



Ministry for the
Environment
Manatū Mō Te Taiao

Review of the Ambient Air Quality Guidelines

Preliminary Review of Strategies for Managing Air Quality

Prepared by A'Hearn *et al.* for the
Ministry for the Environment's Review
of the *Ambient Air Quality Guidelines*

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Foreword by the Ministry for the Environment

This report by A'Hearn et al. has been prepared for Ministry's review of the *Ambient Air Quality Guidelines 1994* (Guidelines 1994). The report reviews the type of strategies needed to manage emissions of contaminants into the air to ensure contaminants levels are within the proposed ambient air quality guideline values, and explores the potential costs and benefits of such strategies. The contaminants considered in this report include those in the 1994 Guidelines, and new contaminants (hazardous air contaminants) discussed in Air Quality Technical Report 13 and the Ministry's *Proposals for Revised and New Ambient Air Quality Guidelines for New Zealand – Discussion Document* (Ministry for the Environment, 2000).

This report will be most useful for those who have had little experience in developing air quality management strategies or assessing indicative costs and benefits of emission control strategies. This report does not contain the cost effectiveness analyses required under section 32 to accompany national environmental standards for air quality. However, the methodology to undertake a more formal analysis is discussed in Chapter 4. Further guidance on meeting the requirements of section 32 can be found in *What are the options? A guide to using section 32 of the Resource Management Act* recently released by the Ministry in 2000.

At this stage, the Ministry is reviewing the 1994 Guidelines and is considering whether other national tools for managing air quality are needed. These include: national environmental standards, legislative changes, economic incentives and education programmes. The need for additional national measures to manage ambient air quality and the further work required to investigate the costs and benefits of such measures, will be discussed during consultation on the Guidelines review. Further analysis will be undertaken within Ministry's Air Quality Management Programme.

Technical reports prepared for the review are available over the Ministry's website at <http://www.mfe.govt.nz/monitoring/epi/airqualtech.htm>

This report has been amended and edited by the Ministry for the Environment in response to comments by reviewers on the draft version.

This is a technical report prepared to assist the Ministry for the Environment and it is not Government policy. Any specific comments on this report should be made in your submission on the Ministry's *Proposals for Revised and New Ambient Air Quality Guidelines for New Zealand – Discussion Document*. The timeframe for submissions is outlined in this report.

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The Ministry for the Environment has edited this report in response to reviewers' comments and added section 1.2 for background information.

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1 Introduction

1.1 Aim of this report

The aim of this report is to carry out a preliminary assessment of the types of strategies or measures needed to maintain and improve air quality in accordance with the proposed new and revised air quality guidelines (Tables 1.1 and 1.2), and the potential economic and environmental costs and benefits associated with such strategies.

The report is not a comprehensive analysis required by section 32 of the Resource Management Act 1991 (RM Act) to develop national environmental standards for air quality. Rather, it describes the likely costs and benefits to human health, the environment, ecosystems and aesthetic values of measures needed to reduce emissions of contaminants into the air from sources to meet guideline values and maintain air quality. These issues should be considered irrespective of whether guidelines values or formal national standards are developed, although standards would require a more detailed assessment than presented here.

The report also discusses how various emission sources may be affected by the introduction of the proposed new guideline values. However, this assessment is restricted by limited (but increasing) knowledge of ambient concentrations of pollutants, whether they are exceeding guidelines, and the degree of management action that might be required.

Section 1 describes the legal framework within which air quality is managed in New Zealand as this influence how strategies are developed and implemented. Section 1 also includes a brief discussion on the variables that should be taken into account when looking at costs and benefits of ensuring that air quality is improvement to meet guideline values or maintained within guideline values.

Sections 2 and 3 take a closer look at possible strategies to reduce emissions of the criteria air contaminants (those covered in the 1994 Guidelines) and hazardous air contaminants (new proposed guidelines) in New Zealand. The report focuses on strategies required to reduce emissions from the main sources of the contaminants, such as vehicles and domestic fires. Methods for reducing emissions from specific industry sources are not considered in detail. The options for national guidance on how to manage industry emissions is contained in the discussion document – *Proposals for Revised and New Ambient Air Quality Guidelines for New Zealand*.

Finally, Section 4 discusses the further work that would be required to prepare a comprehensive analysis that meets the requirements of section 32 of the RM Act if national environmental standards for air quality were pursued.

Table 1.1 Proposed changes to the existing 1994 Guideline values

Contaminant	1994 guideline value		Proposed new/revised guideline values		
	Value	Averaging time	Value	Averaging time	Percentile
Existing contaminants					
Carbon monoxide	30 mg/m ³	1-hour	30mg/m ³	1-hour	99.9
	10 mg/m ³	8-hour	10 mg/m ³	8-hour	99.9
Particles:					
PM ₁₀	120 µg/m ³	24-hour	50µg/m ³	24-hour	99.5 (daily monitoring) 100 (1 day in 6 monitoring)
PM _{2.5} ¹	40 µg/m ³	Annual	Withdrawn		
			25µg/m ³	24-hour	99.5 (daily monitoring) 100 (1 day in 6 monitoring)
Nitrogen dioxide	300 µg/m ³	1-hour	200µg/m ³	1-hour	99.5
	100µg/m ³	8-hour	100µg/m ³	8-hour	99.5
Sulphur dioxide ²	500µg/m ³	10-min	Withdrawn		
	350µg/m ³	1-hour	350 µg/m ³	1-hour	99.9
	125µg/m ³	24-hour	120µg/m ³	24-hour	99.5
	50µg/m ³	Annual	Withdrawn		
Ozone	150µg/m ³	1-hour	150µg/m ³	1-hour	99.9
	100µg/m ³	8-hour	100µg/m ³	8-hour	99.9
Hydrogen sulphide	7µg/m ³	30-min	7µg/m ³	1-hour	99.9
Lead ³	0.5–1.0µg/m ³	3-month	0.2 µg/m ³	3-month moving average, calculated monthly	100
Fluoride	Range of guideline values		See guidance on managing air pollution effects on ecosystems		

Notes

¹ PM_{2.5} is proposed as an interim guideline value (see discussion below).

² The sulphur dioxide guideline values do not apply to sulphur acid mist.

³ The guideline values for metals are for inhalation exposure only; they do not include exposure from other routes. These other routes should be considered in assessments.

All values apply to the gas measured at standard conditions of temperature (0° C) and pressure (1 atmosphere).

Table 1.2 Proposed ambient guideline values for new contaminants

New contaminant	Guideline value	Averaging period	Percentile
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Benzene (year 2000)	10µg/m ³	Annual	100
Benzene (year 2010)	3.6µg/m ³	Annual	100
Toluene	190µg/m ³	Annual	100
Xylene	950µg/m ³	Annual	100
1,3-Butadiene	2.4µg/m ³	Annual	100
Formaldehyde	15µg/m ³	Annual	100
Acetaldehyde	30µg/m ³	Annual	100
Benzo(a)pyrene	0.0003µg/m ³	Annual	100
Mercury (inorganic)	0.33µg/m ³	Annual	100
Mercury (organic)	0.13µg/m ³	Annual	100
Chromium VI	0.0011µg/m ³	Annual	100
Chromium (other forms)	0.11µg/m ³	Annual	100
Arsenic (inorganic)	0.0055µg/m ³	Annual	100
Arsine	0.05µg/m ³	Annual	100

1.2 Air Quality Management in New Zealand

This section briefly outlines the framework for air quality management in New Zealand. It is important to understand this framework because the potential strategies for achieving the guidelines, and therefore the costs of strategies, will be highly influenced by it.

