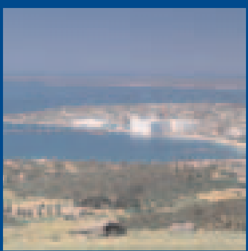
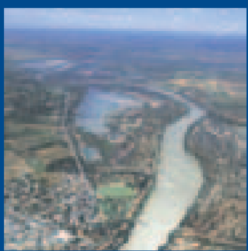
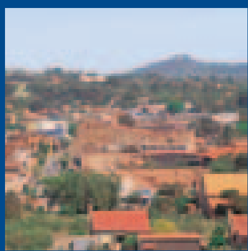
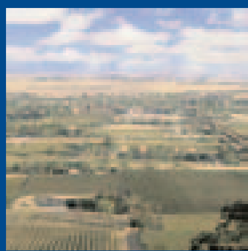
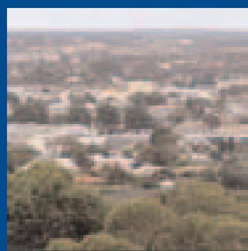
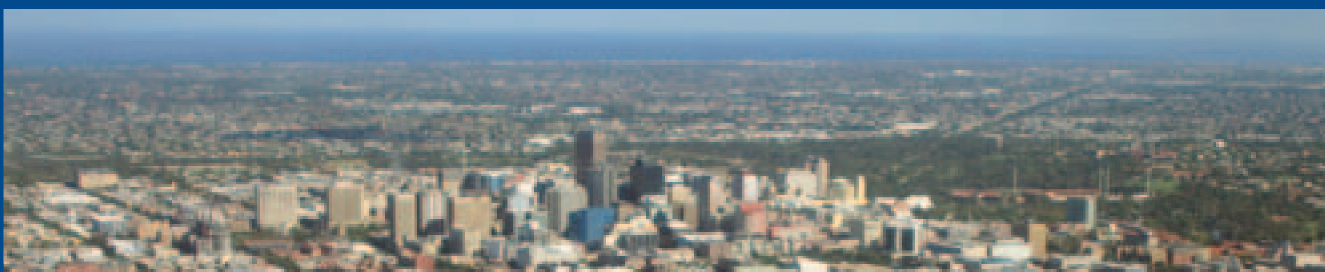
ENVIRONMENT PROTECTION AUTHORITY

South Australia's Ambient Air Quality Monitoring Program –a Review

Government of South Australia

EPA South Australia

AIR

South Australia's Ambient Air Quality Monitoring Program

A Review

May 2005

South Australia's Ambient Air Quality Monitoring Program: A Review

Author: Farah Adeeb

Cover photos representing SA airsheds (l to r): Port Lincoln (Eyre); Waikerie (Riverland); Whyalla (Upper Spencer Gulf); Barossa; Mount Gambier (South East); Adelaide

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ABBREVIATIONS

AAQFS	Australian Air Quality Forecasting System
Air NEPM	Ambient Air Quality National Environment Protection Measure
AMG	Australian Map Grid Co-ordinates
AQI	Air Quality Index
BoM	Bureau of Meteorology
CBD	central business district
CO	carbon monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EDMS	environmental data management system
EP Act	*Environment Protection Act 1993*
EPA	Environment Protection Authority
GIS	geospatial information system
HVS	high volume sampler
NATA	National Association of Testing Authorities
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
Ni	nickel
NO	nitrogen oxide
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
O_3	ozone
PAH	polycyclic aromatic hydrocarbons
Pb	lead
PIRSA	Primary Industries and Resource South Australia
PM_{10}	particles in the air of less than 10 μm in diameter (aerodynamic equivalent)
$PM_{2.5}$	particles in the air of less than 2.5 μm in diameter (aerodynamic equivalent)
PMS	performance monitoring station
PRC	Peer Review Committee
QA	quality assurance
QC	quality control

RPI	regional pollution index
SO_2	sulfur dioxide
SoE	State of Environment
TAPM	The Air Pollution Model
TEOM	tapered element oscillating microbalance
TSP	total suspended particles
ULP	unleaded petrol
Vic EPA	Victoria Environment Protection Authority
VOC	volatile organic compounds
WHO	World Health Organization

Units of measurement

$\mu g/m^3$	micrograms per cubic metre
μm	micrometre
kg	kilograms
mg/m^3	milligrams per cubic metre
mm	millimetres
MW	megawatts
ng/m^3	nanograms per cubic metre
ppm	parts per million by volume

SUMMARY

Air quality monitoring in South Australia was originally established to determine the state of our air quality. Since 1998 the monitoring has had the primary objective of meeting the requirements of the Ambient Air Quality National Environment Protection Measure (Air NEPM). However, it is generally recognised that the key objective of an air quality monitoring program is to determine the exposure of the community to pollutants and to assess the effectiveness of whatever standards have been adopted. It is also recognised that an air quality monitoring program's four main broad requirements are to:

- provide data for Air NEPM reporting on the state of air quality in South Australia
- determine trends over time
- provide data and information for State of the Environment (SoE) reporting
- provide data for the validation and verification of air pollution dispersion models
- assess the effectiveness of air quality management strategies.

The current South Australian monitoring program was established in 2001 following approval by the National Environment Protection Council of an Environment Protection Authority submission on the requirements of monitoring in metropolitan Adelaide and selected country regions. The submission covered the placement of air monitoring sites, instrumentation, data collection, handling and reporting issues. This report provides a description, critical analysis and initial review of the effectiveness and adequacy of the current air quality monitoring network in South Australia and makes recommendations for improving and streamlining the program.

The conclusion that the air quality monitoring network is reasonably extensive and appropriate, and that performance has improved over the past three years, is tempered by the fact that some important gaps remain in the locations of monitors to fulfil the requirements of the 2001 air plan, data quality, assessment and reporting. The major findings of this review are as follows:

- On a purely numerical basis, the current ambient air monitoring network generally compares well with the number of CO and SO_2 monitoring stations proposed in the 2001 monitoring plan. However, a notable gap exists between the number of operational PM_{10}, O_3 and NO_2 monitoring sites in metropolitan Adelaide and the number proposed, because monitoring sites in the southern area of the metropolitan Adelaide region and Hope Valley are not yet operational.

- There have been some delays in validating (3-4 months) and reporting the data (e.g. 2–4 years for the annual report). However, steps are being taken to minimise the time between data collection and reporting.

- The different levels of validated air quality data do not allow for the optimum use of the data; in many cases this creates confusion. An independent audit of air quality monitoring sites in Whyalla in early 2004 identified issues with data validation; however, significant efforts have been made to rectify the problem.

- The current monitoring program is dynamic in the sense that new sites are added as needed and old sites discontinued when they are no longer useful. However, a clear

understanding of how, when and why changes are made is lacking and relevant documents were not available at the time of this review.

Major conclusions from this review

1. An efficient reporting process needs to be developed. At the end of each campaign monitoring (12-month period), a report should be prepared that highlights the findings of the study, and includes discussion of the data gaps, uncertainties in measurements, concentrations of different pollutants obtained and recommendations for further work. It should also highlight the need (if any) for maintaining a permanent site.
2. Storage and maintenance of air quality data in the Environmental Data Management System (EDMS) should be arranged on a priority basis. Such a system should provide a download of complete validated air quality datasets for all measured pollutants.
3. Campaign monitoring for lead (Pb), sulfur dioxide (SO_2) and particulate matter of less than 10 micrometres (μm) equivalent aerodynamic diameter (PM_{10}) in the existing regional centres needs to be reviewed as a matter of priority.
4. The pollutants being monitored at Whyalla should be reconsidered. In particular, total suspended particulates (TSP) and PM_{10} monitoring should be thoroughly reviewed with an aim of rationalising the monitoring sites while still addressing community concerns.
5. The presentation of air monitoring data in the EPA air quality reports can be improved (e.g. by adding narrative to explain the significance or interpretation of the data presented, and use of pollution roses and box plots for visual depiction of the data).
6. The size distribution of particles is poorly understood in the Adelaide region and other areas of South Australia. It is recommended that short duration studies (e.g. one summer and winter) be conducted into particle size distribution at locations with specific particle pollution issues (e.g. Mount Gambier).
7. Monitoring site information on the web site could be improved (e.g. with GIS maps) to give, for example, details of site characteristics and distance of monitoring stations from roads.
8. The quality assurance program of the air monitoring laboratory covering each calendar year should be evaluated. This is required as part of NATA accreditation.
9. Particulate matter monitoring in the Mount Gambier region should be carried out as a priority.
10. To fulfil the requirements of the 2001 monitoring plan, it is suggested that a campaign monitoring site be established in the Riverland region for SO_2 and PM_{10}.
11. Consideration needs to be given to the use of airshed models to determine if significant photochemical pollutants accumulate in the outer fringe of Adelaide, especially in the southern areas. The results from such an analysis would assist in determining if the placement of monitors in these areas is appropriate. Air quality modelling can effectively complement and optimise the monitoring program.
12. A rigorous triennial (once in three years) review should be conducted to critically assess the ambient air quality program to determine if the program is successful in fulfilling the monitoring objectives of the EPA and, if necessary, adjusted every three years. The

Air NEPM requires revision of monitoring plans, so the timeframe for this revision might be appropriate. This is also to ensure that the ambient monitoring program is conducted efficiently and effectively, and remains relevant to legislative requirements and emerging priorities.

Main conclusions on the distribution of monitoring sites and site types

- Monitoring for O_3 and NO_2 should be discontinued at Northfield and Port Pirie. Consideration needs to be given for adding a monitoring station in the south of the city to comply with the requirements of the 2001 monitoring plan.
- At present most of the O_3 stations also monitor oxides of nitrogen (NO_x). To fully understand the complex relationship between O_3 and its precursors, measurement of VOCs at least at one of the O_3 station (at Netley) is recommended.
- Monitoring of CO at Elizabeth should be discontinued as the concentrations are very low.
- PM_{10} monitoring has the highest number of exceedences. This will probably continue to remain the case since suspended airborne matter is generally the most common concern, due to a wide variety of sources and wide spatial distribution. The current PM_{10} stations almost satisfy the locational requirements of the 2001 plan but the absence of monitoring sites in the southern metro area and at Hope Valley prevents the monitoring program from fulfilling current criteria. Due to growing interest in finer particulate emissions from wood smoke heaters, an additional monitoring site in the Adelaide Hills (e.g. at Mount Barker where growth in the region is greatest) is also needed. It is recommended that a campaign monitoring station be established in the Adelaide Hills to monitor PM_{10} and CO (pollutants associated with wood smoke).
- SO_2 monitoring in Port Pirie needs to continue.
- Meteorological data collection is an important component of the air monitoring program. Although the appropriate meteorological parameters are monitored, there are some issues with validated data not being available for most of the monitoring sites, especially historical data. The requirements for meteorological data related to air quality assessment, hotspot monitoring programs and modelling need to be reviewed in detail for South Australia.
- Hot spot monitoring at Birkenhead in the Port Adelaide area during 2004 recorded a number of exceedences of the PM_{10} standard. A permanent PM_{10} monitoring site should be established in this area, along with meteorological monitoring.

There is a need for a national protocol to assess the adequacy of an air quality monitoring network. There are quality assurance (QA) methods and protocols for data quality but no protocol for assessing the relevance of a network to current needs—i.e. are we monitoring the most appropriate pollutants?

The current monitoring network should be flexible enough to address issues of community concern. It is expected that discontinuing the monitoring of some pollutants at some sites will allow the redistribution of resources, thus improving the flexibility of the network.

1 INTRODUCTION

Air quality monitoring[1] in South Australia is conducted to assess compliance with national air quality standards, assess trends over time and for Statement of Environment (SoE) reporting and other purposes.

South Australia's current air monitoring program was established in 2001 following approval by the National Environment Protection Council (NEPC) of an Environment Protection Authority (EPA) submission on the requirements of monitoring in the more populated parts of the state. The submission included the placement of air monitoring sites, instrumentation, data collection, management and reporting air quality for the purposes of the Air NEPM (Clause 10, Air NEPM, established 26 June 1998). The Air NEPM (sulfur dioxide (SO_2), lead (Pb), ozone (O_3) nitrogen dioxide (NO_2) carbon monoxide (CO) and particulate matter of less than 10 micrometres (μm) equivalent aerodynamic diameter (PM_{10})) established a set of standards and goals for the six air pollutants and outlined the methods by which these pollutants were to be measured, assessed and reported. In May 2003, the Air NEPM was varied to include advisory reporting standards for $PM_{2.5}$ (particles less than 2.5 microns equivalent aerodynamic diameter)[2].

This report reviews the adequacy and appropriateness of the existing air quality monitoring, provides an initial exploration of the issues that surround the current monitoring program in South Australia, and makes recommendations to improve the program.

South Australia typically has good air quality most of the time and air quality in metropolitan Adelaide (population approximately 1.03 million) has significantly improved over the last ten years (EPA 2004). Overall, air pollution associated with SO_2 from stationary combustion sources has almost been eliminated in Adelaide. Road traffic has now become the greatest source of air pollution in the state and concern has clearly shifted to a range of pollutants associated with vehicles, which are relatively new in air quality control and management. Pollutants of most recent concern are $PM_{2.5}$ and a wide variety of volatile organic compounds (VOCs) including carcinogens such as benzene.

Ambient air quality monitoring in Adelaide from 1979 to 2003 (EPA 2004) determined that levels of CO, NO_2, O_3, SO_2 and Pb are very low and well below Air NEPM standards. Since the introduction of unleaded petrol in 1985, lead concentrations in air have been steadily decreasing. In 2002, they dropped to below 1% of the Air NEPM standard and as a result monitoring for lead in metropolitan Adelaide ceased in June 2003. Particle concentrations are also low most of the time, apart from occasional dust storms that elevate particle levels in Adelaide and in most parts of southern South Australia (i.e. cropping areas in the state). In the industrial centre of Port Pirie (site of the world's largest integrated lead and zinc smelter), Pb and SO_2 from the smelter continue to be a major problem to the nearby community. In the eastern end of Whyalla, particle

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[1] Ambient air quality monitoring is a scientific method for 'determining, at a specific point in time and space, the concentration or level of a particular pollutant present in the external atmosphere'.

