative purposes only.

Table 13.6

Estimated Incidence of Mortality Due to Exposure to Current Ambient PM_{10} Levels

Health Effect	Morgan et al 1998 Sydney Population	Extrapolated to Australian Population
Mortality	397	2,400

While the mortality effects of PM_{10} are significant, morbidity effects associated with exposure to elevated ambient particulate levels are also important. Simpson's estimates exclude the effects of PM_{10} on asthma attacks in susceptible sub-groups. Previous studies have observed a relationship between increased asthma attacks and increased ambient particulate concentrations. A study conducted at the Royal Children's Hospital in Melbourne (Rennick and Jarman, 1992) for example, identified a positive 2.3% variance in asthma attendances associated with API index - a good surrogate measure for $PM_{2.5}$. Similar studies reported in Dockery and Pope (1994) showed an approximately 3% increase in asthma attacks for each 10 $\mu g/m^3$ increase in PM_{10} concentrations.

In addition to the issues elaborated above, PM_{10} standards also raise an additional issue that may be most appropriately considered in the social context. Elevated particulate levels have been consistently linked with morbidity and the risk of premature death. Such risks may be irreversible, debilitating and life-threatening and as such measures which manage and reduce the uncertainty and risk associated with the health effects of PM_{10} pollution are valued highly by a generally risk averse public. The reduction and removal of such a risk is therefore an important social benefit accruing from the proposed standard.

The other principal benefit categories include all benefits accruing from reductions in hazardous air pollutants (also, referred to as air toxics); these include reductions in damage to cultural resources, buildings, and other materials; reductions in adverse effects on wetlands and, forests, and aquatic ecosystems; and a variety of additional human health and welfare effects of criteria pollutants.

13.9.2 Other impacts of particles

In this section, a description will be provided of some of the anticipated impacts, which will flow from the implementation of the particles standard.

For particles, it is important to recognise the distinction between reductions in directly emitted particles and reductions in ambient concentrations of particles in the atmosphere. Changes in particle air quality depend both on changes in emissions of particles and on changes in emissions of gaseous pollutants, such as sulfur dioxide and nitrogen oxides, which are later converted to particles through chemical transformation in the atmosphere. This highlights an important and unique feature of particles as an ambient pollutant. More than any other pollutant, reductions in particles are actually achieved through reductions in a wide variety of air pollutants. In other words, controlling particles means controlling "air pollution" in a very broad sense. Reductions in sulfur dioxide, nitrogen oxides, volatile organic compounds, and directly-emitted particles achieved by control programs would result in an overall, national average reduction in total concentrations of particles.

Atmospheric transport and transformation of pollutants from one species to another (eg., transformation of gaseous sulfur dioxide to particulate sulfates) make it difficult to estimate benefits and costs by individual pollutant.

Clearly, both the benefits and the costs of implementation action cannot be solely attributed to action implemented to achieve the standard. Furthermore, given that jurisdictions will be able to choose those management options most suited to their own situations, it is not possible to provide definitive total estimates of the cost and benefits of the various management options. However, case studies and examples can be used to illustrate the likely impacts of achieving the standard.

13.9.3 Motor vehicles

The use of catalytic converters on motor vehicles reduces particle emissions together with a number of other pollutants. New Australian Design rules for petrol vehicles have also helped to reduce particle emissions. Of greater concern with regard to particles are emissions from diesel vehicles. Diesel vehicles contribute up to 80% of vehicle produced particles in major cities. New ADRs for diesels are currently being developed which will reduce fine particle emissions.

13.9.4 Wood heaters

The annual data mask significant seasonal variations associated with the prevalence of wood burning for domestic heating. In areas such as Melbourne, Launceston and Perth, the contribution from domestic sources may well account for 50% or more of total particulate emissions during the cooler seasons. The maximum reduction in emission of particles is expected to be a two third reduction, as the indicative exposure shows that in general, monitored areas of Australia meet a 24 hour, 150 $\mu g/m^3$ PM_{10} goal and if the standard was to be 50 $\mu g/m^3$ then the particle emission reduction in some airsheds would need to be up to two thirds. One possible option that would need careful consideration might be for jurisdictions to adopt a more stringent emission standard for wood heaters or if that is not practicable, restriction on the use of wood heaters in parts of major airsheds where dispersion is poor or there are topographical features that cause high concentrations. An alternative management strategy to educate the community about the impacts of using wood heating was discussed in Chapter 6.

13.9.5 Bush fire hazard reduction burning

Particle emissions from prescribed burning for fuel reduction may also be significant. In Australia, 30 million hectares are burnt annually (source: National Greenhouse Inventory). Nationally, better data on inventory levels are needed to assess the likely impact and strategies for optimising their management. Fire authorities, environment protection agencies, other government bodies and private land managers are continuing to work co-operatively to improve this information base.

Many public authorities are charged with undertaking practical steps to prevent the occurrence of bush fires on public land in addition to activities undertaken by private land managers. Prescribed burning for fuel reduction is used to manage combustible vegetation fuel to protect human life, community assets, private property, habitats and promote biological diversity.

The fire management practices used in Australia have been developed in the context that fire is a natural and vital part of the continent's landscape. For example, fire is a necessary process for the long term health and management of much of the flora and fauna that has evolved to occupy the continent.

Fire authorities and land managers have developed a range of management practices to reduce the likelihood and impact of bush fires. As prescribed burning for fuel reduction is required over large areas of land in order to have any impact on high intensity, widespread fires, prescribed burning for fuel reduction is the method most economically and ecologically relevant. This is especially the case for large scale operations, but prescribed burning for fuel reduction is also often essential for very small strategic protection. Public and private land managers also use established fire management practices for purposes such as creating fire breaks and removing crop residues associated with agriculture and forestry.

In some limited circumstances involving generally modified habitats, the following practices may also be utilised: grazing, slashing of vegetation, pruning (softwood forests), and other methods such as mulching. ploughing, herbicide application and rolling. Such methods must be compatible with flora and fauna objectives and cognisant of their wider impacts.

The window of opportunity for prescribed burning for fuel reduction is limited to a few days at any location each year and hence it is important to balance the conflicting impacts of health effects from increased fine particle concentrations with the potential increased loss of human life and injuries from bush fires that might result if prescribed burning for fuel reduction was to be further restricted.

It is not intended to measure near-source events as these are outside the scope of the NEPM as monitoring and reporting on major sources is not covered by the NEPM. Performance monitoring stations would not normally be located near such operations outside of the metropolitan region and would not normally be sited within the metropolitan area to determine such an impact. The NEPM is only a reporting mechanism and does not restrict well-controlled essential prescribed burning for fuel reduction . In fact, to do so could be counter productive, in that bushfires resulting from fuel build-up, could have a higher health impact. Better planning and optimising prescribed burning for fuel reduction appear to offer resolution of this issue. Many state environmental agencies, such as NSW EPA liaise directly with their State Bush Fire Control agency, in this case the NSW Rural Fire Service and provide three day forecasts of poor dispersion conditions that could affect decisions regarding prescribed burning for fuel reduction. Negotiations then take place if there is a likely conflict. Experience so far has shown conflicts are few and they can be resolved satisfactorily.

In Victoria, liaison between the Department of Natural Resources and Environment and EPA takes place in relation to prescribed burning for fuel reduction. Prescribed burning for fuel reduction takes place within the framework of the Code of Practice for Fire Management on public land. Smoke management issues are considered in the context of this Code of Practice.

Recent experience of prescribed burning for fuel reduction in the Sydney region has shown that the standard can be met and would only on rare occasions increase ambient levels of fine particles above the standard. Levels of particle pollution measured during the weekend of 29 August to 1 September 1997 confirmed this assessment. In view of the forecast calm conditions, NSW EPA issued a No Burn Notice prohibiting the burning of fires in the open on Saturday and Sunday, with specific exemptions for a number of existing or planned prescribed burning for fuel reduction. Due to an unexpected sea breeze on the Saturday, large volumes of smoke were recirculated, with the Sydney Basin being covered in a highly visible blanket of smoke. Despite the persistence of this blanket of smoke over 3 days, all of the 17 monitoring stations with Tapered Element Oscillating Microbalances (TEOMs, continuously recording PM_{10} instruments) recorded levels below the standard. Although this is only one example, (it is the only one that has been supplied to the project team) it does offer a practical example in a large airshed of wide ranging hazard reduction burns being able to be successfully carried out while still meeting the standard. In some jurisdictions the issue of fires which are used for Aboriginal cultural reasons eg hunting or habitat manipulation, needs to be sensitively considered so that these activities are provided for while recognising the need to also consider any potential health impacts which might result.

The performance target of 5 exceedences by the 10th reporting year, should provide sufficient leeway for prescribed burning to be carried out while acknowledging the practicability of optimising their management further. It is considered that this standard could be met with a co-operative approach in the envisaged time scale of ten years and that there should be no curtailment in essential prescribed burning.

13.9.6 Point Sources

The nature of particle emissions has important repercussions in terms of control measures. At present most industrial point sources already incorporate particulate emission controls in the form of bag filters, electrostatic precipitators, scrubbers or other technologies. In general these control measures are effective.

Particle emissions from area based sources such as unpaved roads, mines and construction sites can be controlled by commonly used environmental management technologies and practices. Over the ten year time frame for the implementation of the Measure, the continued application of these environment management technologies and practices should ensure that the standard can be met at designated performance monitoring stations. For example, the best information available to the project team indicates that application of commonly used environmental management practices in the mining and extractive industries would be consistent with meeting the standard at the relevant performance monitoring stations. However in a very small number of area sources, it is recognised that it may take longer than the 10 year timescale envisaged to achieve the standards based on current management strategies.

Controls from industrial point and area sources (wood heaters are the main area sources) to provide a two thirds reduction in particle loads are estimated to cost, across the nation, between $160 million to $540 million per annum (Pacific Air & Environment 1997).

Controls from industrial point sources do not include estimates on retrofitting large power stations. Jurisdictions considering particle controls from power stations in specific airsheds would be aware of the large capital costs involved and the level of particle control technology already incorporated. For example, installation of fabric filters on a 2000 MW power station would cost in the order of $110 million in capital expenditure and a further $5 million per annum in operating costs. This is usually standard practice now on modern power stations and when coupled with tall stacks (200m) fabric filters controls normally reduces particles to negligible concentrations at ground level.

13.9.7 Health system savings

In an attempt to provide an illustrative example of how estimates of cost savings might be calculated using health cost data from US EPA (1997) and extrapolated estimates from Morgan et al (1998) and assuming a halving in health impacts because of generally lower particle levels outside of major capital cities and a similar halving in health impacts caused by the proposed standard. Naturally these estimates are sensitive to the assumptions used but Table 13.7 illustrates the substantial costs involved.

Table 13.7

Illustrative Example of Costs of Averted Health Effects From Exposure to Ambient PM10 Levels

Health Effect	Population Affected	Value in $million
Mortality	600	4,300

There has been criticism of the illustrative example by industrial stakeholders. The US EPA employ (as do a number of Australian regulatory bodies) "value of life estimates" and it is argued by the industrial stakeholders that if a life is shortened by only 6 months, with a life expectancy of 78 years in Australia) the appropriate value of mortality would be around $45,000, not the $7 million used in the example. However, the US EPA (1997) multi million dollar study "Benefits and Costs of the Clean Air Act", is a revised draft of a report to the US Congress which was completed in April 1997, and submitted to the Science Advisory Board for final review. It is an up-date on an earlier draft report published in 1996 and has a number of changes related to the value of averted health effects. It is presumed that many of the arguments have been taken into account in the final draft, and as this is the most comprehensive work on health effects of the specific NEPM air pollutants, it is the most appropriate work to base the illustrative examples on. However, the US EPA reference recognises that there are substantial controversies and uncertainties which pervade attempts to characterise adverse human health in dollar terms. To many, dollar-based estimates of the value of avoiding outcomes such as the loss of human life, pain and suffering, do not capture the full and true value to society as a whole.