1.2.1 Resource Management Act 1991

The RM Act sets out the overarching legal framework for managing the environment in New Zealand. The overall purpose of the RM Act is to promote the sustainable management of natural and physical resources. The meaning of sustainable management and the principles of the RM Act are specified in sections 5 to 8.

Under the RM Act, regional councils (and unitary authorities) are responsible for managing discharges of contaminants into the air in such a way as to achieve sustainable management (section 30). Section 15 (1)(c) outlines that discharges from industrial or trade premises are not allowed without being expressly allowed by a rule in a regional plan, resource consent or regulations, and section 15(2) specifies those discharges that are allowed, unless otherwise specified in a plan.

To assist them in managing the environment, councils must prepare a regional policy statement (section 59) and can prepare a regional plan (section 63). Within regional plans, councils can specify rules to permit certain activities subject to conditions, specify others that require resource consents and prohibit activities that are known to have serious adverse environmental effects. Policy statements and plans must be prepared in accordance with section 32. Among other things, section 32 (Appendix 1) requires the council to consider the costs and benefits of the chosen policy options or rules, and the costs and benefits of the principle alternative means available.

1.2.2 Regional plans

The preparation of regional plans usually involves an number of stages. These stages are discussed in detail in the 1994 Guidelines. In brief, they typically involve:

- determining the state of the air through air quality monitoring programmes
- obtaining good information about the sources of emissions by using emission inventories and other techniques
- developing a good understanding of how emissions of contaminants from different sources are affecting the air quality and other influences such as meteorology
- determining how best to address air quality problems or maintain good air quality using the management options available
- discussing the options with the local community
- implementing the most appropriate and cost effective option or options

- monitoring the effectiveness of the options and revising them accordingly.

The management options available to councils include regional plans, advocating central government, educational programmes, and economic incentives. Determining the most appropriate method or methods involves predicting how well of each of them, and the variations within each, will reduce emissions and improve air quality. Together with an estimate of the costs and benefits of each method, the most cost effective and appropriate methods can be devised, discussed with the local community, chosen and then implemented.

Air quality guideline values fit into this regional planning process at an early stage and have been used to develop rules in plans, assess the effectiveness of methods and determine whether air quality improvements are required. Guideline values therefore play an integral role in air quality management and must be based on sound health, environmental and economic factors.

1.2.3 National policy development and the Minister for the Environment

There are a number of central government agencies that advise Ministers and the government on environmental management. These include the Ministry for the Environment, Department of Conservation (DoC), Ministry of Transport (MoT), Ministry of Health, Ministry of Fisheries, and the Environmental Risk Management Authority. The Office of the Parliamentary Commissioner for the Environment also plays an important role in environmental management and they report directly to Parliament.

The Ministry for the Environment is the main policy agency responsible for advising the Minister for the Environment and government on environmental issues. The Ministry acts on behalf of the Minister for the Environment in carrying out her duties under the RM Act. The Ministry's roles also include reporting on the state of New Zealand's environment, developing national guidance and regulations and reporting on the way that environmental laws and policies work in practice. However, as discussed above, councils (particularly regional councils) deal with most of the day-to-day air quality management decisions.

The Ministry works closely with other government departments and stakeholders to develop measures for addressing environmental issues on a national basis (e.g. national environmental standards and good-practice guidance), amending other legislation, implementing education programmes and developing economic instruments. For example, the policy initiatives agreed to in the Vehicle Fleet Emissions Control Strategy (VF ECS) will be implemented through a range of mechanisms including:

- rules and regulations under the Land Transport Safety Act (administered by the MoT and the Land Transport and Safety Authority) and the Petroleum Fuel Specifications (administered by the Ministry of Commerce)
- education of the motor vehicle industry, particularly in relation to maintenance of diesel vehicles
- research, development and promotion of the use of assessment tools such as Environmental Capacity Analysis by those responsible for managing traffic flows.

National ambient air quality guideline values also play a significant role in national policy development. Analysis undertaken for the VF ECS used guideline values to determine the nature of the impacts of transport emissions on air quality and the comparative significance of

different contaminants. Where contaminants released from vehicles caused the guideline values to be breached, the extent and regularity of the breaches were used to estimate the necessary reductions in vehicle emissions. In this way the most effective measures for dealing with the particular air quality concern were developed¹.

Since 1997, the Ministry for the Environment has developed the Air Quality Management Programme supported by Green Package funding. This Programme aims to on prepare the most effective national tools for managing air quality. So far these tools have tended to focus on preparing guidance, training and information to assist councils and resource users. The relevant publications include: *Ambient Air Quality Guidelines* (1994), *Odour Management under the Resource Management Act* (1995) and a *Guide to Compliance Monitoring and Emissions Testing of Discharge to Air* (MfE, 1997). The Ministry is also working on good-practice guides for *Air Quality Monitoring and Data Management*, *Assessing and Managing the Environmental Effects of Dust Emissions* and intends to commence a review of the guide to *Odour Management under the Resource Management Act* (MfE, 1995) in 2000.

The Ministry is now considering whether other national tools are required, particularly national environmental standards. The first environmental standards will probably be for dioxins, furans and polychlorinated biphenyls (PCBs). The promulgation of national environmental standards requires analysis to be undertaken in accordance with section 32. This involves estimating the costs and benefits of the environmental standards, assessing their cost effectiveness in comparison to the principle alternative means of addressing the issue. In the case of ambient air quality the principle alternative to ambient standards is likely to be ambient guideline values i.e. the *status quo*.

The issue of national environmental standards for ambient air quality is discussed in more detail in the Ministry's discussion document (Proposals for Revised and New Ambient Air Quality Guidelines) and during consultation on the Guidelines review.

1.3 Impact assessment approaches

The first step is to consider the best approach to assessing costs and benefits and the variables that influence the costs of emissions control strategies. Any assessment of costs and benefits of ambient air quality guideline values or standards that might be carried out should function as a tool to facilitate:

- a transparent policy development process
- informed public comment on the recommended guidelines (or standards)
- informed decisions regarding the adoption of guidelines (or standards).

Examples of the techniques that could be used in developing such an assessment are:

- historical evidence (for example, case studies of environmental problems, reviewing similar approaches used elsewhere)
- surveys and/or case studies of impacts of compliance
- gathering scientific information

¹ *Ambient Air Quality and Pollution Levels in New Zealand; Targets for Vehicle Emissions Control* (Ministry for the Environment and Ministry of Transport, 1998)

- risk assessment techniques
- economic or decision-support models
- canvassing the views of, and information from, potentially affected parties
- focus groups and market research techniques
- sensitivity analyses.

The level of detail included in this report and in any future assessment to meet the requirements of section 32 is limited by a number of factors, including:

- the range of information available
- resources, requiring choices about various assessment techniques on the basis of their cost and the time required to conduct them
- the degree to which the incidence of the impacts can be identified (recognising that those who benefit may be different to those who bear the cost)
- the reliability of the information available
- the ability of impact assessment techniques to deal with the uncertainty involved in environmental decision-making
- difficulty in clearly attributing impacts to the proposed recommended guidelines (in particular, identifying whether impacts flow only from the adoption of those guidelines or from other influences such as commercial considerations and international trends) in a consistent manner.