[2] It was part of the plan that two of the monitors would be run as $PM_{2.5}$ and then reinstalled for PM_{10}. This has happened for the Elizabeth site. Then the $PM_{2.5}$ variation required South Australia to do co-location monitoring and so one of these TEOMs will remain at Netley for a period to do this.

concentrations still regularly exceed air quality criteria due to the influence of the steelwork's pellet plant.

1.1 Context

Air quality monitoring plays an important role in the understanding of air quality in South Australia. It determines whether air quality is adequate to protect the health and well-being of the population (see Appendix A for brief information on health impacts of air pollutants) and provides the platform for developing strategies to improve air quality when this proves necessary. The long history of air quality monitoring in South Australia began in Adelaide in the 1970s. Early in that decade, wet chemical methods were used for measuring SO_2, while a high volume sampler (HVS) was used for measuring dust concentrations in late 1970s. In the mid-1980s a program started to upgrade the HVS and to install a size-selective inlet for PM_{10}. The extensive long-term records at several sites for PM_{10} include some concurrent measurements of total suspended particles (TSP) and PM_{10}. Since late 2001 the number of stations and sophistication of their equipment has greatly increased with the expanded, and better funded, program.

The air quality monitoring network was outsourced between November 1996 and August 2001. After the contract was terminated the EPA was left with little and questionable quality data for that period and the instruments were generally in poor condition.

The EPA's current air quality monitoring program was fundamentally designed to meet requirements of the Air NEPM, which specifies the number of ambient air monitors required to produce adequate information about priority air quality issues in the airsheds (shown in Figure 1). The existing program has generally achieved this objective and has been a valuable tool in reporting the status of key air pollutants to NEPC and detecting trends in the state's air quality.

However, the monitoring program is not flexible enough to take into account changes in the nature and sources of pollution. It also does not cover the full range of pollutants for which information is required. There is a need for a wider range of data to address public concern over potentially harmful substances in the air (e.g. toxic air pollutants[3]), especially those whose adverse effects are evident at short-term exposure. Proper quality assurance and quality control measures are necessary to ensure that the data is efficiently turned into information and provides value for the costs incurred in running the monitoring program.

The EPA Strategic Plan (EPA 2002) outlines the importance of making data and information available for the community and for decisions on the environment. In order to deliver on this strategy, it is important to incorporate a range of tools, including web-based interfaces, timely air quality reports, technical documents and information brochures.

The review assesses the existing program to identify potential gaps and possible improvements. This report is mainly intended to review the program's scope and nature to ensure consistency with national requirements and pollutants of future concern, and

[3] Toxic air pollutants are pollutants (e.g. benzene, toluene) known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects.

to assess the degree to which current monitoring fulfills the needs of the EPA and the wider community.

This review defines the current performance of the monitoring program against particular NEPM standards—an objective assessment of whether monitoring should continue for specified species at each site. The review does not assess operation and maintenance of monitoring instruments and measurement techniques (EPA laboratories have recently undergone initial assessment for National Association of Testing Authorities (NATA) accreditation, and the performance of the laboratories has been discussed in internal NATA reports).

1.2 Objectives

The objectives of this report were to review whether:

- the current monitoring program meets Air NEPM requirements and particularly the 'Air Quality Monitoring' endorsed by NEPC in 2001
- the current arrangements for data collection, data storage, verification, assessment and reporting provide sufficient information to assist trend and comparative analysis
- monitoring is sufficient for other needs such as model verification purposes.

The specific focus of this document is on the measurement of both NEPM and non-NEPM air pollutants. Related issues, such as an overall assessment (e.g. quality control and quality assurance issues related to measurements), hotspot monitoring[4], measurement of meteorological parameters and air quality modelling are not treated in detail in this report.

1.3 Methodology

To carry out this review, four steps were taken:

1. **Pollutants of concern:** Appraisal of the pollutants of current and future concern was based principally on the understanding of national developments, together with discussion with different stakeholders.
2. **Existing monitoring program:** Information on current monitoring in South Australia in terms of pollutants covered, site type, site distribution, data management, assessment and reporting has been obtained from existing databases, the *Ambient Air Quality Monitoring Plan for South Australia* (EPA 2001), *State of the Environment Report* (EPA 2003) and the report on *Ambient Air Quality Monitoring in South Australia 1979-2003* (EPA 2004). The adequacy of current monitoring has been evaluated based on legislative requirements, consultation with various stakeholders, examples of similar air monitoring programs in other Australian states and extensive peer review.

[4] Monitoring designed to investigate pollution sources and assess air quality at a specific location.

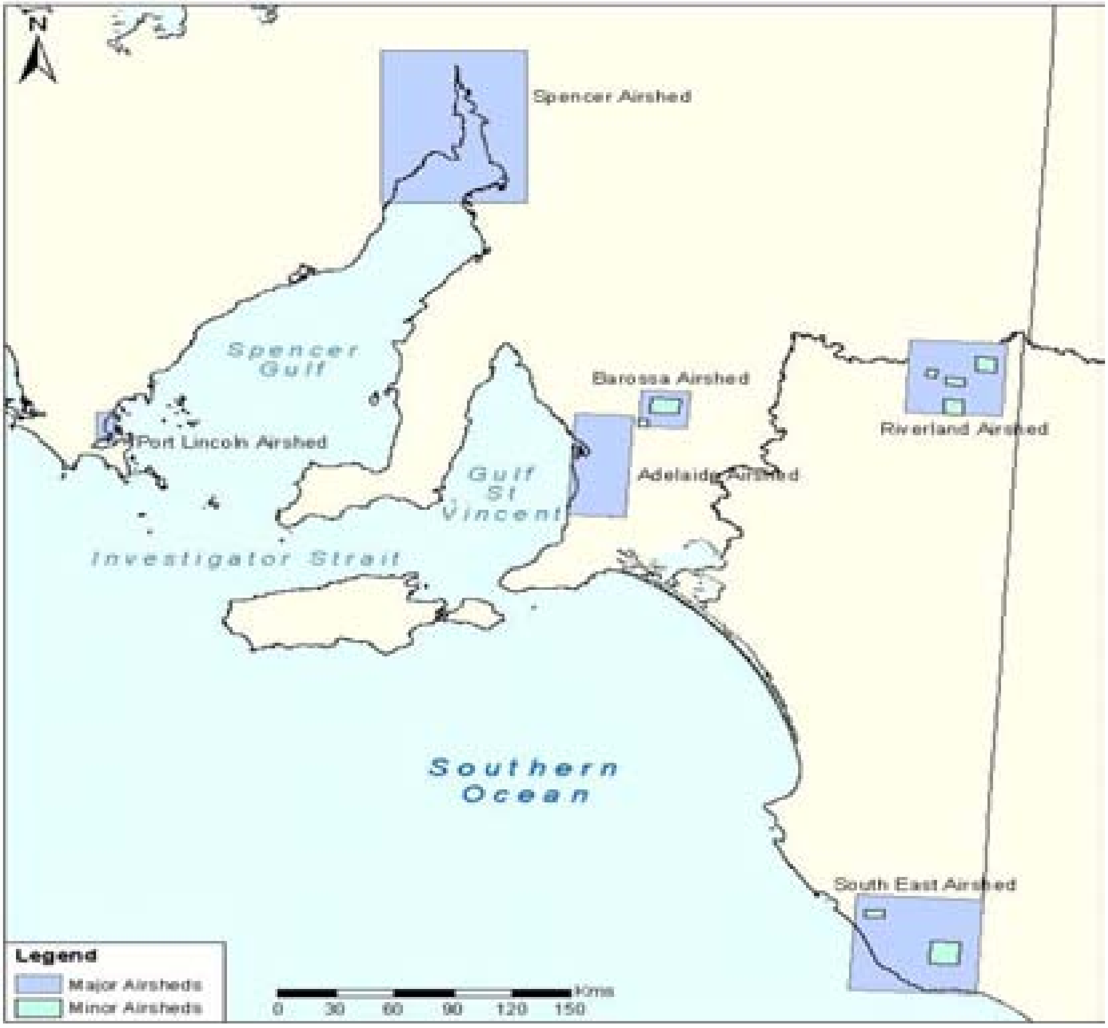

Figure 1. **Location of South Australian regional centres relevant to the Air NEPM and showing airsheds**

3. **Identification of gaps:** Gaps in the existing air quality monitoring program (including data management, assessment and reporting) were identified for both siting characteristics of monitors (i.e. locality of monitoring system) and pollutants monitored. The basis of discussion was mainly a comparison of the current monitoring program with the network proposed by EPA in 2001 (EPA 2001).
4. **Consultation:** Consultation has formed an important part of this review report. Interested parties were consulted on the EPA's current monitoring activities and future requirements through a facilitated consultation workshop in Adelaide, a survey on the current air quality index system sent to various stakeholders, and peer review of the report. A synthesis of comments from all reviewers was used to update the final draft report.

Facilitated consultation workshop

At the one-day consultation workshop, held in Adelaide on 21 April 2004 and attended by various stakeholders (listed in Appendix B), participants were divided into four groups and asked to comment on the following issues:

- Do the range and distribution of pollutants measured meet the required needs of the EPA? Are there any gaps in the range of pollutants measured?
- Do we need to add other stations elsewhere and/or other parameters?
- What outputs (e.g. reports/web-based data/newsletters) would you like to see?
- Are there opportunities for linking air quality monitoring programs (across government)?
- Are there any emerging issues that may need inclusion into the ambient air monitoring program?

The recommendations from the workshop have been incorporated into Chapters 4 and 5.

Air quality index survey

During October–November 2003, a survey was conducted of South Australian Government departments and selected private companies to assess the effectiveness and usefulness of the air quality index (AQI) reporting process and to seek opinions on its possible improvement. The results of the survey are discussed in Chapter 4 and attached in Appendix C.

1.4 Structure of report

The legislative framework and Air NEPM formulae for monitoring individual pollutants as applicable to South Australia is presented in Chapter 2. The level of monitoring currently in place is outlined in Chapter 3 with regard to pollutants covered and methods of measurement. Chapter 4 of the report examines the current state of the South Australia ambient air quality program and seeks to identify gaps in the program. Chapter 5 sets out recommendations for monitoring individual or groups of pollutants in the future, including those covered by the existing network and those for which measurement stations need to be established. Quality assurance, quality control and other relevant issues are also considered to some extent in Chapter 5.

2 Background

2.1 Legislative requirements—*Environment Protection Act 1993*

The EPA is required to undertake legislative monitoring and reporting requirements under the *Environment Protection Act 1993* (the Act).

The Act requires the EPA to provide for monitoring and reporting on environmental quality on a regular basis to ensure compliance with statutory requirements, and maintenance of a record of trends in environmental quality.

The EPA is also required to prepare and publish the SoE Report, which must:

- include an assessment of the condition of the major environmental resources of South Australia
- identify significant trends in environmental quality based on an analysis of indicators of environmental quality
- identify significant issues and make recommendations that should be drawn to the attention of the minister.

The *Environment Protection (Air Quality) Policy 1994,* together with the Act, is the principal legislation used to implement control of air pollutants in South Australia. The policy is currently under review, being declared a transitional policy when the Environment Protection Act replaced the *Clean Air Act 1983.*

The Air NEPM requires that each Australian jurisdiction reports on general air quality, breaches relative to NEPM standards, and trends based on monitoring network data. The Air NEPM was taken up automatically in South Australia through section 28A of the Act and operates as an Environment Protection Policy under that Act (NEPC 2003a).

2.2 Compliance with Air NEPM requirement

The Air NEPM places a requirement on South Australia to maintain and report on air quality within a nationally consistent approach (see the web site *www.ephc.gov.au/nepms/nepms.html* for details).

On 26 June 1998 the NEPC made the Air NEPM, which sets out health-based National Environment Protection standards and goals for six pollutants at an averaging period, maximum (average) concentration and frequency of allowable exceedences of the standard (see Table 1, or *www.ephc.gov.au/nepms/air/air_nepm.html* for more details). Compliance with the Air NEPM goal is achieved if the standard for a pollutant is exceeded on no more than a specified number of days in a calendar year (none or one day per year for all pollutants except PM_{10}, which may be exceeded no more than five days per year). The national environment protection goal of the Air NEPM is to achieve the standards (as assessed by the monitoring protocol) by 2008. A review of the Air NEPM is scheduled to begin in 2005[5].

[5] When the NEPC made the Air NEPM, it agreed to a program of future actions, including a staged review of some NEPM standards.

Table 1. Air NEPM standards and goals as contained in schedule 2 of the Air NEPM

Pollutant measured	Averaging period	Maximum concentration	Maximum allowable exceedences (NEPM goal)
Carbon monoxide (CO)	8 hours	9.0 ppm	1 day/year
Nitrogen dioxide (NO_2)	1 hour	0.12 ppm	1 day/year
	1 year	0.03 ppm	none
Ozone (O_3)	1 hour	0.10 ppm	1 day/year
	4 hours	0.08 ppm	1 day/year
Sulfur dioxide (SO_2)	1 hour	0.20 ppm	1 day/year
	1 day	0.08 ppm	1 day/year
	1 year	0.02 ppm	none
Lead (Pb)	1 year	0.50 µg/m^3	none
Particles as PM_{10}	1 day	50 µg/m^3	5 days/year

µg/m3 = micrograms per cubic metre; ppm = parts per million by volume

For the purposes of the Air NEPM the following definitions apply:

- Pb sampling must be carried out for a period for 24 hours at least every sixth day.
- Measurement of Pb must be carried out on TSP or its equivalent.
- Averaging periods are defined as:
    - 1 hour—clock hour average
    - 4 hour—rolling 4 hour average based on 1-hour averages
    - 8 hour—rolling 8 hour average based on 1-hour averages
    - 1 day—calendar day average
    - 1 year—calendar year average
- Time periods are defined as:
    - day—calendar day during which the associated standard is exceeded
    - year—calendar year
- All averaging periods of 8 hours or less must be referenced by the end time of the averaging period. This determines the calendar day to which the averaging periods are assigned.
- For the purposes of calculating and reporting 4- and 8-hour averages, the first rolling average in a calendar day ends at 1.00 am, and includes hours from the previous calendar day.
- Maximum concentrations are the arithmetic mean concentrations.