Another way of estimating averted health costs might be to use the exposure data and consider the number of people exposed to incremental 24 hour exposures of 10 $\mu g/m^3$ PM_{10} above the standard. The 1% increase in mortality could be used to estimate the population affected. However, a number of assumptions would be needed and it is not clear if the data is available to provide a better illustrative estimate that is more robust than the one presented. It is clear that substantial amounts are involved in terms of costs averted and in terms of risk assessment, a risk of $1x\ 10^{-2}$ (per 10 $\mu g/m^3$) is substantial when compared to common deminimus risk levels of 1×10^{-6}.

13.9.8 Aesthetics

The potential benefits in relation to improved aesthetics associated with the introduction of the proposed PM_{10} standards are likely to be similar to those issues identified previously. That is, an improvement in a community's aesthetics and amenity associated with elevated particulate levels and a more equitable distribution of the costs of air pollution across the community. While the techniques for deriving estimated monetary valuations of aesthetic benefits are not very reliable, they can provide some indication of the significance of the impact. For example, studies which have attempted to characterise the impact of house prices to indicate impacts upon amenity observed a reduction in house prices of 0.05 - 0.14% with every 1% increase in ambient particulate levels. These reported values are indicative of the relative costs to the community of continued elevated particulate levels. The significance in this case is due to the number of persons exposed and the pervasiveness of elevated particle levels.

13.10 SUMMARY OF COSTS AND BENEFITS FOR THE PARTICLES STANDARD

Because the NEPM deals only with the assessment of air quality by governments the only direct costs associated with the introduction of the standard for particles are the monitoring and reporting costs, required by the NEPM protocol, which will be incurred by governments when assessing ambient air quality. There is no other requirement placed upon governments. In most cases some changes to existing monitoring and reporting programs for assessing air quality will be required. Until detailed jurisdictional monitoring plans have been developed, the costs associated with monitoring particles for the purposes of this NEPM cannot be definitively identified.

Most jurisdictions have active air quality management programs for particles which they continuously monitor, revise and refine over time. The NEPM will provide a sound basis for assessing the extent of any particle problems in the major airsheds and, therefore, assist governments in determining the priority to be given to the management of the effects of particles on ambient air quality in the context of overall government programs. Voluntary programs will continue to play an increasing and effective role in those air quality management strategies. These include both industry emission reduction programs and behaviour change programs by motorists often sponsored by motoring organisations. It is expected each jurisdiction will continue to work closely with the community (including industry where necessary) in determining the appropriate mix of strategies to maintain or achieve the NEPM goal set for particles.

13.10.1 Benefits

Although some double counting may exist with reductions in PM_{10}, it is unlikely to be significant in changing any overall benefits. The data associated with health benefits is based on US EPA estimates and due to lack of comparative studies in Australia, is used here as a best approximation. It is assumed that US and Australian health costs associated with respiratory illnesses are broadly comparative. Table 13.10 showed the results of a calculation based on studies in Sydney and extrapolating Australia wide which indicated the possible benefits in term of averted health impacts (of some $4 billion) associated with incremental or marginal changes in reduced emissions of PM_{10} occurring from implementation of the standard.

13.10.2 Costs

Emissions of particles arise from a variety of sources which differ markedly from one location to another depending upon the presence of industry and dominant landuse. Major sources of PM_{10} emissions in capital cities are from motor vehicles and wood heating stoves. Hence, in the urban areas currently impacted by PM_{10} emissions, any costs attributed to PM_{10} control, would need to focus on mobile sources and wood heaters. It is expected that existing programs such as ADR 37/01 would be the main mechanism of control of petrol fuelled motor vehicles in general and new ADRs for diesels. Air quality management plans being developed by jurisdiction such as the recently announced NSW's "Action for Air" (1998) is an example of an air quality management plan spanning 25 years to focus initially on ozone, NO_2 and particles. Costings of the various strategies, in terms of $ per tonne of pollutant reduced are also contained in the plan. Similar plans are being developed in other jurisdictions.

13.11 Issues raised during public consultation on particle standards

For a detailed summary of issues and responses refer to the Summary and Response Document. Some of the points raised during public consultation included:

- $PM_{2.5}$ standard is more relevant than PM_{10} – should have both standards;
- Particle standard too high/too low;
- Annual Standard should be included for $PM_{10}/PM_{2.5}$;
- 5 exceedences for particles too few/too many for particles;
- Continuous monitoring is required for particles; and
- Review Period for particles is too long.

13.12 Conclusions - Particles

Having considered the comments made during the public consultation phase, including written submissions, and the available scientific, social and economic data the following conclusions have been reached:

- That adverse health effects are associated with fine (PM_{10}) or ultra-fine ($PM_{2.5}$) particles, as opposed to total suspended particles.
- That there is no discernible threshold below which no adverse health effects occur.
- That there is a strong association between mortality and increased particulate loads, to the extent of a 1% increase in premature mortality with every 10 $\mu g/m^3$ increase in PM_{10}.
- Millions of fewer person event exposures per annum with a significant reduction in health effects such as decreased lung function and acute respiratory symptoms would be achieved by compliance with the standard.
- Substantial savings in health costs should be achieved with attainment of the 50 $\mu g/m^3$ standard; (more than $4 billion per year in the illustrative example indicates substantial savings in health costs are involved).
- Costs of control are expected to be included in existing control programs.

- Improved aesthetics (including visibility) and amenity will provide a major benefit to affected communities.
- The PM_{10} standard would be the equivalent in some air sheds to a 20 to 30 $\mu g/m^3$ standard for $PM_{2.5}$ depending on seasons.
- $PM_{2.5}$ or $PM_{1.0}$ may, within a short period of time, be a better indicator of public health impacts if measurement problems can be resolved.
- A five year time frame for review is recommended in view of the rapid developments in the area with a review period commencing in about three years time.
- Environmental agencies should continue or commence studies into $PM_{2.5}$ and $PM_{1.0}$ to ensure adequate data is available for this proposed review.

Accordingly the standard for particles (PM_{10}), as measured at each performance monitoring station is:

- 50 $\mu g/m^3$ (microgram per cubic metre) averaged over a one day period.

[The Goal being to meet the standard within a 10 year timeframe. Five exceedence days are allowed each year.]

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APPENDIX 1
COMMONWEALTH, STATE AND TERRITORY AIR QUALITY IMPLEMENTATION PLANS

This section provides an overview of the air quality implementation plans likely to followed by each jurisdiction as of October 1997. The information contained in this section should be used as a guide only, the reader is directed to each individual jurisdiction for precise information on the individual implementation plans.

The implementations plans are provided in the following order:

- Commonwealth
- ACT
- New South Wales
- Northern Territory
- Queensland
- South Australia
- Tasmania
- Victoria
- Western Australia

COMMONWEALTH

AIR QUALITY OBJECTIVES

The Commonwealth Government currently recognises NHMRC public health ambient air quality goals for Australia, and where applicable, uses these to guide its decision making.

LEGISLATION

There are currently three principal pieces of Commonwealth legislation which are used to manage air quality. These are the Environment Protection (Impact of Proposals) Act 1974, the Motor Vehicle Standards Act 1989 and the Airports (Environmental Protection) Regulations Act (1997).

The object of the EP (IP) Act is to ensure that matters affecting the environment (including air quality) to a significant extent are fully examined and taken into account in respect of all Commonwealth proposals and activities.

The Motor Vehicle Standards Act establishes a legislative base to a certification system of design rules for road vehicles and trailers. The Act empowers the Minister for Transport to make standards, of relevance in this instance, for motor vehicle noise and emissions, for all motor vehicles supplied to the market for the first time, be they manufactured in Australia, new vehicle imports or second hand imports. The Act is intended to ensure the national uniformity of standards relating to safety, emissions & noise and the prevention of theft of vehicles. The standards are referred to as Australian Design Rules (ADRs).

The following ADRs are applicable to air emissions:

- ADR 27 (Superseded in 1986 by ADR 37/00) light vehicles (under 2.7 tonnes) petrol engine. Limit emissions of NO_x, CO and HCs (evaporative and exhaust).
- ADR 30 compression ignition engines (diesel). Limits emissions of visible smoke.
- ADR 36 heavy vehicles (spark ignition- petrol) Limits emissions of NO_x, CO and HCs.
- ADR 37/00 (Superseded 1997-99 by ADR 37/01) light vehicles (under 2.7 tonnes) petrol engine. Limit emissions of NO_x, CO and HCs (evaporative and exhaust). Eliminates emissions of lead from motor vehicles through the mandatory use of unleaded petrol.
- ADR 70 compression ignition engines (diesel). Limit emissions of NO_x, CO and HCs and particulate matter.

The object of the Airports Regulations is to establish, in conjunction with NEPMs, a Commonwealth system of regulation of, and accountability for, activities at airports that generate, or have the potential to generate, pollution or excessive noise. They are also used to promote improving environmental management practices for activities carried out at airport sites. As Commonwealth regulations are already in force with respect to aircraft engine and noise emissions (the Air Navigation Regulations), the Airports Regulations do not cover these emissions. State/Territory laws relating to pollution from motor vehicles, occupational health and safety matters, ozone depleting emissions or the use of a pesticide remain in effect at airports or airport sites.

The Commonwealth also played a role, through ANZECC, in the development of national guidelines for control of emission of air pollutants from new stationary sources, in 1985. The levels in these guidelines are recommended to statutory authorities in States and Territories as considered opinion on emission limits, which can be realised by the use of best practicable control technology.

Implementation of NEPMs

The Commonwealth is currently finalising legislation to implement NEPMs. The National Environment Protection Measures (Implementation) Bill 1997 provides for the implementation of NEPMs in respect of Commonwealth places and relevant activities carried out by, or on behalf of, the Commonwealth or Commonwealth authorities.

In line with Commonwealth obligations under the IGAE, it is intended to apply State/Territory environment law to Commonwealth places and activities for the purpose of the implementation of a NEPM. However, where this is not possible or practicable, the Bill provides mechanisms whereby the Commonwealth can implement a NEPM using:

- another law of the Commonwealth which, in the view of the Environment Minister, will deliver the appropriate environmental outcomes; or
- Commonwealth regulations; or
- an environmental management plan.

Commonwealth air quality initiatives

The Commonwealth Government has allocated $16 million over 5 years (commencing in 1996) from the Natural Heritage Trust to fund a national air quality initiative, the *Air Pollution in Major Cities Programme*. The objective of the Programme is to develop national strategies and standards, within a framework of sustainable development, to minimise the adverse impacts of urban air pollution. It is also intended to address key threats to sustainability with respect to air quality as identified in the 1996 State of Environment Report. The focus of the programme is the six pollutants to which the majority of Australians are currently exposed.

The main components of the Programme are:

- the development of national air quality standards under the auspices of the National Environment Protection Council (NEPC) and other national cooperative fora;
- an independent inquiry into urban air pollution, the objective of which is the identification of practical solutions to air quality problems, associated with the six pollutants, which can be implemented by governments, industry and the community;
- improved monitoring of air quality across Australia to allow improved targeting of management strategies;
- an air quality research program; and

- community education on air quality issues.