1.4 Relationships between pollutants and timeframes for compliance

The assessment of the costs and benefits of adopting a particular recommended guideline cannot be carried out in isolation. Strategies for the management of particular substances that affect air quality (for example, carbon monoxide (CO), nitrogen dioxide (NO₂) and sulphur dioxide (SO₂)) are often closely interrelated. A management strategy to reduce emissions of one pollutant will often reduce emissions of other pollutants as well. Reducing the direct discharge of pollutants can also lead to reductions in those pollutants produced in the air environment by chemical reactions, particularly ozone (O₃) and some particles.

For example, a strategy to reduce CO emissions from motor vehicles may lead to reductions in peak CO concentrations in urban centres with a resultant reduction in the health impacts of exposure to CO. However, there can be other benefits from some measures used to reduce CO emissions from motor vehicles. These include the reduced emission of other pollutants such as nitrogen oxides, which have produced additional benefits, in terms of reduced impacts on health and the reduced likelihood of a severe photochemical smog event. A CO reduction strategy may also lead to reduced direct emissions of certain hazardous air pollutants.

The timeframe for compliance in situations where a recommended guideline is not currently being achieved is another important factor in determining the relationship between costs and benefits. In general, the costs of achieving compliance with a recommended guideline will be significantly reduced if the compliance timeframe allows for:

- the period required for the development of agreed air-shed management strategies

- the length of time necessary to allow turnover of the motor vehicle fleet to be reflected in emissions from that source
- the long investment cycles of industry, where over a 10-year period we might expect one or two minor or perhaps one major investment in capital equipment or process technologies that will have a substantial impact on the environmental performance of companies
- the length of time required to effectively influence and change those community behaviour patterns that have an adverse effect on air quality.

2 Key air contaminants

2.1 Carbon monoxide

2.1.1 Sources

Carbon monoxide (CO) is produced during combustion processes. Mobile sources, particularly motor vehicles, are the major source in urban airsheds: studies indicate that mobile sources make up approximately 90% of CO emissions in the Auckland region (Victorian Environment Protection Authority, 1997). Domestic fires also contribute a significant proportion of CO emissions in winter. *The State of New Zealand's Environment* report suggests that “in Christchurch, for example, motor vehicles and domestic fires contribute about equally to ambient wintertime carbon monoxide pollution” (MfE, 1997).

There are few significant biogenic sources of CO that impact on urban centres, except for disasters such as fires and volcanic eruptions.

2.1.2 Emissions control strategies

There is a range of options available for reducing emission levels of CO.

Mobile sources

Mobile sources include motor vehicles, lawn-mowers, commercial and recreational ships and boats, and aircraft. Emissions of CO from motor vehicles represent the large majority of mobile source emissions in urban air sheds, and are therefore the obvious target for emissions reduction strategies.

However, reducing emissions from the country's motor vehicle fleet is a complex issue, and can be tackled in a range of different ways (either separately or concurrently). A major policy implementation process is underway to address the effects of vehicle emissions on air quality that were developed through the VF ECS (MoT, 1997 and 1998). These initiatives were approved by Cabinet in June 1999 and the MoT is in the process of implementing them. The options investigated to address vehicle emissions included those for reducing total emission loads from the motor vehicle fleet and for reducing emissions in the major urban traffic corridors where peak ambient concentrations are experienced.

Stage 1 of the VF ECS focused on addressing CO emissions from vehicles. This stage included a detailed analysis of the potential costs and benefits of pursuing various control options (MoT, 1997). The final stage of the VF ECS looked more widely at other pollutants including NO₂ and some hazardous air pollutants.

The final initiatives that were approved by the Government are described below.

To improve emissions from individual vehicles:

- Implement systems that formalise vehicle importers current practice of complying with international emissions standards, for all vehicles introduced to the national fleet, through the Land transport Safety Authority (LTSA) rules process. This will also cover the “type” approval certification of pre-used imports, to ensure their conformity with the emission standards in force at the time of manufacture in their country of origin.
- Review the automotive fuel specifications, to ensure that control of fuel quantities is compatible with the requirements of all imported vehicles, and their future emissions control and fuel-efficient technologies designed to meet these emission standards and with environmental, health and safety requirements.
- Introduce guidelines for the identification of excessively smoky vehicles on public roads similar to the “10 second rule” used in Australia. The LTSA should develop appropriate procedures in consultation with appropriate parties
- Encourage the vehicle service industry, through its industry associations, to improve conversancy with modern engine technologies, and in particular diesel technology (with its increasing use in the light vehicle sector). This will improve the wider availability of qualified and experienced vehicle servicing capabilities, for the correct maintenance of these engine technologies

To improve traffic management:

- promote and demonstrate environmental capacity analysis (a way of quantifying emissions from different traffic scenarios) as an additional method for evaluating network management options
- encourage dialogue between road controlling authorities, land use planners and air quality managers.

To improve air quality management:

- review and develop air quality guidelines for all of the relevant pollutant types, and promote the guidelines’ adoption. Consider the development of these guidelines into air quality standards
- ensure that the Environmental Performance Indicators approach to setting future targets for air quality improvement is implemented and observed consistently
- develop consistent methodologies for local air quality monitoring.

Other policy options for reducing CO emissions from vehicles that may be applied on more local levels include:

- management strategies to shift demand for transport services from private vehicles towards alternatives such as public transport, walking or bicycle use
- strategies to reduce the demand for transport services, such as through changes in urban form that locate developments of residential, commercial and other facilities in close proximity, leading to a reduced need for travel by motor vehicle (the ‘urban villages’ concept)
- Improving vehicle movement in congested urban areas. The VFECS suggests that analysis has shown the magnitude of pollution reduction that can be achieved by moving from

congested to interrupted to free-flow traffic conditions far outweighs the gains achieved through technical fleet performance options, particularly in the short term.

Other options that were considered within the VFECS but were found not to be cost-effective include:

- strategies that encourage better maintenance and tuning of vehicles, and the adoption of improved driving techniques to reduce both fuel consumption and emissions levels
- encouraging the introduction of alternative fuel technologies such as hybrid, hydrogen, electric and fuel-cell vehicles.

Further assessment on the costs and benefits of implementing some of these initiatives, such as the development of emission standards for new vehicles and complimentary measures is currently underway by the MoT.

Domestic fires

The use of open fires and controlled-combustion heaters in households, and the back-yard incineration of wastes, can be significant contributors to CO emissions levels in urban areas. Combustion of wood and coal for domestic heating in winter is of particular concern.

The State of New Zealand's Environment report indicates that “nationally, the number of homes with open fires has been declining, so that now only one-quarter of homes have them. Meanwhile, the proportion of homes with slow-combustion fires... has been increasing” with nearly 35% of households having a slow-combustion fire in 1995 (MfE, 1997).