In May 2003, the NEPC made a variation to the Air NEPM, which introduces advisory reporting standards for fine particles 2.5 µm or less in size (Table 2).

Table 2. Air NEPM for $PM_{2.5}$ particles (NEPC 2003b)

24-hour	Annual mean
25 µg/m^3	8 µg/m^3

The advisory reporting standards will assist in gathering sufficient data nationally on fine particles, with the information used to inform the review process for the Air NEPM.

In regard to siting and operating performance monitoring stations, Clause 13, Air NEPM states:

1. To the extent practicable, performance monitoring stations should be sited in accordance with the requirements for Australian Standard AS 2922-1987. Any variations from AS 2922-1987 must be notified to council for use in assessing reports.
2. Performance monitoring station(s) must be located in a manner such that they contribute to obtaining a representative measure of the air quality likely to be experienced by the general population in the region or sub-region.
3. A performance monitoring station should be operated in the same location for at least 5 years unless the integrity of the measurements is affected by unforeseen circumstances (NEPC 1998).

Part four of the Air NEPM outlines the monitoring protocol to be followed by jurisdictions to determine whether the standards defined in the Air NEPM are being met. Clause 14 within Part 4 relates to the number of performance monitoring stations required. This clause is reproduced below:

1. Subject to sub-clauses (2) and (3) below, the number of performance monitoring stations for a region with a population of 25,000 people or more must be the next whole number above the number calculated in accordance with the formula:

   $1.5P+0.5$

   where P is the population of the region (in millions).
2. Additional performance monitoring stations may be needed where pollutant levels are influenced by local characteristics such as topography, weather or emission sources.
3. Fewer performance stations may be needed where it can be demonstrated that pollutant levels are reasonably expected to be consistently lower than the standards mentioned in this Measure (NEPC 1998).

Therefore, performance monitoring is only required in regions with a population of 25,000 people or more.

A performance monitoring station should be operated in the same location for at least five years unless the integrity of the measurements is affected by unforeseen circumstances (NEPC 1998).

The main aim of clauses 13 and 14 of the Air NEPM is to ensure that ambient air quality in public places poses no significant risk to health and quality of life but without imposing unacceptable social or economic costs. The locations of monitoring stations are thus chosen on the basis of determining pollutant distributions in populated areas and therefore focus on locations where members of the public are regularly present and may be exposed to pollutants over the averaging time of the NEPM standards.

2.3 Monitoring purpose

Monitoring can serve many purposes but unless these purposes are clearly defined at the outset there is a risk that the data collected will be inappropriate or will be subject to unreasonable expectations for its use. Ambient air quality monitoring can provide data which, given that it is sufficiently reliable (i.e. has gone through appropriate quality control and quality assurance procedures), can be used with appropriate analysis and interpretation, to:

- determine ambient concentrations of selected air pollutants
- determine the population's exposure to a particular ambient air pollutant
- provide the data necessary to meet Air NEPM and other applicable air quality standards and guidelines
- provide air quality information to the public and raise awareness
- establish a sound scientific basis for policy development
- provide exposure data for possible health effects studies, including evaluation of future interventions from changes in transport, fuel, etc.
- be able to determine within a reasonable time frame (5-7 years) whether there has been a statistically significant change in the key parameters of ambient air quality in an area
- provide data for SoE reports and other reports to the public on air quality
- assess the effectiveness of air pollution control policies/strategies, especially to establish scientific support for policy making on pollutant emission control, traffic management and industrial development
- validate and calibrate air pollution dispersion models.

Therefore, the ultimate purpose of monitoring should not be to merely collect data, but to provide consistent information based on that data for scientists, regulators, health agencies and public. It should help policy makers to make informed decisions in managing and improving the air quality in an area. In essence, a successful ambient monitoring program must be flexible and must offer value for the money being spent in monitoring. There is little value in monitoring a large number of sites for a broad range of characteristics in the hope that some will prove to be significant (Cugley 1995).

3 A review of the existing ambient air monitoring program

3.1 Introduction

This section sets out the current position in air quality monitoring in South Australia, and describes the organisational structure, the types and numbers of sites involved, the range of pollutants measured and the basic descriptive information (i.e. metadata) collected at selected air quality monitoring stations.

Information for this section has been obtained from the EPA's existing databases, reports, SoE report, annual reports to NEPC and the report on ambient air quality in South Australia during 1979-2003 (EPA 2004). The information reported focuses on long-term sites (still operational or recently decommissioned). Details were also provided for various mobile monitoring stations, or short-term sites (e.g. those set up to monitor around industry), but data was of limited value because of the short time span. This review did not examine actual monitoring data, but relied on the recent ambient air quality monitoring report (EPA 2004).

3.2 An overview of air monitoring regions in South Australia

The EPA's current monitoring stations are located in the following regions:

- metropolitan Adelaide
- Mount Gambier (city)[6]
- Upper Spencer Gulf (including the cities of Port Pirie, Port Augusta, Whyalla).

A brief overview of these regions follows. Details about physical characteristics of the regions can be found in the *Ambient Air Quality Monitoring Plan for South Australia* (EPA 2001).

Adelaide region

Adelaide (with a population of approximately 1.03 million) is the capital of South Australia and lies between the boundaries of 34° 55′ S and 138° 35′ E. The Adelaide plains are bounded on the east and south by the Mount Lofty Ranges, and by Gulf St Vincent to the west. The central portion of the Mount Lofty Ranges, to the east of the city, is known as the Adelaide Hills and includes the highest peak of the ranges—Mount Lofty—at about 700 m. South Australia's population is largely concentrated (73%) in the Adelaide metropolitan area.

Whyalla and Mount Gambier are the two largest centres outside Adelaide, followed by Port Pirie, Port Augusta and Gawler. Nearer to Adelaide, the largest settlements are Murray Bridge (12,831), Victor Harbor (7300) and Mount Barker (8300)[7]. Figure 2 shows the Adelaide airshed, with major EPA-licensed industries.

[6] Monitoring site in Mount Gambier was decommissioned in September 2002.

[7] Census data is for 2001 (*www.abs.gov.au* and www.citypopulation.de/Australia-UC.html#i666).

The Adelaide region is a Type 1 region[8] as detailed in National Environment Protection Council Peer Review Committee (PRC) guideline paper no. 2 (NEPC 2000b). Adelaide has no significant topographical features in the metropolitan area that can influence the general diurnal wind patterns within the coastal plain lying between the hills and the gulf. To the north, the airshed is open and pollutants are able to move up the coast beyond Gawler, given suitable meteorological conditions.

Adelaide has a moderate Mediterranean climate, with long, warm to hot summers and short, mild winters. Annual average rainfall in Adelaide is approximately 553 mm[9].

Significant point sources are either south of the residential suburbs, or in the north-western sector of the metropolitan area close to or on the Lefevre Peninsula and its port facilities. In the north-west are three gas-fired power stations totalling in excess of 1600 MW electrical capacity, as well as a cement works, soda ash plant and glass works.

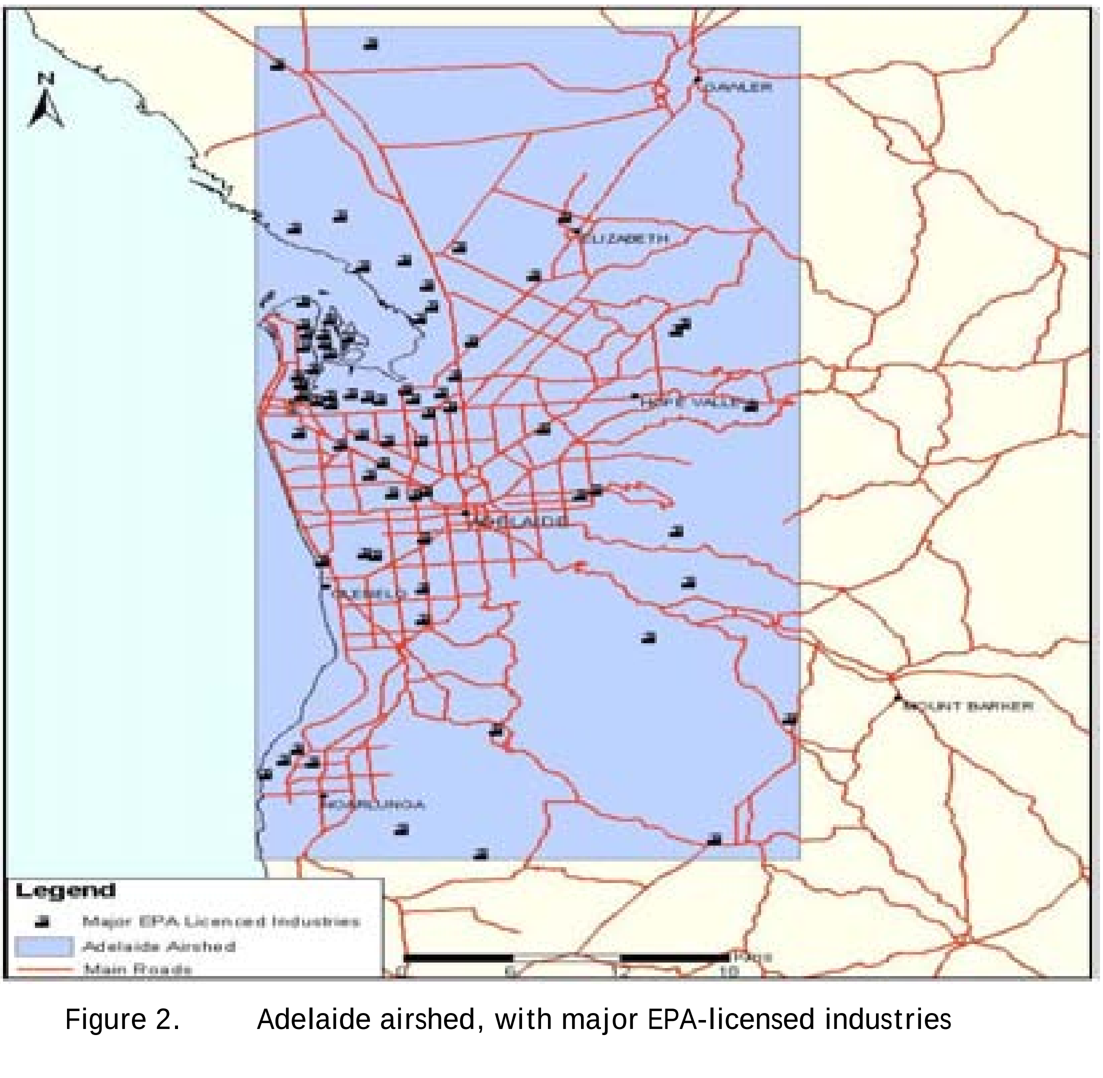

Figure 2. Adelaide airshed, with major EPA-licensed industries

8 Type 1: a large urban or town complex with a population in excess of 25,000 that requires direct monitoring and is contained within a single airshed.

9 www.bom.gov.au

Upper Spencer Gulf

The Upper Spencer Gulf holds a large steel works at Whyalla, a lead smelter at Port Pirie and the state's only brown coal power station at Port Augusta. It is considered a Type 2 region[10] as defined in National Environment Protection Council Peer Review Committee (PRC) guideline paper no. 2 (NEPC 2000b). Figure 3 shows the Upper Spencer Gulf airshed including Port Augusta, Port Pirie and Whyalla airsheds.

Whyalla

Whyalla, located on the western side of Spencer Gulf, is South Australia's largest regional city, with a population of 24,000 residents. Early settlement was close to the major industry and newer development extends westward away from the coastline. Overall, the land in Whyalla rises gently from the coastline to the Middleback Range west of the city plain. There are drainage flows from the ranges to the west and gulf breezes from the east.

Air pollution from industrial activities is a major concern in Whyalla. The steelworks, currently trading as OneSteel Manufacturing Pty Ltd, produce structural steel, rails and semi-finished slabs, billets and blooms, and has a capacity of 1.2 million tonnes of metal product per year. The steel plant is the primary industrial source in the town, especially of particulate matter (ENVIRON 2003).

Ambient air quality monitoring shows that, for periods of short duration, relatively high particulate matter concentrations are recorded in the vicinity of the pellet plant at the eastern end of Whyalla. Analysis of the ambient monitoring data also shows that particulate impacts arising from OneSteel's emissions reduce substantially with increasing distance from the pellet plant (ENVIRON 2003). Most of the dust generated from the pellet plant is fugitive in nature.

Port Augusta

Port Augusta has a population of about 14,000 and is located approximately 322 km north of Adelaide, at the head of the Spencer Gulf. The terrain of the city is flat; the Flinders Ranges are approximately 12 km east of the town. An average summer day temperature is 32.2ºC, while an average winter day temperature is 17.1ºC; average annual rainfall is around 243 mm.

NRG Flinders' Augusta power stations are located approximately 5 km south of the Port Augusta township, on the eastern side of Spencer Gulf. The stations comprise the coal-fired generating plants of Northern Power Station (2x260 MW baseline plant) and the recently refurbished Playford 'B' Power Station (250 MW peaking plant, currently in commissioning phase). Electricity generated is sold into the National Electricity Market. Coal burnt at Augusta power stations, mined at Leigh Creek approximately 250 km north of Port Augusta and railed to Augusta power stations, is a lignite or brown coal of approximately 28% moisture and 22% ash.