A new National Greenhouse Strategy is being developed to update the earlier National Greenhouse Response Strategy (NGRS) which followed Australia's international commitment to address greenhouse-related matters. Several of the pollutants for which standards are being developed under the NEPM are being targeted in the NGRS, as they are also greenhouse gases. Action related to achieving air quality improvements is also targeted in the NGRS because eof the potential for concurrent greenhouse gas emission abatement.

The Commonwealth Department of Defence has developed a draft policy and accompanying environment statement which includes a goal relating to waste minimisation, pollution control and remediation. The goal gives broad direction to Defence personnel and aims to keep air emissions within acceptable limits.

AUSTRALIAN CAPITAL TERRITORY

AIR QUALITY GOALS

The ACT Government currently recognises NHMRC goals where these have been set and US EPA goals for 1 hour carbon monoxide and 1 day total suspended particulates.

LEGISLATION

The *Environment Protection Act 1997* and Regulations commenced on 1 June 1998, replacing the existing Air Pollution Act 19*84* and regulations made under that Act.

The new legislation enables a more integrated approach to environmental management with the emphasis to be shifted from end of pipe controls to pollution prevention and cleaner production principles. It establishes Environment Protection Policies (EPP) a draft Air EPP was released for public comment in May 1998. The Ambient Air Quality NEPM will form the basis of the Ambient Air Quality component of the EPP.

Carbon monoxide

The ACT is expected to meet the proposed standard.

Existing data shows that elevated carbon monoxide levels coinciding with evening peak hour traffic occasionally occur in Civic. These are not expected to exceed the proposed standard but measures being developed to reduce pollution from vehicles should result in an overall reduction in carbon monoxide levels in the future.

Particles

In general, the ACT will meet the proposed standard but the standard may be reached or slightly exceeded occasionally in Tuggeranong.

The ACT Government has introduced and is proposing to introduce several measures which will overcome any current problems with particle levels. The measures are:

- The Air Pollution Act 1984 was amended in 1994 to require all new solid fuel burning appliances sold in the ACT to comply with Australian Standard AS 4013. As new appliances replace older models, there will be a progressive reduction in particle emissions from this source. This provision has been carried over into the Environment Protection Act.

- Fire authorities are co-operating with Environment ACT to minimise the impact of smoke from hazard reduction burns on ambient air quality.

- A ban on the backyard incineration of wastes in urban areas has been introduced under the Environment Protection Act. Such incineration is currently permitted, subject to certain restrictions.

- A fuelwood strategy is currently being developed.

Other pollutants

Levels of ozone, nitrogen dioxide, lead and sulfur dioxide in the ACT are well below the standards proposed in the draft NEPM.

Measures to reduce vehicle emissions

The ACT has introduced a number of economic measures to reduce vehicle emissions by encouraging the use of public transport and car pooling. Measures have also been taken to reduce emissions from the ACTION bus fleet. A bicycle strategy was introduced in November 1997.

NEW SOUTH WALES

AIR QUALITY GOALS

Prior to the finalisation of this document the NSW Government released its Air Quality Management Plan for Sydney, the Illawarra and the Lower Hunter, entitled “Action for Air”. “Action for Air” should be referred to for a detailed and up-to-date review of strategies in NSW for ozone, nitrogen dioxide and particles**.**

LEGISLATION

A Protection of the Environment Operations Act has been passed by and will repeal and replace the Clean Air Act of 1961 and other environmental acts of Parliament (Protection of the Environment Operations Act 1997

Through the protection of the environment policies (PEPs), the Act provides the means for adopting the environment protection measures set by the NEPC. Examples of possible PEPs include ambient air quality objectives, and air quality management plans to meet those objectives.

The new legislation focuses on pollution prevention and cleaner production rather than on the current media-specific approach which has resulted in an emphasis on ‘end of pipe’ controls.

The Protection of the Environment Operations Act 1997 provides for a system of licence fees based on the load of pollutants discharged by an activity. The load-based licensing scheme adopts the polluter pays concept in order to reduce pollution at the least cost to both the community and industry. The EPA is currently finalising specific proposals on load-based licensing and is consulting the details of the scheme.

The Regulations under the Clean Air Act have been remade (effective from 1 August 1997) as follows:

- Clean Air (Domestic Solid Fuel Heaters) Regulation 1997, requiring new solid fuel home heaters to meet the appropriate emission standards.

- Clean Air (Plant and Equipment) Regulation 1997, setting emission limits for a number of pollutants, for scheduled and non-scheduled premises. Changes include coverage of additional pollutants such as heavy metals, dioxins and furans and a requirement for municipal incinerators to meet standards for dioxin and furan emissions.

- Clean Air (Motor Vehicles and Motor Vehicle Fuels) Regulation 1997. Changes include updating to ensure consistency with national standards, reduction of maximum lead concentration of leaded petrol, the prescription of certain anti-pollution devices and provisions relating to registration of motor vehicles and powers of authorised officers.

Carbon monoxide

Carbon monoxide is not of concern on a regional scale but can be a local issue. Motor vehicles are the dominant source of CO, contributing more than 88% of the total of CO emissions in the Sydney region. The declining trend in measured concentrations is consistent with the increasing proportion of motor vehicles that are fitted with catalytic converters (which oxidise carbon monoxide to carbon dioxide). Initiatives to reduce motor vehicle emissions further will reinforce this trend. (Developing an Air Quality Management Plan for Sydney, the Illawarra and the Lower Hunter, NSW EPA, Chatswood, May 1996, p 13)

Nitrogen dioxide

About three-quarters of nitrogen dioxide in the Sydney region can be attributed to motor vehicles. The components of the Air Quality Management Plan (AQMP) dealing with oxides of nitrogen emissions will help control nitrogen dioxide (Developing an Air Quality Management Plan for Sydney, the Illawarra and the Lower Hunter, NSW EPA, Chatswood, May 1996, p 12)

In addition to measures in the AQMP aimed at reducing emissions from motor vehicles, the EPA is developing a NO_x policy for major industrial sources which will assist in reducing ambient levels of ozone, nitrogen dioxide and fine particles. It is intended that the policy will include measures such as load based licensing, an annual cap on industrial NOx emissions and a trading scheme for such emissions. Until load based licensing and the full trading scheme are operational, the EPA is requiring proposals (both replacement and greenfield) to meet the emissions standards in the Clean Air Regulations, and to meet the safety net requirement that no new plant should cause extra exceedences of the goals for nitrogen dioxide and ozone in local or adjacent areas.

Photochemical oxidants (as ozone)

The current national health-based ozone goals of 0.10 parts per million averaged over one hour and 0.08 ppm averaged over four hours were established by the NHMRC in 1995. This is a reduction from the previous goal of 0.12 ppm (averaged over one hour). The NSW Government, in 1996, also nominated the WHO ozone goal of 0.08 ppm averaged over one hour as a long term target for air quality in NSW. (Developing an Air Quality Management Plan for Sydney, the Illawarra and the Lower Hunter, NSW EPA, Chatswood, May 1996, p 10)

Transport, especially the motor vehicle, is a major source of emissions in the Sydney basin, particularly those that form photochemical smog (Developing an Smog Action Plan for Sydney, the Illawarra and the Lower Hunter, NSW EPA, Chatswood, May 1996, p 9). The MAQS region continues to exceed the ozone goal under adverse weather conditions. Population growth, resultant urban expansion and increased motor vehicle use will lead to deteriorating air quality in the medium to long term unless additional action is taken (Developing an Air Quality Management Plan for Sydney, the Illawarra and the Lower Hunter, NSW EPA, Chatswood, May 1996, p 10)

Initial analysis by the EPA indicates that strategies based on control and technological changes will, alone, not achieve the reductions required. Strategies that target urban design and transport demand (particularly the use of motor vehicles) will be equally important (Metropolitan Air Quality Study, EPA NSW, Chatswood, March 1996,p 38).

Following public consultation on the air quality management green papers, the NSW Government has adopted an Air Quality Management Plan (AQMP) “Action for Air” which includes a comprehensive mix of emission management strategies dealing with all sources of photochemical smog precursors (that is, transport, industry, commercial and domestic). The strategies also deal with the process of land use and transport planning, so that the urban structure also reduce travel demand and encourage public transport, bicycles and walking.

Key strategies aimed at photochemical smog precursors include:

Slowing the growth in motor vehicle use

The projected growth in overall vehicle kilometres travelled by cars and trucks over the next 25 years has the potential to neutralise much of the air quality gains made across the industry, commercial and domestic sectors. The NSW Government has taken action on a number of fronts which will assist in reducing the projected growth in vehicle kilometres travelled:

- Established the Ministry of Urban Infrastructure Management in December 1996. Its role is to improve coordination and integration of infrastructure planning and expenditure in the Greater Metropolitan Region. High priority will be given to air quality goals in all phases of infrastructure planning and funding.

- A revitalised commitment to public transport to provide choices that will reduce the community is growing dependence on private car use including:

- Implementing the Greater Western Sydney Public Transport Strategy to address public transport needs in the fast growing region of western Sydney.

- Augmentation of the heavy rail network, including the New Southern Railway and the extension of the Eastern Suburbs Rail Line.

- Opening of the new light rail service between Central Railway and Pyrmont and development of a strategic plan for a light rail network.

- Improving public transport on roads including implementation of a number of bus priority schemes.

On-going support through all transport and planning agencies to improve the opportunity for safe and convenient bicycle use. Key programs include the Cycleways Program run by RTA and Local Councils, the Bicycles and Public Transport Strategy managed by Department of Transport; and the Bicycle User Support Program, a joint initiative of the RTA, NSW Police Service, education agencies and Local Councils.

Changing travel behaviour through information and education, including promotion of school and community education programs covering environmental and health implications of transport and land use and planning choices; and the provision of comprehensive information on all modes of public transport. The Government is supporting initiatives such as the NRMA Clean Air 2000 Task Force in exploring options such as increased ride sharing and teleworking.

Transportation provision for the Olympics will be used as an exemplar for future transportation planning. To facilitate public transport access to the Olympic Park, a new railway station and ferry wharf have been constructed. A comprehensive system of bicycle and pedestrian pathways has been designed to facilitate travel within and near to the Olympic Park area.

Improving management of freight transportation. RTA and Department of Transport are working with stakeholders to improve the operational efficiency of urban freight movements. This includes consideration of dedicated freight corridors on strategic urban arterial roads.

Making cars and trucks cleaner

Light duty vehicles

Tighter emission standards for new light duty vehicles came into effect from January 1997.

Significant work has also been done to develop an in-service maintenance program for light duty vehicles (Developing a Smog Action Plan for Sydney, the Illawarra and the Lower Hunter, NSW EPA, Chatswood, May 1996, p 9)

Other strategies include:

- Reviewing research on and promoting new engine technologies (Developing a Smog Action Plan for Sydney, the Illawarra and the Lower Hunter, NSW EPA, Chatswood, May 1996, p 10).

- Promoting the reformulation of petrol and diesel to complement current vehicle emission requirements, and the use and production of alternative fuels such as compressed natural gas (Developing a Smog Action Plan for Sydney, the Illawarra and the Lower Hunter, NSW EPA, Chatswood, May 1996, p 10).

- Standards for vehicle or engine modifications (Developing a Smog Action Plan for Sydney, the Illawarra and the Lower Hunter, NSW EPA, Chatswood, May 1996, p 16).

Heavy vehicles

Emission standards for new diesel-powered heavy vehicles came into force during 1995. NSW is advocating national action to set more stringent emission standards for heavy duty diesel vehicles through the revision of ADR 70.