Possible management strategies to reduce CO emissions from domestic fires include:

- education programmes to make the community aware of the impact of solid fuel combustion for domestic heating on urban air quality
- encouraging or regulating for the use of improved technologies and cleaner fuels in domestic heating appliances
- discouraging the use and construction of open fires and other inefficient combustion appliances through planning restrictions
- encouraging the installation and use of alternative heating systems in households reliant on solid-fuel combustion for heating
- education programmes to provide the community with information regarding the proper use of solid-fuel appliances to reduce emissions (for example, by ensuring the use of dry fuel and adequate oxygen availability so that the fuel burns cleanly)
- encouraging the increased adoption of energy-efficient building design and construction.

2.1.3 Benefits of emissions control

CO levels are of concern from a human health perspective if they exceed recommended air quality guidelines, which are generally based on a No Observed Adverse Effect Level (NOAEL) of 2.5% carboxyhaemoglobin in blood.

If ambient levels are currently below the recommended air quality guidelines, then there is arguably no human health benefit to be gained from reducing CO emissions alone. However, as noted above, the relationship between CO emissions reductions and the management of a range

of other pollutants of concern make this isolated comparison simplistic. In reality, most strategies to achieve reductions in CO will lead to reductions in other pollutants and will therefore lead to a broader range of benefits.

In situations where the recommended air quality guidelines are being exceeded, reductions in ambient concentrations of CO can lead to human health benefits. There are also economic benefits through the avoidance of these health impacts, both in terms of reduced health-care costs and avoided productivity losses. Social benefits are in the form of reduced stress and discomfort, which may not affect productivity and earning capacity but do reduce the enjoyment of life.

The emissions control options discussed above can also generate a number of other possible benefits, including:

- motor vehicle emissions standards, or improved motor vehicle maintenance, may lead to reduced fuel consumption and an overall reduction in running costs
- the use of more efficient domestic heating appliances will lead to reduced fuel bills
- increases in the adoption of energy-efficient housing design can lead to long-term reductions in operating costs for residential properties (although this may be offset by reductions in indoor air quality as a result of reduced ventilation).

2.2 Nitrogen dioxide

2.2.1 Sources

Nitrogen dioxide (NO₂) is one of several oxides of nitrogen. For most combustion processes nitrogen oxides are emitted primarily in the form of nitric oxide (NO), and lesser quantities of NO₂. In the high temperature zones of combustion processes, nitrogen in air and in the fuel reacts with oxygen in air to form nitrogen oxides. The NO then slowly oxidises to NO₂ in the atmosphere.

Sources of nitrogen oxides include *“all types of road vehicles... domestic burning of wood, coal, natural gas and LPG and certain industrial processes. ... Depending on the presence of other local sources such as thermal power stations and industry using significant combustion processes, motor vehicles are estimated to contribute up to 80 to 95% of total emissions”* of nitrogen oxides (MoT, 1998).

NO₂ is also formed naturally by lightning and by the oxidation of ammonia (National Environment Protection Council, 1998). However, these sources generally constitute an extremely small contribution to total NO₂ levels in an urban area.

2.2.2 Emissions control strategies

The control strategies for limiting emissions of CO from combustion sources (motor vehicles, domestic fires and major industry sources) are equally relevant for achieving reductions in levels of NO₂. Strategies aimed at motor vehicles would give the most likelihood of significant reductions.

There may be instances where control of major point sources (for example, thermal power stations) is a more appropriate or cost-effective method of achieving an emissions reduction. This is likely to be the case in rural or small urban areas with a major point source emitter.

2.2.3 Benefits of emissions control

NO₂ contributes both to morbidity and to mortality, especially in susceptible subgroups such as young children, asthmatics and in those with a chronic inflammatory airway disease. These health effects lead to significant economic and social costs associated with increased illness, which emissions controls would seek to avoid.

NO₂ (and nitrogen oxides more generally) is a significant pollutant not only because of the health effects it directly causes, but also as a result of the role it can play in the generation of photochemical smog (O₃) events and the production of secondary particles that cause visibility degradation. As such, any assessment of the benefits of reduction measures for nitrogen oxides must also take into account the benefits that may be derived as a result of reduced O₃, reduced particle levels and improved visibility.

There may also be benefits in terms of preventing damage to property and vegetation: “At high levels nitrogen dioxide can corrode materials such as metals, and damage plants” (MfE, 1997). However, there are unlikely to be many (if any) situations where such levels are being reached in New Zealand.

2.3 Ozone

2.3.1 Sources

Ozone (O₃) is a secondary air pollutant formed by reactions of primary pollutants – oxides of nitrogen and photochemically reactive organic compounds in the presence of sunlight. O₃ is the principal component of photochemical oxidants (commonly known as photochemical smog), along with formaldehyde, other aldehydes, and peroxyacetyl nitrate.

The primary pollutants that can lead to the generation of O₃ arise from a range of sources. As mentioned previously, nitrogen oxides come from motor vehicles, and commercial, industrial and domestic combustion activities. Sources of reactive organic compounds include motor vehicles, oil refining, printing, petrochemicals, lawn-mowing, aviation, dry-cleaning, other industrial and domestic uses of solvents and coatings (for example, paints), and other combustion activities. Biogenic emissions of reactive organic compounds from vegetation can also be important.

There is limited information available regarding O₃ levels in New Zealand (Fisher and Noonan, 1997). However, studies have found that atmospheric conditions suitable for photochemical reactions occur around 10 days per year in Auckland, 15 days in Hamilton and 4 days in Christchurch. In Auckland, breaches of the guideline values were found at sites 35-40km north and south of the city. Further O₃ monitoring is being carried out by councils to determine its extent and significance.

2.3.2 Emissions control strategies

The control of O₃ requires management strategies that target reductions in nitrogen oxides and/or reactive organic compounds. Emissions control strategies would need to be carefully designed to target the most easily managed component of the suite of emissions affecting O₃ production. One component (either nitrogen oxides or reactive organic compounds) is likely to be the ‘limiting’ pollutant, and it may be that targeting these emissions will provide the most effective mechanism to reduce O₃ levels (National Environment Protection Council, 1998).

In the absence of an understanding of which pollutant is ‘limiting’, it may be appropriate to take a precautionary approach and instigate measures to reduce the range of precursor pollutants. This is likely to be achieved as a result of any programmes adopted to reduce emissions of the other criteria air pollutants discussed in this document.

The range of emissions control strategies discussed above for motor vehicles, domestic fires and major industry will all contribute to reductions in the primary pollutants that can lead to photochemical smog events.

The other strategy that may be effective, if reductions in emissions of reactive organic compounds are required to manage O₃ events, is targeting activities that lead to these emissions; that is, encouraging the adoption of low-emission technologies and/or products. For example, domestic paint technologies now allow for the production of paints with low volatile organics content, and dry-cleaning can be managed to reduce emissions levels.

The adoption of cleaner production approaches at industrial facilities that emit reactive organic compounds (and, indeed, any other criteria pollutants or air toxics discussed below) should be seen as a priority for achieving cost-effective emissions reduction for the firm(s) in question. Emissions control devices at industrial facilities and businesses such as petrol stations, which handle large quantities of products that lead to reactive organic compounds emissions, are another option.

Table 2.1 gives estimated costs and cost-effectiveness of recently developed “Action for Air” strategies related to photochemical smog in Sydney (New South Wales Environment Protection Authority, 1998).