The most common air emissions from coal-fired power station stacks are oxides of nitrogen (NOx), SO_2 and particulates (carbon dioxide, which is also emitted, is dealt with under national greenhouse gas issues and not discussed here). Dispersion of these pollutants is by the station stacks (apart from some fugitive particulate emissions),

[10] Type 2: a region with no one population centre above 25,000 but with a total population above 25,000 and with significant point source or area-based emissions so as to require a level of direct monitoring.

which were designed using plume dispersion modelling based on local topography, meteorology and impact assessment. Nevertheless, particulate emissions from the Playford 'B' Power station have in recent years been the main community concern about the operation of the facility. Consequently, NRG Flinders has committed significant expenditure on refurbishing Playford 'B' Power station, and major environmental improvements are expected from the installation of low dust coal-handing equipment; low NO_x burners; and a baghouse system to replace the old electrostatic precipitators (designed to reduce operational particulate levels to below 75 mg/m^3, considerably lower than the current Environment Protection (Air Quality Policy (1994[11]) limit of 250 mg/m^3)).

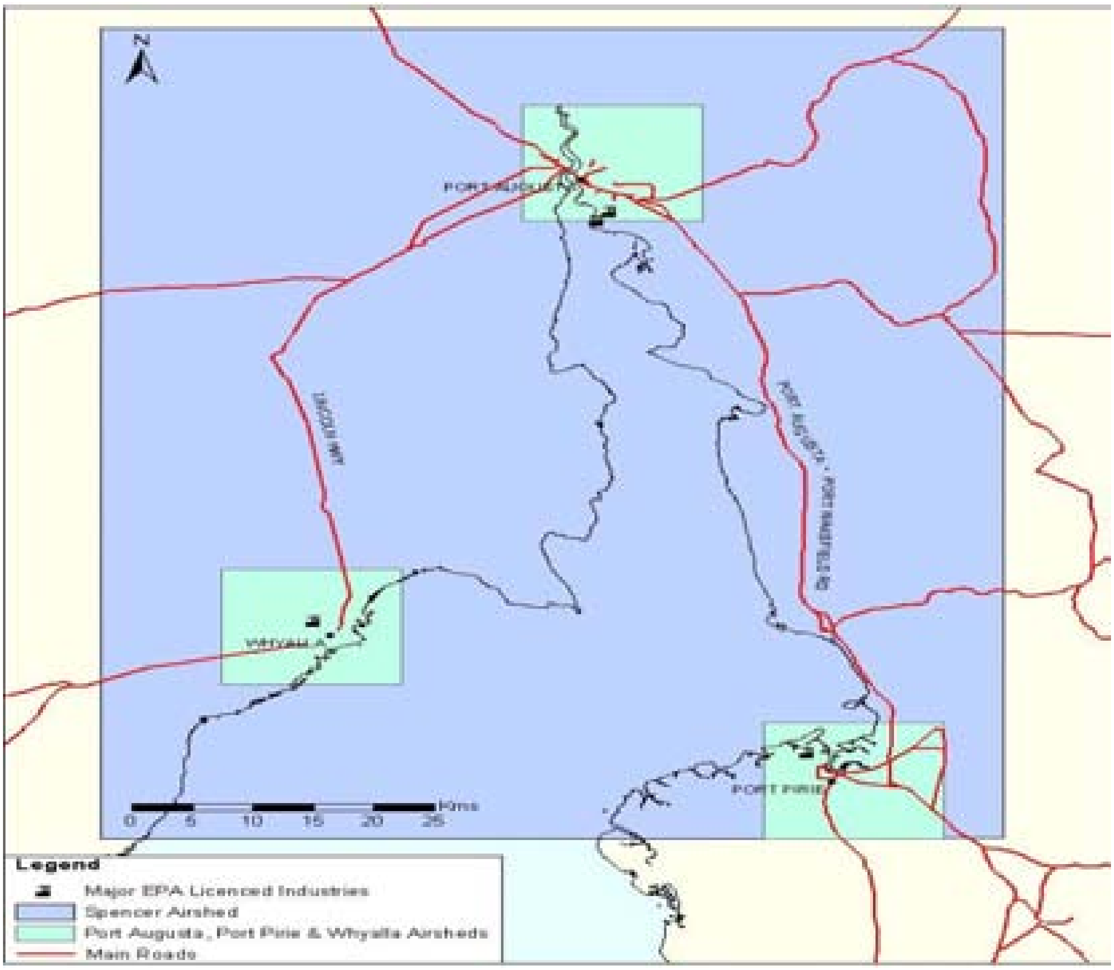

Figure 3. Upper Spencer Gulf airshed with major EPA-licensed industries

Port Pirie

Port Pirie (229 km north of Adelaide) has a population of 15,000. It is located on the east coast of Spencer Gulf in the mid-north of South Australia. The city has been a major port and industrial centre since about 1900. The world's largest lead smelter, currently owned by Zinifex Ltd (formerly Pasminco), is based in Port Pirie. Other

[11] http://www.epa.sa.gov.au/pdfs/epp_air.pdf.

principal industries include medium to heavy engineering, fish processing, fibreglass manufacturing, industrial clothing manufacturing and dairy processing.

Night-time drainage in Port Pirie from the Flinders Ranges (a few kilometres east of Port Pirie) has been considered important to the distribution of certain air emissions around Port Pirie.

Due to the presence of the lead smelter, Port Pirie has been the focus of extensive studies (by CSIRO, Department of Human Services (now Department of Health) and the EPA) on Pb and SO_2 over the past 30 years. A famous Port Pirie landmark, the 'tall stack' (205-metre chimney), was built in 1979 to overcome air pollution in the town. It was specifically designed to disperse gases (mainly SO_2) to the atmosphere high above the town to ensure a constant and improved air quality. Hibberd et al. (1996) found that a thermal internal boundary layer can result in incidences of unusually high but localised concentrations of SO_2 in a section of the city. The study also indicated that for 98.5% of the time the tall stack works effectively. When it does not work effectively a sulfurous odour may pervade the town (mostly under convective[12] weather conditions).

Mount Gambier

The Mount Gambier Region (Type 2 region) contains the majority of the state's large timber mills, creosote treatment plants and particleboard plants, emissions from which can lead to high ambient level of atmospheric particulates. Figure 4 shows the South East with Mount Gambier and Millicent airsheds[13].

The city of Mount Gambier is South Australia's second largest urban centre, with a population of about 23,600. It is situated 460 km south-east of Adelaide.

The primarily rural area surrounding Mount Gambier supports farming, horticulture, dairying and forests. The region is bordered to the north and east by farmlands and forests, and to the south and west by coastal geography.

The volcanic surrounds of Blue Lake and Valley Lake rise to 170 m, while the rest of the land ranges 30–60 m above sea level. This physical setting is favourable to the build-up of air pollutants.

The climate of Mount Gambier is Mediterranean, with summer day temperatures of 16-42°C (the latter being very rare). Annual rainfall averages about 700 mm and most rains occur during the period May-October.

The winds are predominantly southerly, ranging from south-easterly to south-westerly for about 50% of the time. North to north-westerly winds are recorded for approximately 35% of a year.

The large wood processing industry in the area may contribute to particle concentrations in the region. Given the coldness of the climate and the abundance of wood, wood heaters are extensively used in winter, which can lead to high ambient levels of atmospheric particulates.

[12] Convection is defined as mass motions within a fluid causing transport and mixing of properties of that fluid.

[13] Millicent airshed is shown for convenience only. It does not have any major industries and has no major licensed sites.

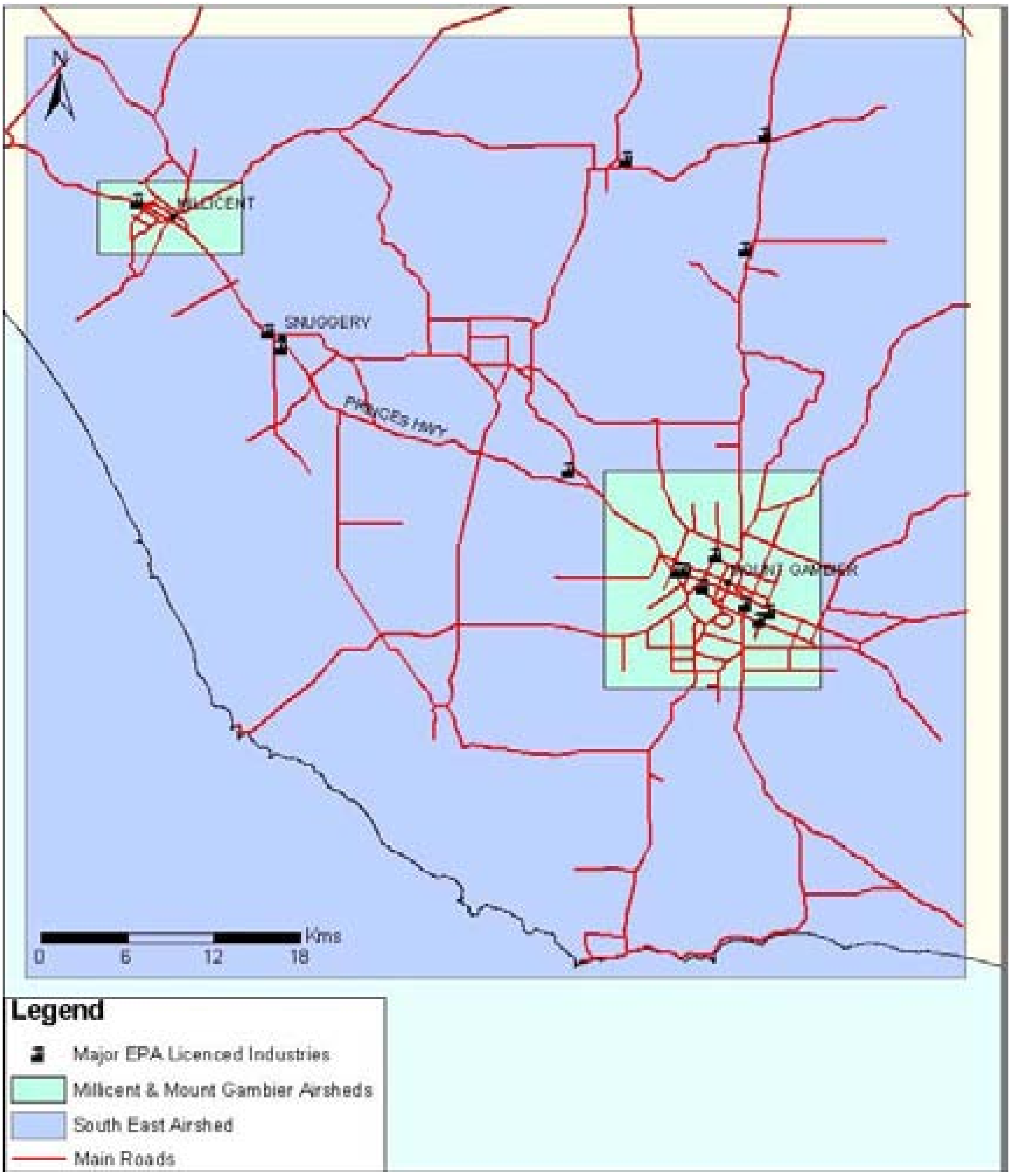

Figure 4. South East airshed, with major EPA-licensed industries

3.3 Current performance monitoring stations

The current performance monitoring stations and the pollutants monitored at each are summarised in Table 3a, while Table 3b shows current non-NEPM monitoring sites. Sites are classified according to Air NEPM recommendations: performance monitoring station (PMS), trend, campaign, or industrial. A PMS station measures performance against national standards and is intended to remain in place over at least five years; a trend station is used to reveal trends over a set period of time, usually at least ten years, and is, by definition, a PMS site; campaign monitors are placed in situ temporarily (usually for 12 months), in order to determine if ongoing monitoring is necessary for that site. Monitoring can also be conducted at the request of an industry, or as required by legislation or through industrial licence conditions.

The site at Hindley Street, Adelaide does not fit any of these definitions. This is a 'peak' site but also a PMS site. It has been placed to measure the peak exposure to air pollutants of workers, visitors and residents of the Adelaide central business district (CBD).

The current monitoring set-up is a mixture of long-term monitoring ('historical') sites and new sites developed from 2002 onwards. Trend analyses generally require fixed sites operating for several years in order to make comparisons with other environmental/health indicators, evaluate legislative and policy implementations and monitor the changing state of the environment. Figure 5 shows the locations of monitoring sites in the Adelaide region. The Mount Gambier site (Figure 6), which is no longer operational, measured NO_2, O_3, SO_2 and PM_{10}. All Port Pirie sites (Figure 7) measure Pb and the Oliver Street site also measures PM_{10}. PM_{10} and TSP are measured at the Whyalla (Figure 8) and Port Augusta (Figure 9) sites.

During 2002 and 2003 the EPA either upgraded monitoring stations and instruments or created new sites to fulfil commitments outlined in the ambient air quality monitoring plan (EPA 2001):

- Air NEPM sites at Elizabeth, Netley and Kensington were upgraded.
- The campaign monitoring site at Gawler was upgraded.
- A campaign monitoring site was developed for Port Pirie (commissioned in the last quarter of 2002 and includes O_3, NO_2 and SO_2 and a continuous PM_{10} monitor).
- A campaign monitoring site at Whyalla (O_3, NO, PM_{10} and SO_2) was established.

Gawler campaign monitoring site and the Port Pirie Oliver Street campaign monitoring site were closed down at the end of 2004 and will be moved to Christies Beach High School and Port Augusta respectively.