The Smoky Vehicle Enforcement Program has been augmented, with more officers authorised from the RTA (Developing a Smog Action Plan for Sydney, the Illawarra and the Lower Hunter, NSW EPA, Chatswood, May 1996, p 10).

EPA, RTA and Sydney Buses, through a joint research program, are working to identify the most effective ways of reducing emissions from existing buses and other diesel vehicles.

Reducing industrial air pollution

Reference has already been made to a number of initiatives that will assist in reducing emissions of photochemical smog precursors from industry:

- Amendment of the Clean Air Regulations.
- Protection of the Environment Operations legislation.
- Development of the Load Based Licensing system.
- Policy framework for industrial nitrogen oxides emissions.
- In addition to these initiatives, the NSW Government is also negotiating with industry in relation to:
- Introducing a leak detection and repair program in petrochemical facilities.
- Reducing emissions of reactive organic compounds (ROCs) from major industrial sources through Pollution Reduction Programs as part of the licensing regime.

Reducing ROC emissions from commercial and domestic sources

The Government is negotiating a number of strategies aimed at reducing ROC emissions from a range of surface coatings and solvents used commercially and in the home.

The Sustainable Energy Development Authority is working through partnerships with local government and the building industry to improve energy efficiency in homes. The Energy Smart Homes Program will focus on reducing the imported energy requirements of new and existing homes for heating, cooling and ventilation. Since such programs reduce reliance on burning of fossil fuels, the environmental benefits include reduced emissions of pollutants and greenhouse gases.

Monitoring, reviewing and reporting

Given its 25 year time frame, the AQMP will be an adaptive plan. Current strategies in the draft plan are based on the best available information and resources in 1997. The specific and cumulative impact of these strategies on air quality will be monitored and evaluated against the goals in the plan as part of the research and planning for the next stage.

Sulfur dioxide

Strategies to reduce emissions of sulfur dioxide around specific sites are contained within the EPA regional environmental improvement programs and pollution reduction programs specific to each industry and to each premises (Developing an Air Quality Management Plan for Sydney, the Illawarra and the Lower Hunter, NSW EPA, Chatswood, May 1996, p 14).

Lead (as TSP)

The Government has signalled lead as a priority issue and has established the Lead Reference Centre to carry out education programs and to coordinate intergovernmental activities. The Government has prepared a comprehensive strategy to deal with lead paint hazards and to make certain that appropriate lead assessment and abatement services are set up so that people can act on the advice they receive through education programs. (Developing an Air Quality Management Plan for Sydney, the Illawarra and the Lower

Hunter, NSW EPA, Chatswood, May 1996, p 14). An education campaign on lead hazards was launched on 22 September 97. The campaign will publish information for health care professionals, parents, do-it-yourself home renovators and building workers.

The Clean Air (Motor Vehicles and Motor Vehicle Fuels) Regulation 1997 (effective from 1 August 1997) lowers the maximum lead concentration of leaded petrol from 0.4g/L to 0.2g/L.

Fine particle emissions

The NSW Government is incorporating in the AQMP a comprehensive mix of emission management strategies dealing with all sources of fine particle emissions, including diesel vehicles, solid fuel home heaters, open burning and industrial plant.

Emissions from solid fuel home heaters are addressed in the emission standards for new heaters in the Clean Air (Domestic Solid Fuel Heaters) Regulation 1997. EPA has also run publicity campaigns aimed at improving heater operation, and has recently introduced a voluntary ‘Don’t Light Tonight’ alert on forecast high pollution days in the Sydney area.

NORTHERN TERRITORY

One of the primary goals of the Strategy for Waste Management and Pollution Control in the Northern Territory, which was drawn up in September 1995, is to support and implement nationally agreed waste management and pollution control programs. The development of a strategy for the management of air quality which addressed, amongst other issues, national ambient air quality goals developed through a National Environment Protection Measure, was one of the many actions adopted to achieve this goal.

If agreed to by NEPC, the NEPM for Ambient Air Quality will be adopted as an Environment Protection Objective under the proposed Waste Management and Pollution Control Act. This will give the NEPM the status of a "statutory policy" and will clearly communicate Government's intention to implement it. Mechanisms in the proposed Waste Management and Pollution Control Act will allow a NEPM to be approved by the Administrator as an Environment Protection Objective without the normal requirement for public review.

Actual reporting could be required through a variety of mechanisms, such as lease conditions or through the licensing regime established under the Waste Management and Pollution Control Act. Reporting of emissions from some sources may be required of facilities which fall outside the above mechanisms; reporting for these facilities are likely to be required by a regulation made under the proposed Waste Management and Pollution Control Act. Reporting of emissions from mining and petroleum activities may be required through lease conditions. A specific regulation making power along these lines has been included in the Bill.

It would take approximately 12 months to put in place the new licensing and regulatory mechanisms.

The management of particulates from bushfire smoke or fuel reduction burning is a significant issue in the Northern Territory. The Department of Lands Planning and Environment will be working with Territory Health Services, the Northern Territory Bushfires Council, local fire authorities and the Bureau of Meteorology to develop ways to predict the onset of smoke events and, if necessary, warn members of the public with respiratory impairments to avoid exposure to smoke. Modelling of smoke dispersion will also enable smoke events to be attributed to particular fires. If wildfires on particular parcels of land continually give rise to significant smoke impacts, then fuel reductions burning early in the dry season may be concentrated in such areas to avoid hotter uncontrolled fires later in the dry.

The Waste Management and Pollution Control Bill was introduced into the Legislative Assembly in February 1998.

QUEENSLAND

LEGISLATION

The Queensland Government has in place comprehensive, modern environmental protection legislation which provides a range of tools to manage air quality. The National Environment Protection Measure for Ambient Air Quality will be implemented in Queensland using this legislation and a number of other complimentary mechanisms.

Environmental Protection Act 1994

The *Environmental Protection Act 1994* is the primary legislation for the management of the environment in Queensland. This legislation was framed to accommodate the principles of ecologically sustainable development. It provides a framework for the holistic management of the environmental impacts of activities and emphasises environmental stewardship.

The legislation covers the following main areas:

- Environmental protection policies, ie subordinate legislation established through two rounds of statutory consultation
- A licensing system which provides for on-going management and accountability of activities at risk of causing environmental harm
- Environmental management programs - these are broad improvement seeking strategies with binding milestones and dates for both licensed and unlicensed activities
- Environmental evaluation, including investigation and audit to determine compliance status and whether harm is occurring
- Financial assurance, where necessary, to guarantee environmental management performance
- Enforcement, including infringement notices, injunctions to cease activity, orders to carry out specified works and prosecution
- Devolution of powers and responsibilities to local government or other State Government Departments

When taking decisions under the Act, the administering authority is required to consider a number of standard criteria. These include:

- the principles of ecologically sustainable development
- any applicable environmental protection policy
- any applicable Commonwealth, State or local government plans, standards, agreements or requirements
- any applicable environmental impact study, assessment or report
- the character, resilience and values of the receiving environment
- all submissions made by the applicant and interested parties
- the best practice environmental management for the activity under the authority

- the financial implications of the requirements of the authority, program or order as they would relate to the type of activity or industry carried on under the authority, program or order
- the public interest
- any other matter prescribed by regulation

Best practice environmental management is considered to be management of an activity to achieve an on-going minimisation of the activity's environmental harm through cost-effective measures, assessed against current national and international practices.

The Act provides that a National Environment Protection Measure is taken to be an Environmental Protection Policy if it is approved by Regulation. Thus, approval of the Measure will ensure that it is considered when decisions are being made about environmental management.

Management of activities

Under the Environmental Protection Act, the administering authority should take applicable Environmental Protection Policies and other 'standard criteria' into consideration when making decisions on environmental authorities, environmental management programs and environmental protection orders. This applies to both environmentally relevant activities (ERA) and other activities.

PLANNING

Growth management planning which addresses environmental concerns such as urban air pollution is being undertaken in several regional areas of the state. In the rapidly growing south-east corner the main planning process is the SEQ 2001 Regional Growth Management Strategy (through the Department of Local Government and Planning) which commenced in 1991. The Regional Framework for Growth Management (1994) produced through this project promotes several mechanisms for minimising urban air pollution.

An Integrated Regional Transport Plan has been developed as part of the SEQ 2001 Growth Management Strategy. The plan promotes several transport initiatives which assist in the management of urban air pollution.

The Department of Environment initiated the South-East Queensland Regional Air Quality Strategy in 1993 as part of the regional planning framework. This is a five-year program designed to acquire sound scientific understanding of urban air quality behaviour and, on the basis of this, to produce an air quality management strategy for the region. The strategy will be completed, and implementation will commence, in 1998.

South-East Queensland Regional Air Quality Strategy

The South East Queensland Regional framework for Growth Management identified protection and improvement of air quality in the south east Queensland region as a priority issue and recommended the development of a regional Air quality Strategy. The South East Queensland Regional Air Quality Strategy (SEQRAQS) is intended to address those aspects of air quality which have regionally significant effects on the environmental values of human health and well-being, visibility and amenity. The strategy is intended to complement other regional initiatives such as the Integrated Regional Transport Plan.

Integrated Regional Transport Plan (IRTP) for south-east Queensland

Queensland Transport has developed the IRTP to better manage the transport system in south-east Queensland.

The IRTP contains a number of strategies which will assist in the management of urban air pollution. These include:

- Developing more sustainable transport by increasing the proportion of trips being made by public transport, walking and cycling and in shared rides
- Improving public transport by ensuring there is a “seamless” public transport system which combines all available public transport operations and provides a range of alternatives to car travel
- Restraining the growth of peak period travel demand by reducing the predominance of single occupant vehicle travel, eliminating unnecessary trips and sharing the traffic load around the network to make the most of the existing transport system
- Providing sufficient road capacity by planning to meet moderated traffic demand and to accommodate the growth of the region’s urban areas
- Ensuring social justice by developing a more inclusive transport system which shares the costs and benefits of transport equitably across the region
- Maintaining environmental quality by encouraging cleaner vehicles and improved approaches to providing transport infrastructure

Management of smoke from vegetation fuel reduction burn-off

Vegetation burn-off smoke can be a problem at times in many Queensland urban areas because of the proximity of bushland and forestry.

The Australian Fire Authorities Council (AFAC), comprising all Australian member agencies (including those in Queensland) using fire as a management tool, has approved a Policy for Prescribed Burning and Smoke Management (1994) which sets out guidelines to minimise the negative impacts of smoke on public health, visual amenity and property. The policy provides the basic guidelines for all agencies to derive individual policies applicable to their own fire management objectives.

The Queensland Department of Primary Industries has drawn on the AFAC Policy in formulating the forestry smoke management policy for Queensland.

MONITORING

In recent years the Department of Environment has expanded its air quality monitoring network in South-East Queensland and in six major regional centres outside of South-East Queensland. The monitoring and reporting requirements for the NEPM are anticipated to be met through the existing air quality monitoring arrangements by utilising and adjusting the priorities of the current monitoring programs.

SOUTH AUSTRALIA

AIR QUALITY GOALS

South Australia adopted the National Air Quality Guidelines endorsed by ANZECC in March 1991 for carbon monoxide, fluoride, formaldehyde, lead, nitrogen dioxide, photochemical oxidants (as ozone), sulfur dioxide and total suspended particulate matter. Where the NHMRC goal has been amended since 1991, the most recent goal has been adopted.