2.3.3 Benefits of emissions control

One means of assessing the benefits of emissions control is to look at the relationship between the contaminant exposure levels and its impacts on health and the environment. This is typically called the dose-response relationship. The dose-response relationship observed for O₃ appears to be linear, and it is not possible to define a no observed adverse effect level (NOAEL) or lowest observed adverse effect level (LOAEL). As a result, any reduction in O₃ events achieved through emissions control can be expected to lead to benefits in terms of reductions in adverse health effects.

The adverse health effects associated with exposure to O₃ are:

- increases in daily mortality, respiratory and cardiovascular disease
- increases in hospital admissions and emergency room visits
- decreases in lung function
- increases in symptoms of respiratory illness such as cough, phlegm and wheeze

- increase in bronchodilator usage.

These health effects lead to significant economic and social costs in terms of premature death, increased health treatment costs, reduced productivity resulting from absences from employment or declining output resulting from ill health, and the social costs associated with increased illness.

There may also be environmental and social benefits derived from reductions in O₃ events, including the following.

- Vegetation damage – O₃ is phytotoxic towards a large number of plant species. Commercial crops, domestic vegetables and ornamentals may be affected.
- 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 eutrophication. O₃ control strategies targeting reductions in nitrogen oxides should reduce such impacts.
- Built environment – some damage to materials and structures can occur. Some rubber and plastic products are particularly vulnerable.
- Aesthetics – O₃ and smog can reduce visibility through the formation of fine aerosol particles, including sulphates and nitrates, and result in a white haze.

Table 2.1: Costs and cost-effectiveness of New South Wales Environment Protection Authority “Action for Air” smog reduction measures

Strategy (possible implementation date)	Financial impacts	Average annual emission reductions (tonnes per year)	Cost-effectiveness (\$ per tonne reduced)
<i>National strategies</i>			
New passenger vehicle emission standards (2003)	\$250–\$650 per vehicle	75,200 tonnes (ROC, NO _x , 1/7CO)	\$460–\$1,600
New heavy-duty truck emission standards (2003)	\$1,300–\$10,000 per truck	1,800 tonnes (ROC, NO _x , 1/7CO)	\$440–\$3,500
<i>State strategies</i>			
Inspection and maintenance programmes (1998–2000)	\$20–\$25 per inspection (excl. repairs and fuel savings)	18,000–26,500 tonnes (ROC, NO _x , 1/7CO)	\$1,800–\$5,100
Lower fuel volatility (1998–2001)	less than \$0.002 per litre (excl. fuel savings)	5,800–8,300 tonnes (ROC, NO _x , 1/7CO)	\$190–\$320
Major industry ROC controls (1998–2003)	\$50,000 to \$100,000 per facility	2,600 tonnes ROC	\$85–\$160
Commercial premises ROC controls (1998–2006)		1,200–2,800 tonnes ROC	\$1,100–\$2,300
Printing (1998–2006)	Net savings	315 tonnes ROC	Net savings
Install petrol vapour recovery units at rail loading gantries (1999)	\$1.5m per gantry	310 tonnes ROC	\$820

Note: ROC – reactive organic compounds; NO_x – oxides of nitrogen

2.4 Particles

2.4.1 Sources

Particles are emitted from motor vehicles (particularly diesel vehicles), domestic fuel burning, fossil fuel-based electricity generation, some industrial processes, and industrial and domestic incinerators. Secondary production of particles can also be significant, with the most important being:

- sulphates, which derive primarily from SO₂ emissions
- nitrates, which derive primarily from NO emissions
- organic aerosols, which derive primarily from volatile organic compound emissions.

Natural sources of particles include dust (which can be exacerbated greatly by human activities), pollens and sea spray.

Air-borne particles can occur in a range of different sizes. From a health perspective, particles smaller than 10 microns in diameter are of greatest concern as they are able to enter the lungs. Most air-quality monitoring is for particles less than 10 microns in diameter (PM₁₀), although increasingly attention is turning to particles less than 2.5 microns in diameter (PM_{2.5}).

The Auckland emissions inventory (Victorian Environment Protection Authority, 1997) showed that domestic and commercial sources contribute approximately 53% of the annual total emissions of suspended particles, and 70% of emissions on a “typical winter day” (domestic heating contributes 90% of this total). Major industry contributes 32% and mobile sources contribute the remaining 15%.

In Christchurch, where the extent of domestic fuel burning in winter is more significant than in Auckland, home heating contributes approximately 82% of the PM₁₀ on a typical winter day, with motor vehicles contributing 10% and industry 8%. The “winter smoke” phenomenon is also experienced in some other South Island urban areas (MfE, 1997).

2.4.2 Emissions control strategies

Domestic fires

The emissions control strategies available for domestic fires are the same as those discussed previously in relation to CO management. Measures could include a combination of regulatory instruments (e.g. standards or guidelines), education programmes and economic incentives.

Major industry sources

Discharges from major industrial sources into the air are usually controlled by Regional Councils through the issue of discharge permits and promulgation of rules in regional plans. These are the key tools available to councils for reducing the contribution of industrial emissions to ambient particle levels.

Emissions reductions may also be achieved by encouraging the adoption of best-practice techniques (e.g. best practicable option (BPO) and best available control technology not

entailing excessive cost (BACTNEEC)); in particular, programmes encouraging the adoption of cleaner production. Other options also include economic incentives and emissions trading regimes in areas where particles pose significant concern.

Mobile sources

The range of emission-control strategies discussed above in relation to CO management are relevant for the management of particle emissions from the motor vehicle fleet, both in terms of reducing the direct emission of particles from motor vehicles, and also in reducing the “as yet unquantifiable contribution of other vehicle emission species to secondary particle formation” (MoT, 1998).

An additional issue that needs to be taken into account is the higher particle emissions rate per kilometre travelled for diesel fuel vehicles compared to petrol fuel vehicles. Where particles from vehicles pose a problem, a management strategy to reduce emissions from diesel fuel vehicles in the fleet could achieve a reduction in total particle emissions. An education programme to improve tuning and maintenance of diesel fuel vehicles also has the potential to reduce particle emissions from this source. This second option, in combination with emission standards for new diesel vehicles, has been selected as a VFECS initiative (MoT 1998).

2.4.3 Benefits of emissions control

Results of epidemiological studies have provided no evidence for the existence of a threshold value below which no adverse health effects from ambient particles in air are observed. This means that human health benefits will be achieved with any reduction in the level of particle emissions (in contrast to, say, CO, for which there is arguably no health benefit derived from reductions below the recommended air-quality guideline).

The major health effects resulting from airborne particles are:

- increased mortality
- aggravation of existing respiratory and cardiovascular disease
- hospital admissions and emergency department visits
- absences from employment, school, etc
- restricted activity days.

These effects lead to significant economic and social costs in terms of premature death, increased health treatment costs, reduced productivity resulting from absences from or reduced activity in employment, and the social costs associated with increased illness and restricted activity levels.

Reductions in particle emissions will also achieve aesthetic benefits in terms of reduced visibility impairment and reduced deposition of particles in the form of dust and grime. This is likely to be of particular importance where aesthetic improvements in the environment will have a positive effect on tourism and related industries.

Table 2.2 gives the capital and energy costs and benefits of three measures, separately and in combination, to reduce levels of particles from domestic heating in Christchurch (Ball, 1998). Other benefits, such as improved public health, reductions in nuisance effects, and enhanced perceptions of Christchurch, are not quantified. However, the costs of the 82,000 reduced

activity days as a result of pollution are estimated to have a value of at least \$5 million per annum.