Table 3. Summary of South Australian current performance monitoring stations

(a)

Performance monitoring station	Region (site type)	Air NEPM pollutants measured						
		CO	NO_2	O_3	SO_2	Pb	PM_{10}[a]	$PM_{2.5}$
Gawler[b]	Adelaide (Campaign)		√	√			√	
Elizabeth	Adelaide (Trend/PMS)	√	√	√	√		√	
Northfield	Adelaide (PMS)		√	√	√		√	
Netley	Adelaide (PMS)		√	√			√	√
Kensington[c]	Adelaide (PMS)		√	√	√		√	√
Christies Beach	Adelaide (Peak)				√			
Hindley Street	Adelaide (Peak)	√						
Mt Gambier[d]	South East (Campaign)		√	√	√		√	
Port Pirie Oliver St	Spencer (PMS)		√	√	√	√	√	
Pt Pirie West Primary School (The Terrace)	Spencer (Peak)					√		
Pt Pirie Frank Green Park (Senate Rd)	Spencer (PMS)					√		
Whyalla Civic Park	Spencer (PMS)							

a PM_{10} monitoring sites include TEOM and gravimetric sites (i.e. using HVSs).

b Monitoring at Gawler discontinued in October 2004.

c $PM_{2.5}$ monitoring at Kensington discontinued in March 2004 when the TEOM was moved to Elizabeth to monitor PM_{10}.

d Monitoring site in Mount Gambier no longer operational.

(b)

Non-NEPM monitoring station	Pollutants measured	
	TSP	PM_{10}
Ellen Street (Port Pirie)	√	√
Hummock Hill, Whyalla	√	√
Walls Street, Whyalla		√
Osborne (Penrice)	√	√

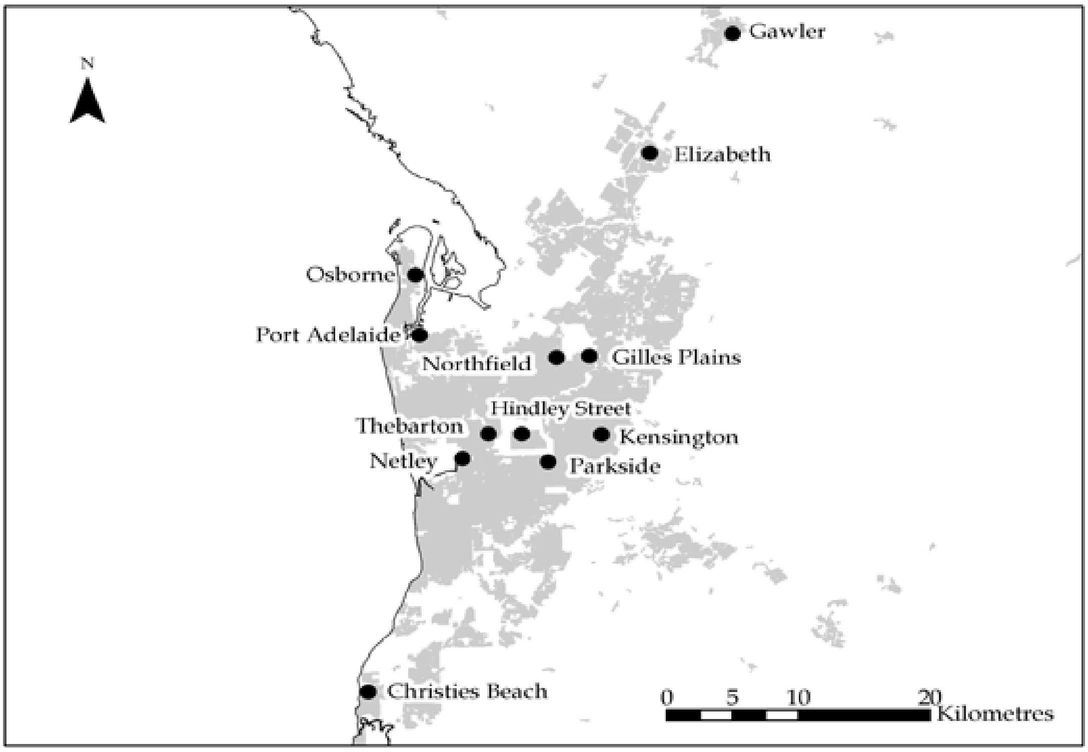

Figure 5. Ambient air quality sites in the Adelaide airshed (current and recently decommissioned). Parkside, Gilles Plains, Thebarton and Port Adelaide are no longer operational. Osborne is an industrial (peak) site.

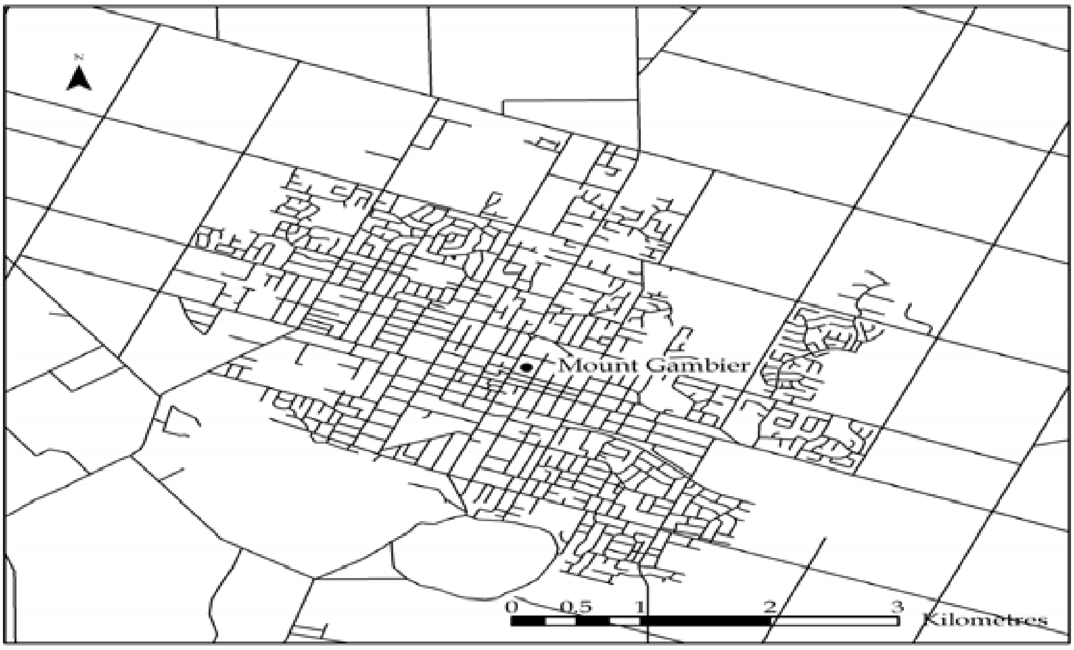

Figure 6. Ambient air quality sites in Mount Gambier

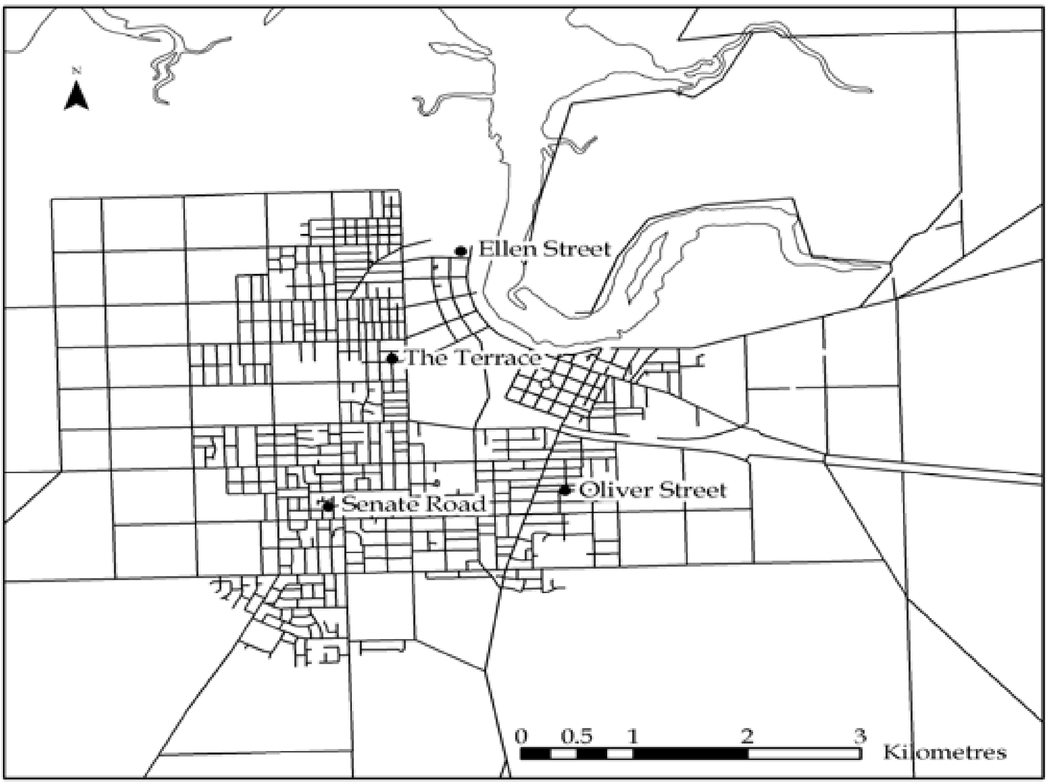

Figure 7. **Ambient air quality sites in Port Pirie. Ellen Street site is not a NEPM site.**

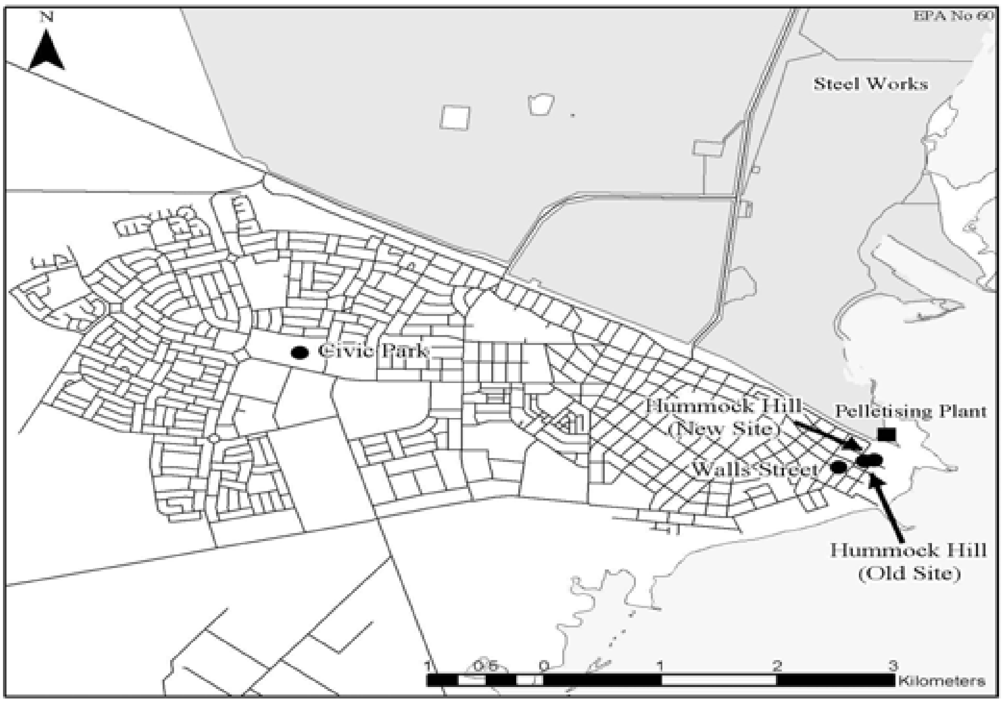

Figure 8. **Map of the Whyalla monitoring sites and location of EPA-licensed industry. Walls Street and Hummock Hill sites are not NEPM sites.**

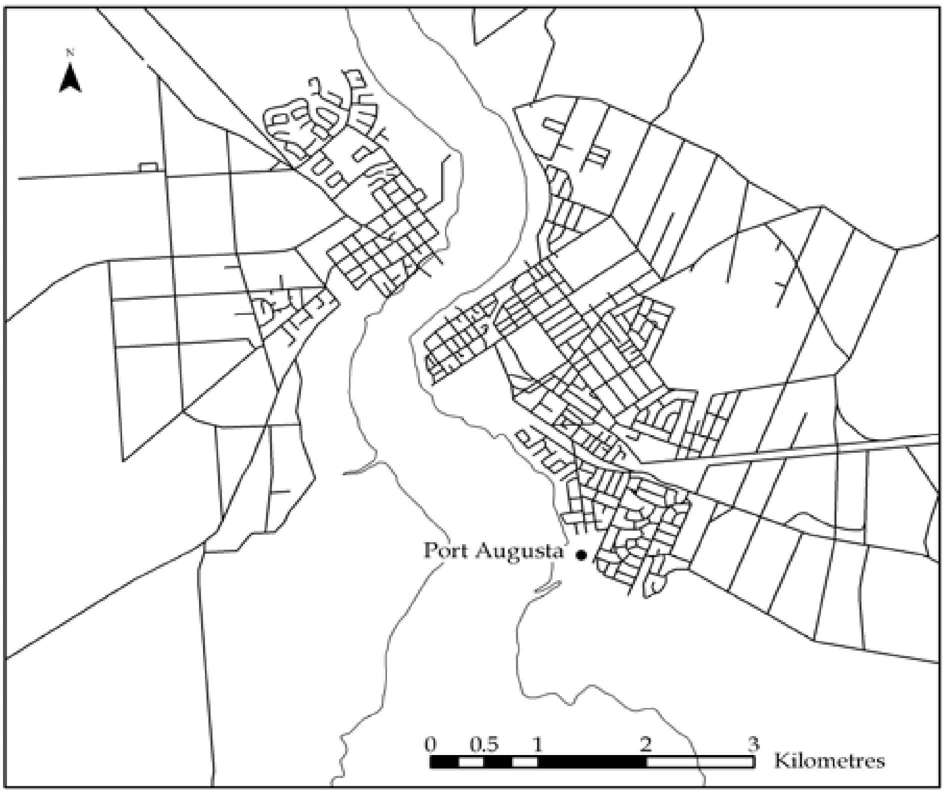

Figure 9. Ambient air quality site in Port Augusta

3.4 Monitoring methods

Concentrations of pollutants in air are usually measured as average values over a specified period of time, which can range from minutes up to a year depending upon the pollutant, the purpose of monitoring and the method employed. Automatic monitoring stations for the continuous measurement of pollutants are the most prevalent in South Australia. Continuous monitoring using automatic analysers typically produces hourly or shorter period average concentrations. The air sample is analysed in real time, which makes this method particularly well suited to the rapid transfer and dissemination of data. The techniques used to measure the six air quality parameters in South Australia are given in Appendix D.