LEGISLATION

The *Environment Protection Act 1993*(EP Act) took effect from May 1995 replacing the Clean Air Act 1984 and its subordinate legislation, as well as 5 other Acts which dealt with aspects of environment protection in South Australia. The current Act establishes the Environment Protection Authority, a 6 person independent statutory body whose responsibility incudes administration of the Act; contribution to National Environment Protection Measures; preparation of draft Environment Protection Policies; encouragement, development and implementation of best environmental management practices and the pursuit of environmentally sustainable development. It deals primarily with stationary sources as the *Road Traffic Act* provides for control of motor vehicles including compliance with Australian Design Rules and maintenance of pollution controls on in-service vehicles.

Examples of existing Policies under the EP Act are the Environment Protection (Air Quality) Policy, Environment Protection (Burning) Policy, Environment Protection (Industrial Noise) Policy and Environment Protection (Waste Management) Policy. The Air Quality Policy prescribes emission limits for certain classes of pollutants and imposes other requirements to minimise discharge of air pollutants. The Burning policy, which is administered by local government, regulates, and in some cases prohibits, burning on domestic, industrial and commercial premises.

The Act provides a number of instruments which may be used to effect environment protection in addition to introduction of Policies. The objects of the Act emphasise prevention and minimisation of pollution and waste rather than “end of pipe” controls and cleanup after a problem has occurred. The use of Environmental Improvement Programmes (EP Act section 44) and Environmental Performance Agreements (EP Act S59) may be developed to implement progressive improvements in conjunction with an organisation’s business plan. Achievement of “performance beyond compliance” and a commitment to continuous improvement is encouraged.

Major activities of environmental significance require a licence which replaces the multiple environment-related licences required before 1995. Licence fees are related to impact on air quality in a simplistic manner, whereas the fees associated with discharge into the marine environment are derived from the volume and characteristics of the discharge itself. The fee system is currently under review to investigate the benefits and disadvantages of directly relating licence fees (or Part of hem) to the environmental impact of the activities. Any proposed scheme must also account for the fact that the Environment Protection

Authority is currently self funded through the Environment Protection Fund and does not draw upon the State's consolidated revenue to fund its operations. It exemplifies commitment to the "polluter pays" principle.

National Environment Protection Measures will be adopted through provisions of the *National Environment Protection Council (South Australia) Act 1995* which ensures their automatic adoption in South Australia upon passage through Commonwealth Parliament in accordance with the federal legislation.

CURRENT STRATEGIES

The pollutants addressed in the proposed Air NEPM are already the subject of management programs aimed at achieving the current ANZECC or NHMRC ambient air goals, whichever are the more stringent.

Motor Vehicles are subject to the provisions of the Road Traffic Act administered by Transport SA. Heavy commercial vehicles must comply with a 10-second smoke rule, aimed at reducing emissions due to poor combustion and therefore primarily targeting solid particles and to a lesser extent, carbon monoxide and hydrocarbons.

Urban lead emissions have been reduced through participation in a national program to encourage the use of unleaded petrol where possible, and a phasedown of the content of lead in leaded petrol. Due to constraints posed by different refinery configurations the latter was achieved by negotiated refinery-specific targets and timetables. In September 1996 Mobil Refineries Australia achieved the nationally agreed target of 0.2 g/litre.

Port Pirie is the site of the world's largest pyrometallurgical lead smelter which has resulted in a specific program to reduce to acceptable levels the exposure of the public to lead. The company is currently undertaking its third 10-year environmental improvement plan since the introduction of clean air legislation in South Australia. State and local governments and the company are also involved in an extensive Lead Implementation Program funded largely by the State Government through the South Australian Health Commission. This program has addressed the multiplicity of factors contributing to elevated lead levels in children's blood in Port Pirie.

The formation of photochemical smog has been addressed primarily through implementation of controls on new motor vehicles, and restrictions hydrocarbon emissions from major industrial sources via licence conditions or works approval conditions. Possible additional strategies have been considered, but not formalised, in view of the current levels of ozone.

Sulfur dioxide ceased to be a pollutant of concern for the urban area after the introduction of natural gas as the principal industrial fuel. The only major sources of SO_2 are licensed industries which operate under a limitation to the mass discharge combined with flue height specifications designed to achieve the NHMRC goals. Further site specific requirements may be imposed as necessary using the existing legislation to ensure that the standards in the NEPM are met.

Nitrogen dioxide levels are also the product of stationary and mobile sources. The relative contribution of the latter is somewhat lower in Adelaide than in other major Australian cities due to the operation of a large natural gas fired electricity generating station within the metropolitan area. Site specific emission limits apply to the major stationary sources to supplement statutory limits in the Air Quality policy. Formulation of a program to deal with in-service motor vehicle emissions including nitrogen oxides emissions is a feature of the Environment Protection Authority's Strategic Plan for the forthcoming 3 years.

Achievement of the NHMRC goals for particulate matter is addressed by current legislation which imposes source limits and through industry specific guidelines and codes of practice. The focus in monitoring and control of dust has moved in the past 2 years from total suspended particulate toward respirable particles such as those known as PM-10 (less than 10 microns in aerodynamic equivalent diameter) due to medical authorities' concern at the association of the latter with respiratory illness. The proposed expansion of the ambient air quality monitoring network over the next 3 years includes instruments to measure these particles.

TASMANIA

CURRENT LEGISLATION TO MANAGE AIR QUALITY

The main legislation relevant to air quality management in Tasmania is the *Environmental Management and Pollution Control Act 1994* and associated sub-ordinate legislation.

The Act establishes functions and powers to prevent and remediate environmental harm, which is defined as any adverse effect on the environment (of whatever extent or duration). This clearly encompasses air pollution, and the Act provides a modern range of legislative tools which can be applied to air quality management. These include provision for the assessment and on-going regulation of those activities which are likely to have the greatest potential for significant point source emissions to air. Conditions may be attached to the operation of such activities via permits or environment protection notices.

Relevant subordinate legislation is summarised below. These Regulations have been "carried over" from the *Environment Protection Act 1993.*

Environment Protection (Atmospheric Pollution) Regulations 1973

- These set "across-the-board" standards for pollutants from point sources. In some circumstances these may be exceeded if it can be demonstrated that specified ambient ground-level standards can be achieved. The Regulations also contain standards for emissions from vehicles.

Environment Protection (Prohibited Fuels) Regulations 1991

- These limit the allowable amount of lead in petrol.

Environment Protection (Domestic Fuel Burning Appliances) Regulations 1993

- These require that new domestic fuel burning appliances, such as wood heaters, sold in Tasmania must comply with AS 4012, 4013 and 4014 1992.

STRATEGY TO GIVE EFFECT TO THE PROPOSED NEPM

<u>Ambient air quality monitoring</u>

Tasmania currently carries out very limited air quality monitoring. Hence a major component of the strategy to give effect to the NEPM must be to establish an air quality monitoring network to meet the minimum requirements of the NEPM. This is likely to involve one or two monitoring stations in each of Hobart or Launceston and one in Devonport and, perhaps, Burnie. Negotiations are underway with the Commonwealth Government to use funds from the Natural Heritage Trust to help establish this network.

Air Quality Management Strategy

An Air Quality Management Strategy for Tasmania is being developed in parallel with the NEPM, and it is envisaged that this will include elements specifically designed to give effect to the NEPM. The strategy is likely to require the development of one or more new policy instruments, such as a State Policy or a new Regulation. It is envisaged that these will, among other things, replace the current Environment Protection (Atmospheric Pollution) Regulations 1973.

Reduction of particle levels in urban centers.

The relatively little ambient monitoring data that are available suggests that Tasmanian urban areas are likely to already comply with five of the six pollutants for which standards are specified in the NEPM. The exception is particles.

It is estimated that to achieve the proposed particle standard, the current emissions of smoke from wood heaters in Launceston will have to be reduced by about 50 - 70% over a ten year period. Somewhat smaller reductions are probably required in other urban centres, but the full extent of this will not be known until monitoring results are available. A number of strategies which could be adopted to achieve this objective have been identified in a recent study on air pollution in Australia. They range from “soft” options such as educating people on how to better operate their wood heaters to reduce emissions, through to “hard” options such as banning wood heaters altogether in areas where pollution is high and dispersion of smoke is poor.

A preliminary analysis of these options suggests that substantial gains can be made from the progressive phasing out of old heaters which do not comply with the Australian standard for emissions, and the continuation of a program to educate the owners of wood heaters to operate in a manner that reduces emissions. However, these measures are unlikely to be adequate by themselves to achieve the extent of reduction required. Hence, a first step towards implementing the NEPM in Tasmania will be the development of a package of measures to be implemented by State and local governments to achieve the desired level of reduction required. The success of this package of measures will be measured by the improved monitoring data which will be collected (see above) and will have to be adjusted as necessary to achieve the NEPM goal.

CURRENT MANAGEMENT APPROACHES TO SPECIFIC POLLUTANTS

Carbon monoxide

- emission standard for vehicle emissions and ambient standard in the Air Pollution Regulations

Nitrogen dioxide

- emission standard and ambient standard in the Air Pollution Regulations

Ozone

- vehicle emission standards for ozone precursors in the Air Pollution Regulations

Sulfur dioxide

- emission standard and ambient standard and other controls in the Air Pollution Regulations

Lead

- emission standard and ambient standard in the Air Pollution Regulations
- restrictions on lead in petrol in the Prohibited Fuels Regulations

Particles

- emission standards and other controls in the Air Pollution Regulations
- Domestic Fuel Burning Appliances Regulations
- promotion of “best practice” use of wood heaters to reduce emissions
- monitoring program in relation to wood smoke, and provision of information on air quality ratings in winter for the public.
- air pollution forecasts in Launceston.

VICTORIA

Several Victorian Government agencies and programs contribute to protecting Victoria's urban air quality. However the framework for protecting urban air quality is to be found in the Environment Protection Act 1970. It is likely that the Air NEPM will be implemented under the Environment Protection Act. In particular, it is likely that the standards specified in the Air NEPM will be adopted in Victoria's Air SEPP. In order to provide some important background context, this first section outlines the key legislative framework for Victoria's environment protection system established in the Environment Protection Act 1970.

LEGAL FRAMEWORK

The Environment Protection Act

The *Environment Protection Act 1970* has evolved over 25 years and reflects our growing understanding of the environment as a complex interrelated system. The Act establishes the Environment Protection Authority (EPA) which is responsible for administering the Act. The Act provides the legal framework for the protection of the Victorian environment, including the protection of the air environment.

The Act enshrines an holistic approach to environmental management which ensures that EPA considers the impacts of *any* activity on *all* parts of the environment. Furthermore, the Act emphasises the *prevention* of discharges to the environment rather than the *clean-up* or *disposal* of pollutants. The Act provides for a range of mechanisms which EPA can use to ensure that urban air quality in Victoria is protected. EPA uses these mechanisms to encourage a co-operative approach to environment protection.

The Act provides for the establishment of State environment protection policies (SEPPs) and industrial waste management policies (IWMPs). These statutory instruments provide the policy framework for the protection of the Victorian environment.

STATE ENVIRONMENT PROTECTION POLICIES

State environment protection policies (SEPPs) express in law the community's expectations, needs and priorities for using the environment. SEPPs describe the *beneficial uses* of the environment (eg the Air SEPP lists the health and well-being of humans and other life forms visibility and aesthetic enjoyment) which must be protected. SEPPs also outline the *environmental objectives* and specify *environmental indicators* which are used in monitoring whether the objectives are being met.

SEPPs also include an attainment program which identifies the type of actions which are needed to ensure that the desired environmental objectives are achieved and, therefore, that the beneficial uses are protected. Importantly the attainment program is not usually prescriptive in describing how these objectives should be met. Instead the SEPPs are designed to provide maximum flexibility so that creative ways can be found to meet SEPP objectives and preserve the beneficial uses of the environment.