Table 2.2: Capital and energy costs and benefits of measures to reduce levels of particles from domestic heating in Christchurch

Measure	Capital costs (NPV)	Energy costs/ (benefits) (NPV)	Net costs/ (benefits)
Ban coal from 30 Sept. 1998	\$1.5m	(\$1.4m)	\$0.1m
Phase-out open fires from 30 Sept. 2001	\$6.7m	(\$13.8m)	(\$7.1m)
Phase-out enclosed burners after 15 years' useful life	\$2.0m	not significant	\$2.0m
All three measures combined	\$9.1m	(\$13.6m)	(\$4.5m)

2.5 Sulphur dioxide

2.5.1 Sources

Sulphur dioxide (SO₂) is produced through the combustion of fuels that contain sulphur. Fuels with a significant sulphur content include coal, fuel oil and diesel. Petrol can also have a significant sulphur content, but this varies widely depending upon the source of the fuel.

In general, New Zealand is fortunate that it has industrial fuels with low sulphur contents when compared with the fuels used in many other countries. The sulphur content of petrol used in New Zealand is generally low. The sulphur content of diesel fuels available in New Zealand is, however, comparatively high.

SO₂ can also be emitted from a number of specific industrial operations, such as sulphuric acid manufacturing, the roasting or smelting of mineral ores containing sulphur, and oil refining.

Natural sources of SO₂ are volcanic and geothermal activity. Bacterial and algal processes can also produce organic sulphur compounds that are gradually converted to SO₂ in the atmosphere.

2.5.2 Emissions control strategies

As discussed previously, emissions to air from major industrial sources are controlled through discharge permits and regional air quality plans. Emissions reductions may be achieved by requiring the adoption of best-practice techniques. These include limiting the amount of sulphur in the fuel being burned and improving combustion leading to reduced fuel use. Non-regulatory programmes encouraging the adoption of cleaner production and alternative fuels may also be effective in reducing emissions.

In some cases, economic reasons will prompt the installation of sulphur recovery equipment to capture sulphur before it is emitted as SO₂ and enable the sale of that recovered material (National Environment Protection Council, 1998).

The VFECS (MoT, 1998) initiatives include one to review the automotive fuel specifications, to ensure that fuel qualities are compatible with the future emissions control, fuel-efficient technologies, best international practice and environmental requirements. This is particularly relevant if sulphur dioxide emissions need to be reduced, as the sulphur content of diesel affects both the SO₂ emissions from diesel vehicles and the generation of secondary sulphate particles (part of the PM10). A decrease in the proportion of diesel fuel vehicles making up the vehicle fleet would also reduce both SO₂ and secondary particle levels.

The Ministry of Economic Development is about to commence a review of the Petroleum Fuel Specifications.

Encouraging the adoption of alternative fuels, such as LPG, CNG and hydrogen, also has the potential to reduce emissions of SO₂ where it may be of concern. This option was not pursued as part of the VFECS because SO₂ from vehicles was not considered to be of sufficient concern in New Zealand (MoT, 1998). However, the role of SO₂ in fine particle formation and methods to address this need further investigation.

2.5.3 Benefits of emissions control

SO₂ has been associated with increases in daily mortality, hospital admissions and emergency room attendances for respiratory and cardiovascular disease, and respiratory symptoms and decreases in lung function. These health effects lead to significant economic and social costs in terms of premature death, increased health treatment costs, reduced productivity resulting from absences from employment or declining output resulting from ill health, and the social costs associated with increased illness.

Reductions in SO₂ levels may also lead to benefits through an avoided or reduced risk of damage to buildings and materials, damage to crops and vegetation, and acid deposition to water and soil. However, there are unlikely to be many situations where such levels are reached in New Zealand (MfE, 1997).

SO₂ is a significant pollutant not only because of the health effects it directly causes, but also as a result of the role it can play in the production of secondary particles. As such, any assessment of the benefits of reduction measures must also take into account the benefits that may be derived as a result of reduced levels of particles.

3 Priority hazardous air contaminants

This section briefly examines the strategies that can be pursued to reduce the priority hazardous air contaminants. The rationale for selecting these contaminants and implications of the proposed guideline values based on current ambient levels are contained within the Air Technical Report entitled *Health Effects of Eleven Hazardous Air Contaminants and Recommended Evaluation Criteria* (MfE, 2000).

3.1 Sources

Benzene

Sources of benzene in air include: motor vehicles, domestic solid-fuel heating, lawn-mowing and other petrol-engine machinery, service stations, oil refining and any other industries handling benzene (Victorian Environment Protection Authority, 1999). Motor vehicle exhaust emissions of benzene derive partly from unburnt benzene in the fuel, and partly from the dealkylation of other aromatic hydrocarbons in the petrol. This is also the case for lawn-mowers and other petrol-engine machinery. So, both the benzene and the aromatics content of petrol are important when addressing possible control measures. New Zealand petrol has fairly high concentrations of benzene and other aromatic hydrocarbons in comparison to petrol in other countries.

Toluene and xylene

Sources include motor vehicle exhausts, lawn-mowing and other petrol-engine machinery, evaporative emissions of fuels, surface-coating operations, and industries producing or using materials containing aromatic hydrocarbons, such as oil refining, petrochemical industries, adhesive formulation and dry-cleaning (Victorian Environment Protection Authority, 1999). For petrol handling and combustion, the aromatics content is the relevant fuel-quality parameter in managing emissions of toluene and xylene.

1,3-butadiene

Similarly, sources of 1,3-butadiene are motor vehicles, domestic solid-fuel heating, lawn-mowing and other petrol-engine machinery, and any industries handling 1,3-butadiene (Victorian Environment Protection Authority, 1999). The property of petrol relevant to emissions of 1,3-butadiene is the olefin content. The olefin content in New Zealand petrol is fairly high compared with other countries, and is currently unregulated.

Formaldehyde and acetaldehyde

These are both emitted as primary air pollutants and are also formed by secondary photochemical reactions in the atmosphere. Sources include motor vehicles, domestic solid-fuel combustion, and various types of industry, such as the manufacture of particle board, plywood, fabrics and furnishings.

Benzo(a)pyrene

This is commonly used as an indicator of polycyclic aromatic hydrocarbons (PAHs). Sources of PAHs include the combustion of solid fuels for home heating, motor vehicles, coke ovens, aluminium smelters, asphalt and pitch production, and waste incineration (Victorian Environment Protection Authority, 1999). PAHs arise from the incomplete combustion of solid and liquid fuels. They are semi-volatile compounds, and occur both in the gas phase and attached to particles.

Mercury

Specific sources include crematoria, waste incineration, gold recovery plants and chlor-alkali plants employing the mercury cell process (which was previously the case at one New Zealand pulp and paper mill). In New Zealand, volcanic and geothermal activity are probably the most significant sources of mercury.

Chromium

This can be released to the atmosphere from metal smelting and foundries, cement production, pulp and paper mills, chrome plating and leather tanning.

Arsenic

Sources include the burning of timber treated with arsenic preservatives, combustion of coal, and copper (and other metal) smelters.