3.5 Monitoring of individual pollutants

Carbon monoxide

Air NEPM standard

9.0 ppm measured as an 8-hour rolling average, not to be exceeded more than once per year.

Measurements in Adelaide

CO is measured at two sites in South Australia, both in metropolitan Adelaide: Hindley Street (city) and Elizabeth.

Hindley Street Adelaide (1988-2003): In Adelaide, CO has been monitored continuously since 1988, in the relatively narrow, busy Hindley Street within the CBD. The site is an area of high traffic density and low traffic flow, so vehicles tend to sit under idling conditions for extended periods. The absence of exceedences of the standard since 1997 is mainly attributed to improvements in traffic flow and reductions in vehicle emissions. At Hindley Street in 2003, eight-hour averages of CO were within the range 0-6.0 ppm, well below the NEPM standard of 9.0 ppm.

Elizabeth (2002-2003): CO has been measured at Elizabeth (newly established site in a residential area), within a school in a suburban area well away from arterial roads (~1 km) since 2002. There have been no exceedences of the standard since monitoring began. The site is regarded as being representative of most Adelaide residential areas (with predominance of domestic wood-fired heaters and dispersed vehicle emissions).

At Elizabeth in 2003, eight-hour averages of CO were within the range 0-1.4 ppm, well below the NEPM standard of 9.0 ppm.

Sulfur dioxide (SO_2)

Air NEPM standard

0.20 ppm[14] averaged over 1 hour and 0.08 ppm averaged over 1 day, no more than one exceedence allowed per year; annual standard of 0.03 ppm not to be exceeded.

Measurements in Adelaide

The EPA conducts Air NEPM monitoring of SO_2 in the ambient atmosphere at locations throughout the Adelaide airshed (Northfield, Kensington, Elizabeth and Christies Beach). Apart from Christies Beach, which lies south of Adelaide city, all monitoring is in residential locations with no significant SO_2 sources nearby. A recent report on the status of SO_2 air quality monitoring in metropolitan Adelaide (Riordan and Adeeb 2004) is available at *www.epa.sa.gov.au/pdfs/SO2_report.pdf*. As a result, monitoring for SO_2 in Adelaide has ceased at all sites except Northfield.

Christies Beach (1992-2003): SO_2 has been measured at Christies Beach, south of Adelaide, since 1992. There has been only one exceedence of the one–hour standard since 1996, when a severe plant malfunction occurred at the nearby refinery. The refinery has now closed. The maximum concentration recorded in 2003 was 0.059 ppm, much lower (by 74%) than the previous year and is most likely attributed to the closure of the refinery in July. As the oil refinery is no longer in operation, and levels of SO_2 since that time have been negligible, it is expected that these criteria will continue to be met for the foreseeable future. Monitoring for SO_2 at this site ceased in Dec 2004.

Elizabeth (2002-2003): SO_2 monitoring at Elizabeth started in May 2002. At Elizabeth, in 2003, one-hour averages of SO_2 were within the range 0-0.032 ppm, with an average for the year of 0.001 ppm. There were no exceedences of the Air NEPM standard (0.20 ppm as a one-hour average) and thus no exceedences of either the one-day (0.08 ppm)

[14] Conversion factor between ppm (volume/volume) and μg/m³ is inversely proportional to the absolute temperature. Australia assumes 0°C as a reference temperature. At 0°C, the conversion factor is 1 ppm = 2,860 μg/m³. This conversion factor is specifically for SO_2 (since it is dependent on molar weight).

or yearly (0.02 ppm) NEPM standard for 2002 and 2003. Monitoring for SO_2 at this site ceased in Dec 2004.

Northfield (2002-2003): One-hour averages of SO_2 at Northfield in 2003 were within the range 0-0.009 ppm, with the average over the year being <0.001 ppm. There were no exceedences of hourly or daily NEPM standard over 2002-2003. Monitoring continues at this site.

Kensington (2002-2003): Kensington is classed as a campaign site. Acceptance limits for the National Environment Protection Peer Review Committee screening procedure (NEPC 2001a) are 55% of the NEPM one-hour standard for one year, or 60% for two or more years, of data collection.

At Kensington, the maximum hourly concentration for 2003 was 0.045 ppm, which is 0.225%* of the NEPM one-hour standard of 0.20 ppm and substantially less than 55% of the standard. Thus the station at Kensington meets the screening criteria for a campaign site. Monitoring for SO_2 at this site ceased in Dec 2004.

Measurements in Upper Spencer Gulf

Port Pirie (2002-2003): SO_2 is measured only at the Oliver Street site in Port Pirie, which is located in a suburb in a suburb approximately 25 km south-south-east of the Zinifex Ltd lead smelter. Monitoring began at this site in June 2002 as part of NEPM campaign monitoring. In six months in 2003 (26 June–31 December) 23 exceedences of the one-hour NEPM standard (0.20 ppm) were recorded and 27 were recorded in 2003. No exceedences were measured for the one-day (0.08 ppm) NEPM standard in 2002, and there was one one-day exceedence in 2003.

The Department of Health is currently reviewing the SO_2 data from Oliver Street site and its recommendations for future monitoring at this site are pending.

Nitrogen dioxide

Air NEPM standard

0.120 ppm measured as an hourly average, 0.03 ppm averaged over one year.

Measurements in Adelaide

The five sites in metropolitan Adelaide began monitoring NO_2 at different times: in 1979 at Northfield, in 1988 at Netley, in 2001 at Kensington, and in 2002 at Elizabeth and Gawler.

In 2003, one-hour averages of NO_2 at the first three sites were within the range 0-0.040 ppm, with an average for the year of 0.007 ppm at Northfield, 0.008 ppm at Netley and 0.005 ppm at Kensington. At all three sites, the levels were well below the NEPM standards.

There have not been any exceedences of the standard since operations began at the Gawler and Elizabeth sites in January 2002. The one-hour average over the year for Gawler in 2003 was 0.003 ppm and for Elizabeth 0.004 ppm, again well below the NEPM standard of 0.03 ppm.

* Erratum: this figure should read '22.5%'

Overall, NO_2 concentrations have decreased in the Adelaide airshed (EPA 2004) and the one-hour NEPM criterion of 0.12 ppm has not been exceeded since 1991 at the long-term monitoring sites (i.e. Northfield, Netley).

Measurements in Upper Spencer Gulf

Port Pirie (2002-2003): NO_2 is measured at the Oliver Street site in Port Pirie, where monitoring began in June 2002 as part of NEPM campaign monitoring. In 2002, one-hour averages of NO_2 were within the range 0-0.019 ppm, with an average for the five months of monitoring of 0.003 ppm. In 2003, one-hour averages were within the range 0-0.016 ppm. No exceedences of NO_2 were recorded in either year.

Lead

Air NEPM standard

0.5 $\mu g/m^3$ measured as an annual average.

Measurements in Adelaide

The monitoring sites in metropolitan Adelaide cover a variety of locations, including suburban, inner city and alongside major high traffic flows, with most of them directed at observing the effects of motor vehicle emissions.

TSP Pb monitoring in metropolitan Adelaide sites (Thebarton, Northfield, Gilles Plains, Kensington and Parkside) ceased in June 2003. Levels recorded during 2002 were approaching the limits of detection with an annual average of 0.02 $\mu g/m^3$, 4% of the NEPM standard. With the phasing-out of leaded fuel in metropolitan Adelaide starting in 1986, total banning of lead in fuel in 2000, and the lack of any other major Pb pollution sources, there was no justification for continued monitoring of Pb (see *www.environment.sa.gov.au/pdfs/lead_aq_report.pdf*). Monitoring of Pb from the Port Adelaide site[15] was discontinued in 2001 due to site redevelopment.

Measurements in the Upper Spencer Gulf

Port Pirie: Since the mid-1990s, the EPA has monitored Pb from four sites in Port Pirie. Three sites (The Terrace (1995-2003), Oliver Street (1998-2003), and Senate Road (1999-2003)) are NEPM PMS sites and are regarded as representative of Port Pirie's residential areas (see Figure 7). Samples are taken once every six days for a 24-hour period and all Pb results are derived from TSP HVS. The fourth site at Ellen Street is situated on the boundary of the lead smelter and is regarded as a peak site (for industrial source management rather than general community exposure).

Concentrations of airborne Pb continue to be measured at levels exceeding the NEPM standard in Port Pirie. In 2003, the annual average Pb concentration at The Terrace monitoring site (located at Port Pirie West Primary School) was 0.72 $\mu g/m^3$. The NEPM standard is 0.5 $\mu g/m^3$. Concentrations in Adelaide, by comparison, are essentially zero, therefore, the Pb mainly originates from the smelter. Other sources in the area include the rail corridor, highly contaminated with Pb originating from Broken Hill which virtually makes a trail of contamination from Port Pirie to Broken Hill. The Pb

[15] Port Adelaide site began TSP Pb monitoring in 1978 to monitor dust levels in an area where there was local industry (e.g. ABC, Penrice and at that time Wallaroo fertiliser works—since closed) and heavy traffic in the vicinity. Monitoring at the site was discontinued in 2001 because ambient lead levels had significantly reduced over the years and the owners sold the land used for the monitoring site.

concentrations at this site have exceeded the NEPM standard of 0.5 µg/m^3 (as an annual average) each year since 1997. The highest 24-hr concentration recorded in 2002 was 9.90 µg/m^3.

At Oliver Street, the EPA's main ambient monitoring station, the Pb criterion of 0.5 µg/m^3 (as an annual average) was very closely approached in 2001 and 2002. In 1999, 2000 and 2003 the lead criterion was exceeded.

The Senate Road site (nominated PMS station) located in Frank Green Park has the lowest annual averaged concentrations of the four Port Pirie sites. Since its inception in 1999, the annual average level has been below the NEPM standard of 0.5 µg/m^3.

Monitoring for Pb at Ellen Street[16] (1995-2003) was discontinued in 1998 but resumed again in July 2001. The highest 24-hr concentration recorded in 2002 was 35.2 µg/m^3.

Ozone

Air NEPM standard

0.1 ppm measured as a 1-hour average and 0.08 ppm averaged over 4 hours, no more than one exceedence allowed per year.

Measurements in Adelaide

Monitoring for O_3 currently occurs at five locations in Adelaide. All sites are NEPM PMS sites and are representative of Adelaide's residential areas. O_3 monitoring began at Northfield in 1979, Netley[17] in 1988, Kensington during 2001, and Elizabeth and Gawler in 2002 (monitoring discontinued at Gawler site in late 2004).

Since 1986, there have been no exceedences of either the one-hour (0.10 ppm) or four-hour (0.08 ppm) NEPM standard at either of the monitored sites. In 2002, the average for the year at Netley was 0.017 ppm, 0.002 ppm at Kensington and 0.020 ppm at Northfield, all well below the NEPM standard. In 2003, the average for the year at Netley was 0.017 ppm, 0.022 ppm at Kensington and 0.020 ppm at Northfield, with none exceeding the O_3 NEPM standard.

Monitoring for O_3 at Elizabeth and Gawler began in January 2002. One-hour averaged concentrations at Elizabeth have not exceeded the NEPM standard since the inception of this site, with a range of 0-0.072 ppm in 2002 and 0-0.077 ppm in 2003.

The Gawler (southern end of the Barossa region) monitoring site was proposed in the Air Monitoring Plan 2001 as a useful position to ascertain any impact from the Adelaide plume (principally photochemical oxidants as a result of transport from the Adelaide urban plume) (Physick et al. 1995). The results to date indicate low values of O_3. There were no exceedences of the NEPM standard for O_3 at Gawler in either 2002 or 2003, the range being 0-0.056 ppm in 2002 and 0-0.078 ppm in 2003.

Measurements in Upper Spencer Gulf

O_3 has been measured in Port Pirie since May 2002 where there has been no exceedence of the NEPM standard.

[16] Results at this site are not directly comparable with NEPM protocol, as it is located near the boundary of the smelter.

[17] Monitoring was discontinued between 1997 and 2000 but began again in 2001.

Particulate matter (TSP, PM_{10}, $PM_{2.5}$)

Air NEPM standard

50 $\mu g/m^3$ for PM_{10} as a 24-hour average; World Health Organization (WHO) guideline for TSP is 120 $\mu g/m^3$ as a 24-hour average.

Measurements in Adelaide

Of the four monitoring sites for PM_{10} in Adelaide, three (Netley, Kensington and Gawler) are NEPM PMS sites and are representative of Adelaide's residential areas. The fourth site (Osborne) is a peak monitoring site near industry.

PM_{10} monitoring began at Netley[18] during 2001, using the tapered element oscillating method (TEOM). In 2002, monitoring for PM_{10} using continuous TEOMs began at Kensington and Gawler. PM_{10} monitoring is also conducted using HVS at Osborne (and previously at Thebarton and Gilles Plains), where samples are taken for a 24-hour period once every six days.