INDUSTRIAL WASTE MANAGEMENT POLICIES

Industrial Waste Management Policies (IWMPs) complement SEPPs and are concerned with the environmentally sound management of the generation, storage, treatment, transport, and handling of industrial waste. In particular, IWMPs emphasise the importance for industry to investigate and implement means of minimising the production of wastes, including discharges to the air environment.

OTHER STATUTORY MECHANISMS

SEPPs and IWMPs set out the policy framework for the protection of Victoria's environment. The Act also provides a range of statutory mechanisms which can be used to deliver the aims set out in SEPPs and IWMPs. They include:

- *Works approval and licensing*. Works approval is required before beginning construction or modifying facilities or process. It ensures that waste minimisation is considered in the design stage. Licences are required before operating. They impose discharge limits, operating conditions and monitoring and reporting requirements. This enables EPA to monitor compliance with SEPP objectives.

- *Regulations*. In some cases, regulations are used to control environmental quality where licensing may not be appropriate, for example, for car exhaust emission and noise. Regulations cover detailed information such as methods for the measurement of discharges, or a comprehensive list of prescribed waste.

- *Notices.* Whereas works approvals and licenses are broad tools to anticipate, prevent and manage environmental risks, notices direct the recipient to take action to manage site specific problems (either actual or potential) at lower risk premises.

- *Offences and Penalties*. EPA is able to impose fines and prosecute where other mechanisms fail.

MANAGING AIR EMISSIONS

Major sources of emissions in the Port Phillip Region

The emissions inventory undertaken by EPA in 1990 gives a good indication of the relative contribution to total emissions of the various sources for the common pollutants. The 1990 inventory also contained projections for the year 2000. . The inventory showed that overall, motor vehicles are the biggest contributor to air emissions, including particles, carbon monoxide and the primary pollutants (ROCs and oxides of nitrogen) that generate photochemical smog. During a typical summer week day for example, almost 80% of the nitrogen oxides, 50% of the VOCs, 45% of the airborne particles and over 90% of the carbon monoxide are due to motor vehicle exhaust and evaporative emissions.

Seasonal differences in emissions are evident for, VOCs, NO_x, CO, and particles . Wood and natural gas combustion contributes relatively higher proportions of carbon monoxide, particles and nitrogen dioxide in winter.; It was estimated that the large majority of emissions are anthropogenic and that natural emissions from vegetation would comprise about 9% of total volatile organic compounds in summer (less in winter).

Apart from motor vehicles and industry, the combined contributions from domestic sources can also be significant, particularly lawn mowers, wood fires, backyard incinerators and volatile emissions from oil-based paints and many household products. Other industrial and commercial contributors include petrol stations and spray painters. This illustrates the widespread and diffuse nature of many of the contributors to urban air pollution.

The new emissions inventory for the Port Phillip region, currently being prepared, will update this information and include all of the other pollutants described above. It will incorporate estimates of emissions from some additional sources, in particular controlled burning and wildfires on the urban fringe.

The following sections outline the approach Victoria will take to managing air emissions.

Industry

Since 1973, companies in Victoria with the potential to be significant polluters have been subject to restrictions set out in licences. These licenses restrict emissions from companies according to criteria specified in State environment protection policies and in accordance with good control practice. This licensing process established specific controls over emissions of pollution.

Under this system, control over emissions to the air from chimney stacks has been achieved by setting maximum discharge limits. This led to a focus on treatment systems to reduce pollutants after they had already been generated in the factory. At the time it was introduced, this “end-of-pipe” approach (as it is known) to controlling emissions from industry dominated in Victoria and other parts of the world.

In 1985, EPA introduced works approvals. The works approval process obliges certain types of industrial premises identified in regulations to obtain EPA approval prior to commencing specified works or construction to ensure they adopt adequate pollution abatement technology and practices. The works approval process also provides a mechanism for EPA to work with planning authorities to avoid conflicting land uses being established too close to each other.

In the late 1970s and early 1980s, there was growing recognition that more success could be achieved if greater attention was paid to what happened further “up the pipe” at the point of generation of the pollutants, particularly at the design stage. That is, prevention is better than cure. This notion of fixing a problem before it is created is what underpins the hierarchy of waste management options: reduce, re-use, recycle, treatment, and disposal. That is, it is more efficient to avoid or minimise the creation of waste in the first place, but any waste which is produced should be re-used or recycled if possible before it is finally disposed of. This principle increased the focus on how production systems could be made more efficient or “cleaner” to avoid or minimise the creation of waste and reduce energy consumption. The phrase “cleaner production” was coined to encapsulate these ideas.

Cleaner production

Cleaner production illustrates clearly that sound business practice and environmental performance are inextricably linked. Businesses that wish to survive and grow within a community that values its clean environment need to incorporate continuous environmental improvement into all their activities. Significantly, companies that have pursued cleaner production practices have often found these practices yield financial as well as environmental benefits.

The adoption of cleaner production to avoid waste generation at source was put onto a statutory basis in Victoria in 1990 with the creation of the *Industrial Waste Management Policy (Waste Minimisation)*. This statutory policy requires all companies applying for a works approval, or obtaining or amending a licence, to prepare a waste management plan. The plan must identify what the company will do to minimise industrial waste (including emissions to air) through the application of cleaner production techniques and commonly available technology (or, in the case of certain priority wastes, best available technology).

The cleaner production theme has been promoted to industry in a number of ways. EPA devised the Cleaner Production Demonstration Program to demonstrate to Victorian industry the financial and environmental advantages of adopting cleaner production practices and technology. Cleaner Production Grants were introduced to assist small to medium-sized businesses to adopt the cleaner production message. The grants provide interest-free loans to support the introduction of innovative cleaner production ideas. EPA also introduced an annual Cleaner Production Award to recognise significant achievements in cleaner production.

Since 1995, the adoption of cleaner production by small to medium sized enterprises has been promoted through the Cleaner Production Partnership Program, initiated by EPA with the support of the Australian Chamber of Manufactures. The program provides financial and other assistance (such as the placement of experienced managers) to facilitate the introduction of cleaner production technology, preparation of waste management plans and environmental management systems.

Best Practice Environmental Management and Regulation

Cleaner production is now clearly seen as an expression of best practice environmental management (BPEM) in industry. BPEM involves the adoption of a management philosophy and complementary systems and practices which lead to a level of environmental performance equal to the best achieved by other enterprises in the same field of operation. BPEM exhibits such features as a pro-active approach to dealing with issues, openness in dealing with the community and rigorous appraisal and auditing of performance.

Best practice environmental management in industry must be complemented by best practice environmental regulation (BPER). That is, an ongoing improvement in the mix of regulatory tools to produce the best environmental outcome, consistent with the community’s social, economic and environmental goals. BPER is flexible enough to encourage responsibility, innovation and initiative by industry in addressing its environmental obligations. Examples of BPER, as it is currently practised in Victoria, include Environment Improvement Plans (EIP) and accredited licences.

An EIP is a demonstration by a company of its commitment to improve the quality of the local environment. Designed to complement a company's own environmental management system, EIPs establish environmental objectives for premises in accordance with relevant policies and standards, and includes a commitment to continuous improvement in its operations. The objectives are set in consultation with, and are regularly reviewed by, the local community. This establishes a greater level of trust within the community of the environmental credentials of industry operating in its midst.

Introduced in 1994, the accredited licensee scheme is designed to recognise good performance by industry. Companies with a good track record in their environmental performance and that have an environment management system, an environmental audit program and an EIP can apply to have a simpler, performance-based licence, a more streamlined approach to works approval and a 25% reduction in their licence fees. Accredited licences provide industry with the flexibility necessary to innovate and develop cost-effective approaches to its environmental imperatives.

A number of Best Practice Environmental Management Guidelines for industries with the potential to be significant contributors to air pollution have been, or are being, prepared to complement these statutory initiatives.

There are many general examples of how changes to practices and technology in an industry have resulted in improved air quality outcomes. For example, reductions in volatile organic compounds escaping to the atmosphere have resulted from the mandatory use of submerged vapour loading and recovery at petrol stations. Similar improvements have also been seen in the dry cleaning industry and flexographic and gravure printing industry.

There are also many specific examples of how the application of cleaner production, BPEM and BPER have produced better outcomes for Melbourne's air. The Altona Chemical Complex is one such example. In the early 1990s, seven companies from the Altona Chemical Complex voluntarily agreed to halve the amount of volatile organic compounds emitted to the air over a five-year period.

Controls on air emissions from industry are well established in Victoria. They aim to achieve a balance between a regulatory safety net and a co-operative, performance-based approach that encourages innovative solutions to potential pollution problems. The current emphasis is on monitoring and refining these initiatives and extending their application.

Although many large companies have good environmental management practices in place, the great challenge is to assist and encourage small to medium-sized enterprises to adopt cleaner production and other improved practices.

Motor Vehicles

Since the mid-1970s, increasing attention has been paid to reducing motor vehicle emissions, as the significance of these emissions has been recognised and the contribution from industrial sources has been reduced. As population and vehicle use continue to grow, efforts to reduce vehicle-related pollution will need to be intensified. Initiatives to reduce motor vehicle emissions are mainly aimed at two general areas: vehicle and fuel characteristics on the one hand, and the way in which our cities accommodate the motor vehicle on the other (for the latter, see the section on Transport and Land Use Planning). The manner in which motor vehicles are driven is also a relevant consideration.

Australian Design Rules (ADRs) are the national mechanism that establishes emission design standards for new motor vehicles. The most significant developments in petrol-engine motor vehicle emission controls, since the introduction of the ADRs in the early 1970s, were the introduction of ADRs 27 A, B and C in the late 1970s/early 1980s and ADR 37/00 in 1986 (ADRs 27 and 37 apply to light vehicles less than 2.7 tonnes gross vehicle mass with petrol engines). These ADRs set emission levels for hydrocarbons, nitrogen oxides and carbon monoxide. ADR 37/00 required the use of unleaded petrol in new light vehicles with petrol engines, and was instrumental in the incorporation of catalytic converters into these vehicles. This also resulted in a major reduction in emissions of air toxics from petrol-engine light vehicles.

It is important to highlight that significant reductions in the amount of lead in the atmosphere have not only been achieved through the introduction of unleaded petrol but more so through significant reductions in the amount of lead in leaded petrol since the 1970s.

The introduction of an ADR can be several years from the time it is created. This is because production planning and other changes to be made by the manufacturers of motor vehicles require a significant lead time.

ADR 37/00 is now being replaced by ADR 37/01, which reduces statutory emission levels to about one third of those of ADR 37/00. The review of ADR 37/01 has already begun with a view to investigating such initiatives as tighter limits, improved design durability, inclusion of liquid petroleum gas and natural gas vehicle emission limits, and requiring on-board diagnostics.

ADR 30/00 for diesel vehicle emissions control has recently been complemented by the more comprehensive and rigorous ADR 70/00 in order to better control diesel emissions, including particles and nitrogen oxides. This ADR is also being reviewed as increasing attention is paid to diesel vehicle emissions and more is understood about the adverse effects of very small particles. Diesel vehicles contribute very significantly to fine particle pollution.

Victoria and NSW have been instrumental in progressing the development of new national motor vehicle emission standards. Information gathered from the vehicle testing stations operated in these states has been particularly valuable in the national context.

The major air pollution problems relating to motor vehicles are hydrocarbons, nitrogen oxides (ozone precursors) and fine particles. The introduction of increasingly stringent new vehicle emission controls since the late 1970s has contributed to the significant improvement in hydrocarbon (and hence ozone) levels in Melbourne since that time.