3.2 Emissions control strategies

The range of emissions control strategies discussed in section 2 for managing the criteria air pollutants are obviously equally relevant for many hazardous air pollutants, given the commonality of major emission sources. For example, improving the combustion efficiency of domestic heating appliances through better design and operation will decrease emissions of various criteria air pollutants (such as particles) as well as priority hazardous air pollutants (such as benzene and benzo(a)pyrene), and lead to reduced operating costs. Improvements in fuel quality are also important.

As mentioned above, petrol in New Zealand contains fairly high concentrations of benzene, other aromatic hydrocarbons and olefins. Motor vehicle emissions controls, changes to the constituents in fuel (or changes in fuel types used), reducing congestion and measures to reduce demand for car travel are important potential management tools for achieving emissions reductions for these hazardous air pollutants.

Other possible control strategies that warrant consideration depending on the scale of problems with HAPs include:

- reducing emissions during the transport and handling of fuels, including the adoption of vapour recovery technologies at industrial sites and petrol stations
- options for fuel substitution to reduce emissions of hazardous air pollutants from combustion processes; for example, substituting the use of any coal, wood or liquid fuels with a high metals content, or the contained use of any geothermal steam with a high mercury content

- the use of alternative products or product components; for example, reducing the benzene content in petrol through the use of an alternative aromatic, or the use of paints with low volatile organics content
- the development of new industrial processes that do not involve the use of hazardous air pollutants or result in the formation of those air contaminants.

Benzene is likely to be the main air toxic that requires control. Based on the Auckland emissions inventory, the total 1993 VOC (volatile organic compounds) emissions in the Auckland Region were estimated to be about 65,000 tonnes. Of these, 63% came from motor vehicles, 13% from domestic solid-fuel combustion, 3.7% from domestic and commercial surface coating operations, and 5.3% from industrial coating operations.

The viable measures for achieving benzene emissions reductions are likely to be focused on sources such as motor vehicles and domestic solid-fuel combustion (which is a significant contributor in winter). Options for reducing benzene emissions from motor vehicles include controlling exhaust emissions and reducing the aromatic content of motor vehicle fuels.

3.3 Benefits of emissions control

Of the priority hazardous air pollutants, eight are carcinogens or suspected carcinogens: benzene, 1,3-butadiene, formaldehyde, acetaldehyde, benzo(a)pyrene, mercury, chromium and arsenic. The other two, toluene and xylene, are not carcinogens.

There are a range of adverse health effects from most or all of this set of hazardous air pollutants. These include: neurological effects such as central nervous system dysfunction, drowsiness, dizziness and headaches; respiratory effects including coughing and wheezing; irritation of eyes, nose and throat; sleep disturbance; impaired reaction time; and developmental effects such as reduced birth weights. Benefits of avoiding these adverse health effects include not only the avoided health costs, but also the social costs associated with ill health.

Bio-accumulation is an important issue to consider in assessing the potential impacts of some hazardous air pollutants, including mercury, arsenic and cadmium. It is a particular concern for mercury. Mercury emissions to air can lead to indirect human health and ecosystem effects through contamination of water, accumulation in fish and the consumption of those fish by humans. The economic and social impacts may also go well beyond the health effects by adversely affecting ecosystem health (for example impacts on fishing, as either a recreational or commercial activity). The benefits of avoiding these outcomes need to be taken into account in assessing the need for reductions in emissions of mercury.

Other environmental benefits may be derived from reduced emissions of some hazardous air pollutants. For example, formaldehyde and acetaldehyde are volatile organic compounds which are precursors to photochemical smog, and reductions in xylene and toluene emissions may avoid odour problems.

4 Key steps from here

4.1 Further assessment of costs and benefits

To conduct a more comprehensive analysis of the costs and benefits of air-quality guidelines/standards, as would be required to meet the requirements of section 32 of the RM Act, the following five basic steps would need to be undertaken:

1. confirm the key sources of each pollutant
2. check the available monitoring data to see which pollutants need action to bring levels below guideline levels or to maintain current low levels
3. check whether there are any additional management options for each pollutant apart from the ones listed in this document
4. investigate the costs and benefits of the identified management options
5. summarise the cost and benefit information.

As noted earlier, in assessing the costs and benefits a range of assessment techniques are used, it is important that the assessment of costs and benefits can be understood by stakeholders and decision-makers. As a result, it is not necessary to express all costs and benefits in monetary terms.

With this in mind, the assessment should be prepared:

- in a practical and common sense way, recognising that there are limits to the information available, and that policy judgements need to be taken in the absence of complete information
- to reflect the range of information used in the development of recommended levels, including scientific analysis, risks to the environment, community views and expressions of environmental values (both monetary and non-monetary)
- so that it is easy to understand, written in plain English and provides simple explanations of scientific, social and economic costs and benefits
- with a focus on key issues, detailing important decision points and discussing the key options considered
- to be as accurate as possible, recognising the uncertainties in anticipating the exact environmental, social and financial costs and benefits, and gaps in our understanding.

As an example of how the costs and benefits can be summarised, Table 5.1 gives estimates of benefits and costs of the Victorian Environment Protection Authority's works approval and licensing system.

Table 4.1: Benefits and costs of Victorian Environment Protection Authority regulations for licensing scheduled premises

Benefits	Costs
<p>A high level of assurance that premises with the potential for significant environmental impact are being effectively managed and are complying with the Environment Protection Act, thereby playing a key role in assuring a high level of environmental quality.</p> <p>A high degree of certainty to industry, with the Regulations providing estimated increased certainty in relation to environmental obligations (95% of companies interviewed), legal obligations (76% of companies interviewed), and investment planning (65% of companies interviewed).</p> <p>Retrofitting costs avoided and waste minimisation opportunities identified partly via the works approval process (estimates ranging from \$0.01m to \$1m per annum in cost savings in individual cases).</p> <p>Reduced likelihood of clean-up costs being passed on to the State (estimates up to \$12m in individual cases) as well as increased likelihood that clean-ups will occur more quickly.</p> <p>High degree of community confidence (with 80% of companies reporting that the works approval and licensing system helped them in terms of maintaining and improving their relationships with the local community).</p>	<p>Total annual licence fees of \$11.7m.</p> <p>Total annual works approval fees of \$0.48m.</p> <p>Total financial assurances in the range of \$0.23m to \$0.29m.</p> <p>Project delays in a small proportion of works approvals (estimated to involve 10–15% of applications).</p> <p>Average annual works approval administration costs to industry of approximately \$0.57m for average annual total project costs of \$520m.</p> <p>Annual licence administration costs to industry, which represent a small proportion of total operating costs or total environment management expenditure.</p> <p>Minor administration costs to other agencies.</p>

4.2 Attribution of costs and benefits

One of the major difficulties in assessing the costs and benefits of environmental regulations or standards is working out how much they have contributed to changes in behaviour.

The environmental management action taken by an industrial point source illustrates this point. A firm may spend money to reduce its air emissions of a particular pollutant. This investment may ensure that the firm complies with some new mandated standard, but does this mean that the costs and benefits of the firm’s action can be solely attributed to the new standard? Not necessarily: it may be that the firm has made the investment for a variety of reasons, including:

- a corporate commitment to act as an environmentally responsible firm (this may be driven by overseas head office policy)
- a desire to maintain good relations with its local community and employees
- a need to reduce emissions because of supply contracts that impose environmental standards
- an objective of reducing production costs through waste minimisation.