In 2002, there were two exceedences of the NEPM standard at the Gilles Plains site[19] and Netley and Kensington had one exceedence each. All exceedences of the NEPM standard in 2002 in Adelaide occurred during two days of severe dust storms, on 8 and 11 July. During the worst, on 11 July, Kensington and Netley recorded a daily average concentration of 104 $\mu g/m^3$ and 79 $\mu g/m^3$ respectively, while Gawler recorded 51 $\mu g/m^3$ averaged over 24 hours. These concentrations exceed the NEPM standard of 50 $\mu g/m^3$ as a daily average. Strong northerly winds had blown dust over the monitoring stations. No exceedence was recorded at other monitoring sites such as Thebarton during this period. Dust storms have been a feature in South Australia in the last two years and occur when the weather has been dry with prevailing strong northerly winds emanating from agricultural areas in the mid-north and Flinders Ranges.

PM_{10} monitoring at Gawler began in June 2002 and continued to 31 July 2003. The daily averaged concentration marginally exceeded the NEPM standard of 50 $\mu g/m^3$ on 11 July in the dust storm. The NEPM goal, which allows five exceedence days per year, was met in both 2002 and 2003.

The PM_{10} monitoring site at Thebarton was constructed in 1993 to determine the impacts of particles next to a major roadway. No exceedences of the NEPM standard were recorded after 1999 and the site was decommissioned in 2003.

PM_{10} monitoring at Netley began in September 2001. In 2002 there was one exceedence of the NEPM standard caused by the July dust storm. In 2003, there were six exceedences of the daily NEPM standard for PM_{10}, with concentrations in the range of 0-119 $\mu g/m^3$.

The NEPM goal, which allows five exceedence days per year, was met for all stations in the Adelaide metropolitan region except Netley (with six exceedences in 2003) over the last five years.

[18] Netley monitoring site is located to the west of the city near the coast and is exposed to the urban plume from both the offshore drift and sea breeze.

[19] Sampling for PM_{10} ceased at Gilles Plains in October 2002.

PM_{10} monitoring at Osborne (non-NEPM site) started in 1988 using high volume sampler[20]. The site was commissioned to determine the air pollution impact of a cement manufacturing plant in the Port Adelaide region on the surrounding environment. As the site is located on the boundary of the plant, data cannot be formally compared with the NEPM standard. Even so, the NEPM goal of no more than 5 days per year over 50 $\mu g/m^3$ has not been exceeded since 1999 (until 2004), when there were six daily exceedences.

The SA EPA started PM_{10} monitoring at Jenkins Street, Birkenhead (non-NEPM site) in response to a development application submitted to EPA for a housing scheme in the Jenkins Street area. Monitoring took place between 6 December 2003 and 3 January 2005. There were sixteen exceedences of the PM_{10} NEPM standard[21] of 50 $\mu g/m^3$ in the monitoring period.

Measurements in Mount Gambier

During the period September 2001-August 2002[22], the EPA collected air quality data from the Frew Park monitoring site in Mount Gambier. The monitoring site was located in the centre of the city, between industrial regions to the east and west. It was situated in a residential area to investigate the combined impact of industry, motor vehicles and domestic air pollution sources on such areas. Concentration of all gaseous air quality parameters monitored in Frew Park were below the NEPM standard. Monitoring data identified that, on occasions, PM_{10} levels in Frew Park exceeded the NEPM standard. Winter measurements of PM_{10} in Mount Gambier are considerably higher than those in summer. It is likely that this is due to residential wood burning in the area. Burning in the open is also likely to be a contributing factor. A separate report by the EPA describing the status of air pollutants in Mount Gambier during the sampling period can be seen at: *www.environment.sa.gov.au/epa/pdfs/aq_mtgambier.pdf*.

Measurements in Upper Spencer Gulf

Port Pirie (1998-2003): Particulate matter as PM_{10} is measured by the HVS method at Port Pirie in Oliver Street, where one-day averaged concentrations of PM_{10} did not exceed the NEPM standard of 50 $\mu g/m^3$ in 2001. There was one exceedence in 2002 and none in 2003. The NEPM goal, which allows five exceedence days per year, was met during the period 1998-2003.

Port Augusta (1996-2003): PM_{10} is measured at Port Augusta by the HVS method. One-day averaged concentrations of PM_{10} at Port Augusta did not exceed the NEPM standard of 50 $\mu g/m^3$ in 2001, nor in 2002, but there was one exceedence in 2003.

The NEPM goal, which allows five exceedence days per year, has been met since 1998.

Whyalla (1989-2003): Since 1989, both TSP (a measure of particles of less than 50 μm in diameter) and PM_{10} have been measured at Whyalla. Monitoring at Hummock Hill (south of the pellet plant) began in 1989 to study the concentration of dust near the pellet plant. Civic Park, 4.5 km west of the pellet plant and where monitoring for PM_{10} began in late 2001, is considered to be a background site. Results at this site are

[20] The sampling frequency is one day in six at this site.

[21] Monitoring site at Birkenhead is a peak site and thus data cannot be formally compared with the NEPM standard. The NEPM standard for PM_{10} has been used as guideline only.

[22] The monitoring actually started 12 months before this but quality control issues made the data unusable.

directly compared to the NEPM goal of five annual exceedences of the NEPM standard of 50 μg/m^3 as a 24-hour average. The site at Hummock Hill was relocated to its current position, 'New Hummock Hill site', on 12 May 2000 because of the Harvey Norman construction at the old location. Before then, the EPA site at Hummock Hill (Old Hummock Hill Site) was located some 70 metres from the OneSteel[23] site. The frequency of sampling was increased from one day in six to one day in three from 8 May 2002 (increasing sample numbers in 2002 over previous years of monitoring). OneSteel and the EPA have co-located instruments at the pellet plant boundary which provide information on daily average concentrations of TSP and PM_{10}. OneSteel uses a TEOM instrument, that logs five minute averages.

The EPA began monitoring PM_{10} at Walls Street in Whyalla from 25 July 2003, using TEOM logging 5-minute and 10-minute averages. The site was chosen on advice from the Department of Health about potential human health impacts from exposure to fine particles of the type present in Whyalla.

At Whyalla, particles as PM_{10} continue to be a concern to local residents, the EPA and industry. In 2003, at the New Hummock Hill site, there were 23 exceedences of the 50 μg/m^3 guide value, with the highest being 400 μg/m^3. In comparison, no exceedence of the NEPM standard was recorded at the Civic Park site in 2003. All concentrations in 2001 were well below the NEPM standard (50 μg/m^3) and in 2002 the daily average exceeded 50 μg/m^3 on one day at this site.

A comprehensive statistical analysis of both the EPA's and OneSteel's air quality monitoring data was commissioned by the EPA in early 2004 following concerns over certain statements made in the 2003 SoE report (EPA 2003). The statistical analysis report concluded:

> *In 2002 the PM_{10} value of 50 μg/m^3 as a daily average at Hummock Hill, adjacent to the OneSteel Pellet Plant, was exceeded 18.5% of the time. This is significantly higher than the mid-1990s when the PM_{10} value of 50 μg/m^3 as a daily average at the old site at Hummock Hill was exceeded about 5% of the time. Relocation of the monitoring station in May 2000 has had a discernible effect on measured dust levels on occasions under certain wind conditions. Nevertheless, since the mid-to-late 1990 there has been an overall worsening of air quality in the area, with levels in 2002 comparable to those encountered in the early 1990s (EPA, 2004).*

At Walls Street monitoring site there were eight exceedences of 50 μg/m^3 in 2003. To date in 2004, there have been 8 exceedences at this site.

Particle concentrations as TSP at the New Hummock Hill site during 2003 exceeded the WHO guideline of 120 μg/m^3 (measured as a daily average) on 25 days out of the 115 days (one in three days) on which measurements were made (i.e. 22% of sampling days).

TSP concentrations at Civic Park during 2001 and 2003 did not exceed the WHO guideline of 120 μg/m^3 (measured as a daily average) but there was one exceedence in 2002.

[23] OneSteel Manufacturing Pty Ltd operates the steelworks to the north-east of the township of Whyalla, situated on the upper shores of the Spencer Gulf.

$PM_{2.5}$

Monitoring for smaller particles, with an equivalent aerodynamic diameter of up to 2.5 μm, began at Netley in 2001 and Kensington in June 2002. The Netley site is continuing, but after running for a period of about 20 months the unit at Kensington was moved to Elizabeth to monitor PM_{10}.

The NEPM standard for $PM_{2.5}$ is 25 $\mu g/m^3$ for one day and 8 $\mu g/m^3$ for one year. During 2003, the yearly average at Netley was 9 $\mu g/m^3$ and at Kensington 7 $\mu g/m^3$. The 2003 maximum for Netley of 28 $\mu g/m^3$ occurred on 11 July 2003, the day of the dust storm mentioned above.

3.6 Meteorological data

Meteorological data is important in both the understanding of air pollution episodes (i.e. high pollution events) and as input data to dispersion models. It can assist in the interpretation of air quality monitoring results and in the tracking and modelling of emissions (or 'plumes') from specific sources or locations. In South Australia, meteorological measurements of wind speed, wind direction, temperature, barometric pressure and total solar radiation are recorded at a height of 10 m above ground at a number of EPA monitoring stations. Currently, the data collected is not subject to any detailed analysis. It can be used for calculating back-trajectories[24] on incidences of high air pollution days by correlating air quality data with source emission data, and for calibration of air dispersion models. While the efficient use of meteorological information is proposed in this report, a detailed description of current monitoring is beyond the purpose of this review.

Furthermore, there have been significant delays in validating meteorological data. For example, pre-1996 meteorological data at Whyalla monitoring site has only undergone a cursory validation process, making its use difficult for any meaningful air quality analysis. The veracity of meteorological data remains problematic, especially in Port Pirie, where the Department of Health found it of limited use in explaining blood lead levels in children (D Simon Department of Health Adelaide, pers. comm. 2004). A detailed review of the requirements for meteorological data related to air quality assessment (including its validation and other quality control issues) is needed as a matter of priority for South Australia.

3.7 Site metadata

To be able to compare data from one monitoring site with another it is important to know what the site characteristics are for each ambient air quality station. The EPA collects metadata (descriptive information about site characteristics) for each sampling site. The metadata sheets are attached as appendices in different EPA reports. In accordance with National Environment Protection Council Peer Review Committee technical paper No. 5 (NEPC 2001e) the EPA collects the following information:

- site information—includes site name and EPA site number

[24] A back trajectory allows the influences of upwind land and air chemistry to be studied on an airmass arriving at a particular location in space and time.

- site details—comprises street address, date established and date terminated (i.e. monitor installation and decommission dates)
- description of surrounding land use
- description of nearby emission sources
- map co-ordinates (AMG, latitude/longitude or other)—precisely enough for the site to be readily located
- names of pollutants measured
- instrument types—make, model, serial number, minimum detection level units, sampling rate, logging interval of raw data, data return, clock adjustment
- data corrections—e.g. zero corrections in ppm and span corrections as factors made per calibration (3 day) (whole month standard correction)
- averaging period—the averaging period within which the monitor collects data.

3.8 QA/QC arrangements

Quality assurance (QA) and quality control (QC) procedures are extremely important aspects of air quality monitoring. QA refers to the overall process of collecting the data (i.e. definition of monitoring and data quality objective, site selection criteria, equipment specifications and personnel/operator training), whilst quality control defines the procedures used to check accuracy and precision following data collection (e.g. calibration, routine checks, field audit and data handling). Whilst QA/QC may be applied to varying degrees, it is essential that these are clearly stated so that data users (scientific community, air modeller groups, the public, etc.) know what level of confidence (i.e. inherent uncertainties in measurement) can be applied to the data. An evaluation of the quality assurance program for the EPA's air monitoring laboratory has not been conducted to date.

A detailed external audit of monitoring sites in Whyalla was conducted in 2004. Specifically the objectives of external audit were:

- to carry out a desk-top audit and field inspection of the EPA's ambient PM_{10} and TSP monitoring network to determine if the EPA is carrying out its monitoring in accordance with current Australian standards and advise on the impact/consequence of any non-conformances
- to review data down-load, verification of results and data editing (e.g. treatment of negative values)
- to conduct a field inspection of the EPA's meteorological monitoring site in Whyalla to determine if the meteorological monitoring practices are in accordance with accepted Australian standards and advise on the impact/consequence of any non-conformances.

An evaluation of the EPA monitoring sites in Whyalla showed that there are some significant siting issues (Vic EPA, 2004). The most significant non-conformance issues were found at the Civic Park site, where the influence of trees around the samplers was believed to have a significant impact on particle levels measured at the site. The audit also found that the EPA has generally been operating its TSP and PM_{10} samplers according to AS 2784.3 and AS 3580.9.6. These standards provide little guidance to air monitoring staff on calibration and quality aspects of high volume sampling. The auditor advised that revised Australian Standards 3580.9.3 (2003) and 3590.9.6 (2003) are considered to represent current best practice guidance for TSP and PM_{10} high volume sampling and recommended that they should be adopted. During the audit of Whyalla monitoring sites, it was also found that no one source of validated data was available for release to external clients (this issue has been fixed now). Other details of audit findings and subsequent recommendations can be found in the report *Audit of the Whyalla ambient particle monitoring network operated by the Environment Protection Authority, South Australia,* available at the EPA.

It is suggested that other monitoring sites in South Australia should be externally audited at least once in three years.

The EPA air quality monitoring laboratories were initially assessed in October 2004 (for six Air NEPM pollutants) for NATA[25] accreditation for ambient air quality monitoring. Recommendations made by testing authorities are being implemented. It is expected that the data quality control and quality assurance issues identified in this report will be substantially addressed once NATA accreditation is achieved.