Since 1990, the Commonwealth and the States have made a number of institutional changes which have clarified responsibilities in relation to the development of vehicle emission standards. Changes include the establishment of the National Environment Protection Council and the National Road Transport Commission. These bodies have had, and will continue to have, a significant impact on motor vehicle policy through the development of air and diesel National Environment Protection Measures, revisions to ADRs, and introducing vehicle in-service requirements through national road law. These changes will ensure greater alignment of state and territory approaches to motor vehicle emissions policy and regulation. However, it is important to remember that there is a long lag time between decisions about changes in emission standards and actual positive impacts on air quality.

A recent report by the Federal Office of Road Safety (FORS 1996) used extensive measurements of in-service vehicles conducted by EPA, Ford and NSW EPA. It estimated that a well-maintained car fleet could reduce emissions of particular pollutants by between up to 9% (for NO_X) and up to 25% (for carbon monoxide), as well as leading to substantial reductions in greenhouse gas emissions and fuel savings. The report also identifies vehicle maintenance as an important issue in emission reduction regardless of vehicle age.

To ensure that the benefits of increasingly stringent new vehicle emissions standards are fully realised, vehicles need to be well maintained. In Victoria, there are regulations governing in-service vehicle emissions. One of the ways in which the existing fleet is managed is that EPA (in conjunction with Victoria Police) conducts roadside inspections; vehicles that fail to comply must be inspected at a later stage to ensure that defects have been rectified.

Through its smoky vehicle program, EPA issues infringement notices and notices requiring rectification of smoky vehicles, or vehicles that have had pollution equipment tampered with. Warnings are issued in response to public reporting of smoky vehicles.

Roadworthy tests in Victoria include some checks of emission equipment. Roadworthiness certificates are required when a vehicle changes ownership, after a roadside inspection determines it is necessary or if the vehicle needs to be re-registered for some reason.

Domestic and rural sources

The 1990 emissions inventory showed that domestic wood combustion is the dominant source of particles (PM_{10}) in winter. There are Australian standards for solid fuel heaters which should encourage the widespread installation of well designed heaters. ANZECC approved draft model regulations for solid fuel heaters in 1992.

Particle pollution from burning of vegetation and domestic refuse has been significantly reduced by a combination of local laws and educational campaigns. Backyard incineration is now banned in many municipalities and severely restricted in others. Strategies to reduce emissions from other domestic activities, such as lawn mowing and the use of paints and solvents, may need to be considered in future.

Controlled burning for fire protection purposes is adopted in many areas on the fringe of the metropolitan area. This sometimes adversely impacts on air quality. Agreements between EPA and the Department of Natural Resources and Environment have been put in place to limit controlled burning to periods when weather conditions favour both safety and air quality.

Transport and land use planning

How cities are planned and developed can have a profound effect on the quality of the air we breathe, both at the local and the regional level. Local issues might include maintaining appropriate buffer distances between residential areas and industrial premises to protect the health and amenity of residents from residual emissions discharged into the air environment. On a larger scale, investment decisions about transport infrastructure and the location of significant trip generators such as educational institutions, office complexes and shopping centres influence the number of vehicle kilometres travelled and hence the pattern and volume of emissions from motor vehicles.

Urban planning decisions are made in an atmosphere of competing demands. The community's desire to protect its amenity, conserve environmentally sensitive areas and see resources used in a sustainable manner tends to conflict with its desire for employment-generating development and accessibility to work, recreation and various services. It is important to realise that demands such as these are all important and need not necessarily conflict with one another. The challenge is in reconciling them.

Transport and land use planning is important to air quality in terms of how it influences the level of motor vehicle use to accommodate society's need for mobility and the provision of services and goods. Swift, safe and efficient transport is necessary for both business and private purposes and the motor vehicle can offer a number of advantages in this regard, particularly its great flexibility. However, these advantages must be balanced against the pollution load and other environmental and social costs that arise from excessive reliance on the motor vehicle as a mode of transport. Decisions about the provision of infrastructure (for transport and activities such as shopping, recreation, education and employment) will inevitably favour some options for the region's urban development and limit others.

A number of key Government policies and strategies recognise these issues and make provision to address them:

Living Suburbs

Living Suburbs provides the framework that will guide the future urban development of Melbourne. It takes account of the commercial, industrial, social, cultural and environmental characteristics of Melbourne and its position in relation to the rest of Victoria.

Living Suburbs has much to say about moderating growth in motor vehicle use and identifies a number of relevant matters for further action, including:

- integrating land development with transport systems, particularly at major transport nodes and activity clusters;
- encouraging the efficient use of land and infrastructure and greater housing choice;
- encouraging redevelopment in areas with under-used infrastructure capacity;
- investing in public transport to increase personal mobility, reduce congestion and make Melbourne's assets more accessible; and

- ensuring that all transport services are customer-focused and conform to the world's best practice.

Initiatives such as these aim to moderate the rate of growth in motor vehicular travel by creating an urban form that reduces the need to travel long distances by car. They also enhance alternatives to the car as a means of travel.

Transporting Melbourne

Supporting the thrust of *Living Suburbs* is *Transporting Melbourne* which provides a strategic framework for an integrated transport system in Melbourne. *Transporting Melbourne* specifically addresses air quality in the context of environmental sustainability and demand management of transport in Melbourne.

Measures proposed for consideration in *Transporting Melbourne* to moderate growth in car travel include:

- strategies to encourage use of public transport;
- land-use policies which reduce the demand for travel by encouraging the development of mixed-use development and activity centres;
- improved traffic and road-use management;
- encouraging non-motorised modes of transport, particularly walking and cycling;
- preferential treatment for high-occupancy vehicles by, for example, the use of transit lanes on freeways;
- voluntary, employer-based trip reduction programs;
- developing car-pooling programs;
- encouraging telecommuting, flexible working hours and other work-related initiatives;
- investigating parking supply and pricing mechanisms; and
- in the longer term, considering congestion pricing.

In *Living Suburbs* and *Transporting Melbourne* both the urban form and transport needs of Melbourne are addressed with environmental issues, including air quality, specifically in mind.

State Planning Policy Framework

Another important policy document is the State Planning Policy Framework (SPPF). The SPPF sets out the State planning policies that apply to all land in Victoria. These policies must be taken into account when preparing, making amendments to, or making decisions under planning schemes. Air quality is addressed in the SPPF in terms of the integration of transport and land-use planning and the zoning of land uses.

The SPPF is a cornerstone of the Victoria Planning Provisions (VPP). The VPP is a state wide planning reference document from which planning schemes are sourced and constructed. The SPPF is that component of the VPP which provides a state-wide context for spatial planning and decision making.

All municipal planning schemes incorporate the SPPF, which states that municipalities should have regard to both *Living Suburbs* and *Transporting Melbourne* in the preparation or amendment of planning schemes and Municipal Strategic Statements (which provide a vision for future development in a municipality and expresses its overall strategic directions.) As such, the messages in *Transporting Melbourne* and *Living Suburbs* are incorporated in the urban planning system in Victoria.

The SPPF also emphasises the obligation on municipalities to comply with the SEPP (The Air Environment), and to ensure that development is not prejudiced and community amenity is not reduced by air pollution. This is done by ensuring, wherever possible, that suitable separation exists between potentially amenity reducing developments and the general community.

Integrated land use and transport planning

One of the main ways in which demand for travel by car can be reduced is by providing services, employment and other trip generators close to where people live or near public transport nodes. This facilitates the use of public transport, cycling and walking.

Opportunities for this concept to be adopted more widely in Victoria were investigated through the Urban Villages Project. This project examined the potential for applying the principles of sustainable urban form to existing urban areas in Melbourne and Geelong.

An “urban village” is a style of urban development which exhibits certain characteristics and observes certain principles, including:

- mixed-use development - residential, commercial and recreational land uses are combined within a particular area to maximise the availability of these requirements to the local population;
- proximity to public transport - public transport, preferably of more than one mode, is at the heart of an urban village thereby encouraging greater use;
- cycling and walking are encouraged - the urban form in an urban village actively encourages the use of bicycles and walking as modes of transport;
- medium-density housing - a range of densities of residential development are offered, but there is an emphasis on medium-density housing; and
- energy-efficient building and street design - buildings and streets are designed to minimise the use of energy.

These principles can have many benefits. One of the most important is that they reduce reliance on the car as a means of meeting the needs of the community. This is achieved by making travel by car discretionary for many purposes rather than mandatory as it often is with conventional urban development which separates residential, shopping, employment and other land uses. This clearly has benefits for air quality and energy consumption, but the benefits of this approach can be more than just environmental. The urban village model can offer greater lifestyle choices, provide more secure living environments and promote a sense of community.

These principles are the principles of good urban design, whatever name is attached to them. The environmental, economic and social costs of servicing further outward urban sprawl are a significant issue confronting the Port Phillip region. Changing household and employment patterns (eg. decreasing household size and the shift to a service economy stimulating employment growth in small business, much of which is home-based) also lend further weight to the adoption of these principles. There is ample scope in the Port Phillip region for the application of these principles in smaller scale urban development as well as in existing developed areas.

WESTERN AUSTRALIA

LEGISLATION

The primary legislation for managing air pollution in Western Australia is the *Environmental Protection Act 1986*. The Act is administered by the Department of Environmental Protection (DEP) and is presently in the process of being amended. A brief outline of the structure of the Act follows:

Part III - Environmental Protection Policies

These allow for flexible, statutory policies which may form an underlying framework for the protection of a specified part of the environment.

Part IV - Environmental Impact Assessment

An independent body, the Environmental Protection Authority, has powers to require various levels of assessment for proposals which may have a significant environmental impact.

Part V - Control of Pollution

Premises which may cause pollution may be "prescribed", following which works approvals and licences are required for the construction/modification and operation of such premises.

Pollution abatement notices or directions may be issued to control pollution from any premises. Other provisions contain head powers in relation to controlling pollution from vehicles and vessels.

Parts VI and VII - Enforcement and Appeals

Various enforcement and appeals provisions exist in respect of the above-mentioned provisions.

Implementation of the NEPM for Ambient Air

State Environmental Protection Policy for Air Quality

It is proposed to implement the NEPM via a state-wide Environmental Protection Policy (EPP) which:

- references the NEPM standards for general application to air quality management programs and the assessment of development proposals in WA, but also;
- excludes application of the standards within industrial areas and residence-free buffer areas around industrial estates;
- for circumstances where the standards are not being achieved due to existing emissions, enables attainment and/or management programs to be established. (The NEPM goal envisages a 10 year period for attainment).

Examples of issues which would need to be addressed via attainment and/or management programs are as follows:

- The existing EPP for sulfur dioxide in the Kalgoorlie region is due for review in 2000. It is likely to be retained for the purpose of defining the attainment and management programs for Kalgoorlie industries. The long term goal is to bring sulphur dioxide levels in designated populated areas into line with the NEPM goal. An area-specific EPP is an ideal means to establish attainment programs, for existing industries, which account for local social and economic factors.
- Air quality at residential areas around the Kwinana industrial area currently complies with the proposed NEPM standards. The airshed management procedures employed under the current EPP must be maintained, as must the integrity of the buffer area.
- Exceedences of dust standards in the Pilbara (often caused by natural events) are inevitable. Good dust management practices can form the basis for acceptable management programs for Pilbara industries.
- A comparative study of life and injury risk from wildfires versus life and health risk from smoke particles is needed. If the former outweighs the latter, a management program for hazard reduction burning which explicitly accommodates possible exceedences of the NEPM particle standard is appropriate. Optimising burning programs to limit smoke impact on major population centres would remain part of the management program (as at present).