Furthermore, the timing of the investment is critical to determining the costs and benefits of that investment. In some cases, if a firm invests before the end of the normal productive life of its equipment in order to reduce emissions, the cost of control measures may be considerable. However, if steps are taken to reduce emissions during re-equipping or installing new equipment, the overall cost to the firm may be reduced. This is because new equipment is invariably more efficient than old equipment, and the emissions are therefore ‘cleaner’.

Any assessment conducted must take care to clearly identify the benefits and costs resulting from a policy or regulation. In particular, where the analysis suggests that management actions to improve air quality will occur as a result of other factors (such as those set out above), the benefits of those actions must not be attributed to the policy or regulation.

One way of addressing the problem of attributing benefits and costs is to send out a questionnaire to those who might have to take action to comply with recommended new levels. For example, the following questions could be asked of an industrial firm which is a point-source emitter of a particular pollutant:

- What factors influence your firm’s approach to environmental management?
- What incentives are there to reduce emissions through control equipment and other options?
- What are your firm’s capital investment plans for the next 5–10 years?
- If you reduce your emissions, will this result in any cost savings?

This approach can be also used for non-industrial sources of pollutants. The key challenges are to design the questionnaire carefully and interpret the results with the above factors in mind. Particular care needs to be taken in adopting this approach for use in assessing options for managing diffuse or mobile sources of pollutants.

4.3 Presentation of the assessment

There are various options for presenting an assessment of the impacts of adopting a set of air-quality guidelines, none of which is inherently superior. As noted above, there is a significant overlap in the major emission sources for many of the criteria air pollutants, priority hazardous air pollutants and the other air-quality issues discussed above. Therefore, costs and benefits could be presented in terms of:

- a pollutant-by-pollutant analysis, which inevitably involves overlap in terms of discussion of the same possible emissions reduction strategies for multiple pollutants
- emission sources, with an identification of which pollutants will be reduced and to what extent according to the various options for management of individual emission sources
- a region-by-region assessment, which identifies the reductions needed for individual urban areas, and sets out region-specific management options and benefit assessments.

For the development of Australia’s National Environment Protection Measure for Ambient Air Quality, a pollutant-by-pollutant approach was adopted, with significant discussion of the interrelationships between pollutants included in the discussion (National Environment Protection Council, 1998). Significant work on one source of many pollutants has already been conducted in New Zealand through the VFCS (MoT, 1997 and 1998).

A number of factors constrain the ability to conduct precise assessments of the management actions needed to achieve recommended guidelines, and the costs and benefits of achieving those guidelines. These include limitations in knowledge and understanding of:

- current ambient air quality, and therefore of the emissions reduction effort needed to meet the recommended guideline values in individual locations
- the relationships between changes in emissions and changes in ambient concentrations (particularly, the effect of meteorology on ambient levels, and the contribution of biogenic sources in different locations)
- the relative importance of various sources of emissions in each location
- the health benefits that will be achieved, given uncertain links between exposure and health outcomes and limitations in our understanding of the health impact of multiple-pollutant exposures
- the costs that may be faced to achieve emissions reduction in the future given the potential for new technologies to emerge, or for changes in the cost of existing technologies.

4.4 Resource requirements

The resource requirements for conducting a section 32 assessment of any guidelines or standards to be adopted are difficult to assess. This will depend on a range of factors, particularly:

- is the recommended guideline being exceeded, by how much, and in what areas (local, regional or national)?
- how many potential sources of emissions reduction need to be assessed?
- are the emissions reduction options local, regional, or national?

The assessment may range between a short and simple assessment to a very complex and expensive assessment depending on the extent of emissions reduction required and the complexity of assessing options to achieve that reduction. As noted above, any assessment needs to be conducted in a practical and common sense way, recognising that there are limits to the information and assessment techniques available, and that policy judgements sometimes need to be made in the absence of complete information.

5 References

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Appendix 1 - Section 32 of the Resource Management Act 1991

Section 32

- (1) *In achieving the purpose of this Act, before adopting any objective, policy, rule, or other method in relation to any function described in subsection (2), any person described in the subsection shall*
- (a) *Have regard to*
 - (i) *The extent (if any) to which any such objective, policy, rule, or other method is necessary in achieving the purpose of this Act; and*
 - (ii) *Other means in addition to or in place of such objective, policy, rule or other method which, under this Act or any other enactment, may be used in achieving the purpose of this Act, including the provision of information, services, or incentives, and the levying of charges (including rates); and*
 - (iii) *The reasons for and against adopting the proposed objective, policy, rule, or other method and the principal alternative means available, or no action where this Act does not require otherwise; and*
 - (b) *Carry out an evaluation, which that person is satisfied is appropriate to the circumstances, of the likely benefits and costs of the principal alternative means including, in the case of any rule or other method, the extent to which it is likely to be effective in achieving the objective or policy and the likely implementation and compliance costs; and*
 - (c) *Be satisfied that any such objective, policy, rule, or other method (or any combination thereof)*
 - (i) *Is necessary in achieving the purpose of the Act; and*
 - (ii) *Is the most appropriate means of exercising the function, having regard to its efficiency and effectiveness relative to other means.*
- (2) *Subsection (1) applies to*
- (a) *The Minister, in relation to*
 - (i) *The public notification of any proposed national policy statement or of any review of, change to, or revocation of any national policy statement;*
 - (ii) *Any recommendation that the Governor-General in Council approve any national policy statement or any review of, change to, or revocation of any national policy statement;*
 - (iii) *Any recommendation that regulations be made under section 43;*
 - (b) *The Minister of Conservation, in relation to*
 - (i) *The public notification of any proposed New Zealand coastal policy statement, or of any review of, change to, or revocation of any New Zealand coastal policy statement;*
 - (ii) *Any recommendation that the Governor-General in Council approve any New Zealand coastal policy statement or any review of, change to, or revocation of New Zealand coastal policy statement;*
 - (iii) *Any requirement, under clause 19(1) of the First Schedule, that a regional council make amendments to a regional coastal plan;*
 - (c) *Every local authority, in relation to*
 - (i) *The public notification, under clause 5 of the First Schedule, of any proposed regional policy statement or proposed plan or of any change to a regional policy statement or of any variation;*
 - (ii) *Any decision made by the local authority, under clause 10 of the First Schedule, on a proposed regional policy statement or proposed plan or on any change to any regional policy statement or on any variation;*
 - (iii) *Any decision made by the local authority under clause 29(4) of the First Schedule on any plan or change requested under clause 21 of that Schedule.*
- (3) *A challenge to any objective, policy, or rule, or other method, on the ground that subsection (1) has not been complied with, may be made only in a submission made under*
- (a) *Section 49 or section 50 or either of those sections as applied by section 57; or*

(b) The First Schedule.

(4) Every person on whom duties are imposed by subsection (1) shall prepare a record, in such form as that person considers appropriate, of the action taken, and the documentation prepared, by that person in the discharge of those duties.

(5) The record prepared by a local authority under subsection (4) in relation to the discharge by that local authority of the duties imposed on it by subsection (1), in relation to any public notification specified in subsection (2)(c)(i), shall be publicly available in accordance with section 35 as from the time of that public notification.