Implementing the NEPM monitoring protocol

The DEP will implement the protocol for monitoring and reporting concentrations of the six pollutants in a manner which both meets the requirements of the NEPM and obtains maximum value from the capital investment in its existing monitoring network. Computer modelling will be employed to demonstrate the acceptability of regional air quality in support of monitoring, or to provide estimates in areas with clean air where the cost of monitoring is not warranted. Specific intentions are as follows:

- A sub-set of the proven ozone, nitrogen dioxide and carbon monoxide monitoring stations in the Perth region will become performance-monitoring stations.
- Data from the established sulfur dioxide monitoring network in the Kwinana area together with computer modelling will be used to demonstrate that concentrations are acceptable in the Perth region and that they reduce with distance from Kwinana
- Performance monitoring at Kalgoorlie will occur where the people live, namely within the city boundaries. The existing monitoring network operated by industries in Kalgoorlie and other nearby towns will remain intact.
- Fine particles will be monitored in Perth and other regions and reported as per the protocol. Complementary programs of campaign monitoring, meteorological forecasting and computer modelling will be employed to develop management programs.

- The DEP proposes to continue to monitor and report lead from a single station in the Perth CBD where the levels are well below the NEPM standard and falling.

AIR QUALITY MANAGEMENT MECHANISMS

Policy

The Western Australian Government is committed to the development and implementation of an Air Quality Management Plan for Perth. This process has been initiated through a Parliamentary Select Committee which was established in May 1997 (Environment Western Australia, 1997, Draft State of the Environment Report, Perth, 1997, p17).

Licensing procedures have recently been changed to incorporate discharge-based licence fees, audited self-management and inducements for best practice which provide greater encouragement for industries to reduce discharges (Government Gazette, 13 September 1996 p4545).

Monitoring

The DEP is continuing to expand its air monitoring system within the Perth metropolitan area and major country centres (Perth Haze Study p8). Quarterly reports containing summarised monitoring data are published (eg Ambient Air Quality Data Summary Western Australia (October 1996 - December 1997), DEP, July 1997).

Modelling

The DEP has dispersion models for photochemical smog formation in the Perth air shed, and for point sources including those in coastal locations. These can be used in a number of ways such as ensuring that new developments do not cause ambient standards to be exceeded and assessing the effectiveness of options for emissions reductions.

Investigations

Scientific studies are being conducted to gather meteorological and environmental data for north west coastal areas in the Pilbara, to provide baseline data for the planning of new industrial developments and estates.

Airwatch

This air monitoring program for schools and community groups is designed to increase community awareness and understanding of air quality problems and solutions.

CURRENT MANAGEMENT APPROACHES FOR NEPM POLLUTANTS

Particulates

Wood heaters

- Ongoing campaigns are conducted to educate householders on the proper operation of wood heaters to minimise emissions of smoke and air toxics (Perth Haze Study p8).

- Legislative changes are planned to address issues such as new wood heaters meeting AS4013 for particle emissions and ensuring that only clean, dry wood is used in Perth wood heaters, so that particulate emissions are minimised (Perth Haze Study p8).

Open burning

Guidelines for the minimisation of pollution from land development sites have recently been revised. The new document contains upgraded procedures for dust control and interim recommendations for dealing with cleared vegetation to prevent smoke pollution (Land Development Sites and Impacts on Air Quality, DEP, November 1996). The burning of cleared vegetation in the Perth region will be banned from December 1997 (Perth Haze Study p8).

The Department of Conservation and Land Management, which conducts most of the hazard reduction burning in the State, uses meteorological information from the Bureau of Meteorology to reduce the smoke impacts from burning upon major population centres.

An environmental guideline will shortly be published, advising the agricultural community on how to conduct weed and stubble burning to minimise smoke impacts upon populated areas (Perth Haze Study p8).

Haze alerts

The DEP will shortly commence issuing haze alerts prior to days when meteorological conditions make the accumulation of smoke in the Perth air-shed likely.

Motor vehicles

The DEP operates a smoky vehicle campaign which allows the public to report smoky vehicles. Following a report, the DEP sends a letter to the vehicle’s owner requesting they fix the problem, if genuine (Perth Haze Study p8).

Photochemical oxidants (ozone)

The Department of Transport has developed and published a Metropolitan Transport Strategy which has the objective of reducing motor vehicle trips in favour of less polluting forms of transport (Metropolitan Transport Strategy, Department of Transport, 1995). The long-term air quality implications of this Strategy are being assessed by the EPA.

A "Travelsmart" educational campaign is under way to raise awareness and understanding of the urban transport choices available, and investigate what motivates people in making these choices.

Regulations have been implemented which control vapours from service stations and bulk storage tanks (Government Gazette, 16 May 1995 p1844).

The DEP is trialing the widespread use of LPG vehicles in their fleet to investigate environmental and economic benefits.

The full implementation of ADR 37/01 from 1 January 1998 will reduce emissions of hydrocarbons from new vehicles.

Nitrogen dioxide

The full implementation of ADR 37/01 from 1 January 1998 will reduce emissions of nitrogen oxides from new vehicles.

Carbon monoxide

The full implementation of ADR 37/01 from 1 January 1998 will reduce emissions of carbon monoxide from new vehicles.

Lead

Regulations have been implemented specifying the maximum lead content in petrol (Government Gazette, 31 December 1993 p6878)

Sulfur dioxide

- Environmental Protection Policies are in place to control sulfur dioxide levels around Kalgoorlie and Kwinana industries.
- The largest sulfur dioxide emitting source in Kalgoorlie has recently installed scrubbing equipment which has led to significant reductions in local sulfur dioxide levels (Department of Environment Protection Western Australia, 1997, Draft State of the Environment Report, Perth, 1997, p22).

APPENDIX 2
COMPETITION POLICY ASSESSMENT

Under the COAG Competition Principles Agreement (1995), an assessment of competitive implications is required as part of the process for making subordinate legislation. If approved by NEPC, the proposed Measure will be adopted as subordinate legislation within most jurisdictions (under the processes for adoption of Measures set out in the NEPC Act passed by each jurisdiction).

The proposed Measure and the anticipated implications of its adoption are explained in detail in the final impact statement (above).

The proposed Measure will not affect competition within any market. The Measure has been framed within the objects of the NEPC (as set out in Section 3 of the NEPC Acts passed by the participating Governments) to ensure that "people enjoy the benefit of equivalent environmental protection from air, water or soil pollution and from noise wherever they live in Australia; and decisions of the business community are not distorted, and markets are not fragmented, by variations between participating jurisdictions in relation to the adoption or implementation of major environment protection measures".

The Measure does not require direct environmental improvement action by firms or individuals. As noted in the final Impact Statement, the Measure establishes a consistent set of national standards (ie. benchmarks against which air quality can be measured) for the protection of human health, and establishes a requirement for Governments to ensure that a consistent and comparable monitoring network is established in appropriate locations across Australia.

The standards within the Measure set bench mark objectives for ambient air quality and will assist in the identification of areas of air quality where improvements are needed to protect human health. In areas where the standards contained in the Measure are not being met, the responsible jurisdiction may choose to develop strategies for air quality improvement, however the only requirement which flows out of adoption of the Measure is to establish a monitoring network which will provide information to be used in developing each jurisdiction's annual reports on performance against the standards.

The monitoring protocols within the proposed Measure do not restrict competition within the market for air quality monitoring equipment. The protocols simply require that the equipment which is purchased and used for the purposes of compliance with the Measure's protocols are able to meet Australian Standards (or in some cases appropriate internationally recognised methods or standards) for the performance of such monitoring equipment. This requirement does not restrict competition within the market for this equipment, but establishes a clear minimum performance requirement which allows the objective of a consistent and reliable set of air quality data to be achieved.

APPENDIX 3
MEMBERSHIP OF AMBIENT AIR QUALITY NEPM GROUPS

The membership lists for some groups imply multiple membership for some jurisdictions. In such cases, membership was sequential and the jurisdiction concerned had only one representative at any given time.

PROJECT CHAIR

Dr Brian Robinson	EPA (Victoria)

PROJECT MANAGER

Mr Brendan Carroll	NEPC Service Corporation

PROJECT TEAM

Mr Jack Chiodo/Mr Tony Robinson	EPA (Victoria)
Dr Michael Dean	NSW EPA
Mr Paul Dworjanyn/Ms Christine Schweizer	Environment Australia
Mr Leo Heiskanen	National Health and Medical Research Council
Dr Phil Morgan/Mr David Wainwright	Department of Environment (Queensland)

ASSISTED BY

Ms Judy Goode	NEPC Service Corporation
Ms Lisa Davies	NEPC Service Corporation
Ms Monina Gilbey	NEPC Service Corporation

JURISDICTIONAL REFERENCE NETWORK

Mr Terry A'Hearn	EPA (Victoria)
Mr Mark Hyman/Mr Ian Carruthers/ Ms Christine Schweizer	Environment Australia
Mr Noel Davies/Mr Ken Raynor/ Mr Paul Vogel	Department of Environmental Protection (Western Australia)
Mr Nigel Green	Department of Lands Planning and Environment
Dr Tony Hodgson	Environment ACT
Mr Warren Jones	Department of Environment and Land Management
Ms Heather Neil	Australian Local Government Association
Mr Peter Nimmo	Department of Environment (Queensland)
Mr Kelvyn Steer	SA EPA
Mr Lou Wiersma	NSW EPA

NON-GOVERNMENT ORGANISATIONS ADVISORY GROUP

Dr Bill Coote	Australian Medical Association
Dr Geraldine Elliot	Asthma Foundation
Mr Frank Fleer	Clean Air Society of Australia and New Zealand
Mr Ian Galbally	CSIRO Division of Atmospheric Research
Mr Roger King	Federal Chamber of Automotive Industries
Mr Peter Kinrade	Australian Conservation Foundation
Dr Jim Le Cornu	Institution of Engineers Australia
Dr Peter Mannins	Environment Management Industry Association of Australia
Mr Laughlan McIntosh/Mr Bob Powell	Australian Automobile Association
Mr Simon Molesworth	Environment Institute of Australia

Mrs Anita Roper/Mr David Collins	Australian Chamber of Manufactures
Mr Ian Satchwell	Minerals Council of Australia
Mr Jim Starkey	Australian Institute of Petroleum
Ms Sandy Vigar/Ms Bernadette George	Royal Australian Planning Institute

TECHNICAL REVIEW PANELS

Each of the groups listed below provided substantial assistance to the project team through the review of consultancies and other literature used in the development of the draft Measure.

Health Review

Dr Malcolm Brown	Shell Company of Australia Ltd
Dr Stephen Corbett	NSW Dept of Health
Professor Michael Pain	Royal Melbourne Hospital
Professor Michael Moore	NHMRC National Research Centre for Environmental Toxicology

Air Quality Management Options Review

Dr Jim Le Cornu	Shell Australia
Mr Hugh Malfroy	Pacific Power, Sydney
Dr Mark McKenzie	NRMA
Dr Ian Ross	Capral Aluminium
Dr Harry Schaap	ESAA
Professor John Todd	University of Tasmania

Impact Assessment

Dr Peter Brotherton	Sustainable Solutions
Mr Colin Burrows	Queensland University of Technology
Professor Tor Hundloe	University of Queensland
Mr David James	Ecoservices Pty Ltd
Dr Harry Schaap	ESAA

Exposure Assessment

Professor Chris Gray	Deakin University
Professor Michael Hensley	University of Newcastle
Dr Peter Mannins	CSIRO, Division of Atmospheric Research
Dr Dino Pisaniello	University of Adelaide