3.9 Data reporting

Reports

Under the Air NEPM, jurisdictions are required to evaluate their performance annually in meeting the standards and associated goal, and publicly report on compliance. The EPA produces an annual report on the state's ambient air quality monitoring and complies with necessary reporting obligations as stipulated in National Environment Protection Peer Review Committee technical paper no. 8, *Annual reports* (NEPC 2002). The annual report to NEPC provides an assessment of air quality in South Australia (at Air NEPM sites) over the previous calendar year and briefly states the changes (e.g. upgrades in monitoring sites or instrumentation) planned in the immediate future. Currently, summary statistics for gaseous pollutants include the number of annual exceedences of the NEPM standard, annual maximums, the percentiles (90th and 99th per cent of each data set) and the percentage data recovery. The latter describes the number of samples taken in relation to the potential number that could be taken over the monitoring period. This is generally calculated by counting the number of one-hour averages (for gaseous pollutants).

Other sources of trend information about air quality include the SoE reports published at the national and state level (EPA 1998;2003).

The monthly ambient air quality report to the EPA contains data summaries for gases and particles for both Adelaide and regional centres, and a summary of the Adelaide metropolitan AQI shown in pie chart form. Many pollutants are averaged over either one hour or one day. Depending on standards and guidelines, data may also be averaged for four hours, eight hours or over one year. The maximum concentration for each pollutant measured and the number of exceedences of the standard for the monitoring period are reported. Published EPA reports are available at *www.epa.sa.gov.au/pub_air.html*.

[25] Maintenance of a quality system through a recognised technical quality assurance regime (NATA).

Air quality index dissemination

As well as comparing pollutant concentrations with health criteria, an AQI[26] describes Adelaide's air quality at each site that monitors pollutants continuously. In 2003, these sites, at Netley, Elizabeth and Kensington, represent central to northern Adelaide (Figure 10). The AQI is updated daily on the EPA web site (10 am and 6 pm). The data used to compile the daily EPA AQI comes directly from EPA air monitoring stations and is unvalidated. There is no Noarlunga monitoring station, and thus the AQI is not necessarily representative of the southern region.

The index is calculated for any given pollutant as its concentrations expressed as a percentage of the relevant criterion.

$$\text{Air quality index} = \frac{\text{Pollutant concentration} * 100}{\text{NEPM criterion}}$$

The AQI standardises the reporting so the public receives the information in a clear and consistent manner. Currently, the AQI uses five air quality descriptors—'very good', 'good', 'fair', 'poor', and 'very poor'—to report the air quality. Table 4 describes each classification and the associated index ranges used in the assessment.

Table 4. Air quality index ranges

Category	Index range and colour
Very poor air quality	**150 or greater (black)**
Poor air quality	**100-149 (red)**
Fair air quality	**67-99 (yellow)**
Good air quality	**34-66 (green)**
Very good air quality	**0-33 (blue)**

The AQI includes sub-indices for O_3, PM_{10}, CO, SO_2 and NO_2, which relate ambient pollution concentrations to index values on a scale from 0 to 150 or greater. This represents a very broad range of air quality from pristine air to air pollution levels that present imminent and substantial danger to the public.

To assess the overall air quality at a particular monitoring station, the highest calculated index is taken to be the AQI for that monitoring station as it represents the worst (or highest concentration) of the pollutants measured. The site with the highest index is then used to summarise Adelaide's air quality. At the moment, there is no use of AQI by local media as the results show what the air quality has been, not what it will be tomorrow. Efforts should be taken to get the media to make use of AQI as they do in New South Wales, Melbourne and Perth.

[26] www.environment.sa.gov.au/reporting/atmosphere/airindex_sum.html

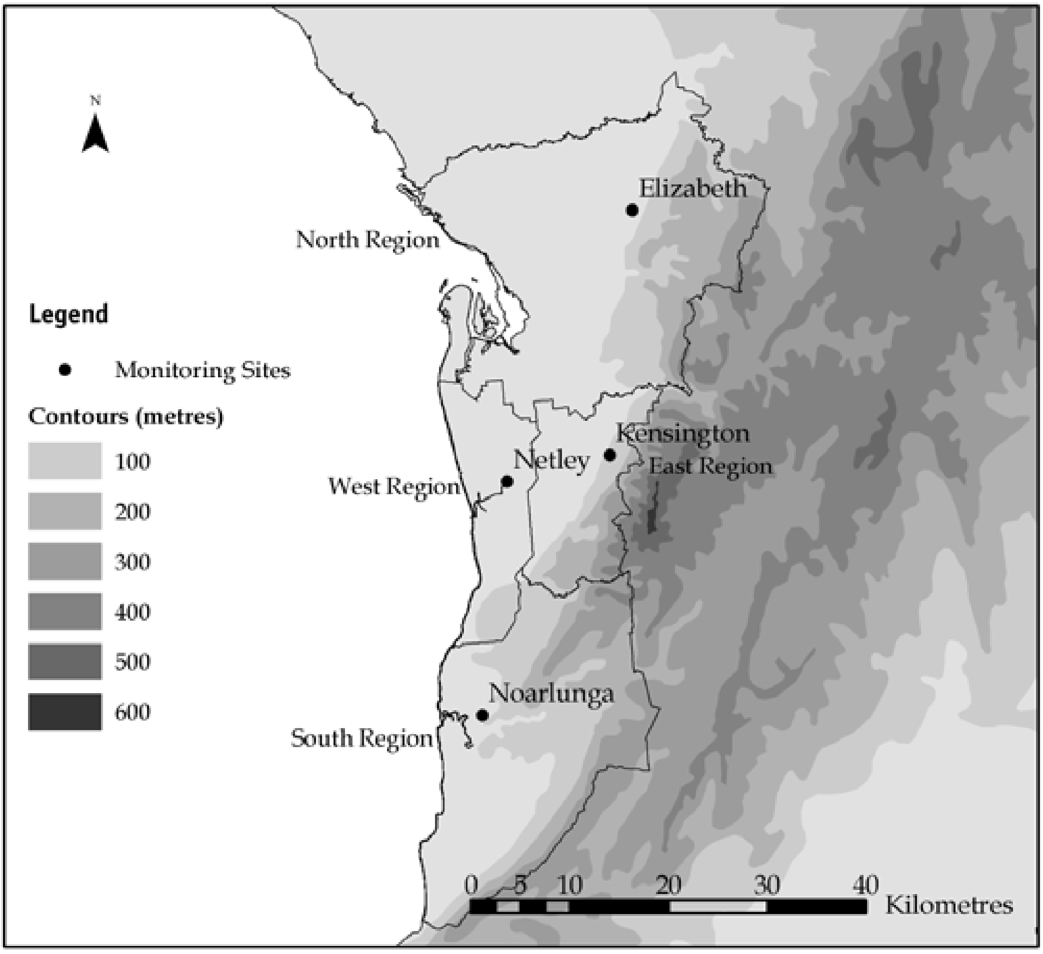

Figure 10. **Air quality index sites in the Adelaide metropolitan area. The site at Noarlunga is not operational at the moment. The boundaries in the map are based on local council areas.**

3.10 Approaches in other Australian states

Regional modelling for air quality surveillance is conducted on a regular basis by the Department of Environmental Protection in Western Australia and the Department of Environment and Conservation in New South Wales. Apart from regular ambient monitoring, there is an emphasis on special air quality studies and investigations. The results of such studies are used in improving air quality management of the region.

Department of Environment and Conservation in NSW uses a sub-set of its total network in reporting against the Air NEPM. Monitoring is essentially needs driven. For example, fine particle measurement takes place only in those areas where significant emissions are likely. Importance is given to good quality data and up-to-date air quality reports to the public. In addition to its twice-daily (9.00 am and 4.00 pm) regional pollution index (RPI), the department's web site provides a summary of air quality for the previous 24 hours for all sites in its network. Historical RPI data monitoring reports, which give statistics for all sites and pollutants, are also available on the site. Air quality forecasts are available for various Air NEPM pollutants, but these forecasts are of a general nature and are restricted to whether the RPI is expected to FALL, RISE or to be SIMILAR the next day. The department has not yet developed an accurate forecasting system. The Australian Air Quality Forecasting System (AAQFS) does not simulate Sydney conditions very well yet (C Eiser, Department of Environment and Conservation NSW, pers. comm. 2004), probably because of the complex geographical situation and the presence of a number of diffuse sources of air pollution, which are not fully depicted in aggregated emission data.

The Victorian EPA (Vic EPA) also uses its web site to provide up-to-date data and air quality information at each monitoring station. The web site is updated twice daily on weekdays, once per day on weekends. A general discussion of likely causes of an exceedence in each parameter is given, and the potential health effects of such an exceedence and how individuals can prevent exacerbation of health conditions are also available. Vic EPA also uses the media to communicate air quality data. This information is disseminated once a day; 'smog alerts' are issued on days of expected high pollution levels. Ambient air quality monitoring data is validated monthly, using a series of documented procedures, and the complete annual datasets are also audited, before annual reporting, to ensure that all data has been captured correctly. Annual air monitoring reports of the validated datasets are then also provided on the web site and as hard copy bulletins.

In Western Australia (WA), the maximum time for data validation is three months from the date of its retrieval from the data logger. However, initial unverified data can be downloaded from the Department of Environmental Protection's web site, which also contains details about the likely cause of an air quality episode. Back-trajectory analysis is used for this purpose, which indicates, for example, the likely reason for an incidence and the place of an incidence. In this way, the EPA fulfils the requirement of NEPC to show why and how an incident happened. Each NEPM exceedence gets a one-page explanation.

The Environment Protection Agency in Queensland conducts ambient air quality monitoring in most of the major population centres, including south-east Queensland, Gladstone, Rockhampton, Mackay, Townsville, and Mount Isa. Each year the data from this state-wide monitoring program is compiled into a summary report containing information about:

- air pollutants and their impacts on human health and the environment
- comparisons against the Environment Protection (Air) Policy or other relevant air quality goals or standards
- comparisons between regions and between monitoring locations within regions
- pollutant concentration distributions
- seasonal variations.

In addition to annual reports, monthly bulletins on air quality are also available for north-east Queensland, central Queensland and northern Queensland regions.

The EPA's AQI displays the latest air quality levels measured at each monitoring station. There is an option to select past dates to display previously collected data. The hourly air quality data includes parameters like CO, NO_2, O_3, SO_2, PM_{10}, $PM_{2.5}$, and visibility. The associated hourly meteorological data includes parameters like wind direction, wind speed, temperature, pressure and solar radiation.

4 Adequacy of current monitoring arrangements

4.1 Introduction

This section of the report examines the current state of the South Australia ambient air quality program and seeks to identify gaps in siting of the monitors and the pollutants monitored. The basis of discussion is mainly a comparison of the current monitoring program with the program proposed by the EPA in 2001. The discussion has taken into account the recent EPA air quality report (EPA 2004), which drew upon ambient air quality trends measured by past and present monitoring stations.

Other factors taken into consideration are:

- pollutants of future concern
- national and state developments on NEPM and non-NEPM pollutants
- support to Adelaide airshed modelling (e.g. for TAPM regional dispersion model) in identifying current concentrations and model verification
- community concerns.

Currently there is no national protocol to assess the adequacy of an air quality monitoring network. The system has quality assurance methods and protocols for data quality, a NATA accreditation system which accredits laboratories to QA/QC standards e.g. ISO 17025 but no protocol for assessing the relevance of a network to current needs—that is, are we monitoring the right things in the right places?

4.2 Compliance with Air NEPM requirements

In 2001, the EPA established six major stations, five of which were initially nominated as performance monitoring stations for O_3 and NO_2. The locations for the stations were chosen on the basis of determining pollutant distributions in populated areas and understanding the likely exposures of people in the various areas. In selecting the monitoring stations, the EPA adopted recommendations arising from two short-term studies:

1. In 1996, the EPA commissioned the CSIRO and the Vic EPA to undertake a study of transport of urban pollutants around the Adelaide airshed. The modelling study, based on two monitoring stations only and thus very limited data, provided an initial framework for a systematic monitoring program within the Adelaide metropolitan area.

2. Additional studies by Flinders University using aircraft provided further insights into pollutant transport in the Adelaide airshed (Clark et al. 1998). The Flinders University airborne monitoring project collected data during the 1997-98 summer between 0730 and 0930 local time. The measurements were made over the Gulf St. Vincent under offshore wind conditions, downwind of the main urban area of Adelaide and following the coast between Noarlunga in the south and Outer Harbor in the north. Background measurements were made behind the Mount Lofty Ranges, upwind of the urban area. This short-term study described Adelaide's morning emissions in a sea breeze moving inland towards the ranges along the Onkaparinga

River valley, south of the city.

On a purely numerical basis, the current ambient air monitoring network generally compares well (Table 5) with the number of CO and SO_2 monitoring stations proposed by the 2001 SA monitoring plan. In regional centres, the number of PM_{10} monitoring stations exceeds the number of sites proposed by the plan.

However, a notable gap exists between the PM_{10}, O_3 and NO_2 monitoring sites located in metropolitan Adelaide and those recommended by the 2001 plan. Sites originally proposed for these parameters included southern metro (Port Noarlunga) and Hope Valley.

Table 5. Proposed number of sites for compliance with 2001 plan

Pollutant	Air Quality Monitoring Plan required sites		Current number of sites	
	Metropolitan Adelaide	Regional centres	Metropolitan Adelaide	Regional centres
NO_2	**6**	**1**	**5**	**1**
SO_2	**4**	**0**	**4***	**1**
CO	**2**	**0**	**2**	**0**
PM_{10}	**6**	**0**	**4**	**5**
O_3	**6**	**1**	**5**	**1**
Pb	**4**	**2**	**0**[27]	**4**

* now reduced to one site due to low levels of SO_2 recorded.

The EPA has therefore not fully implemented the NEPC-endorsed air quality monitoring plan. The delays in complying with the plan are due to late recruitment of technical and scientific staff responsible for carrying out the monitoring.

Ozone

O_3 concentrations have been continuously recorded by the EPA in Adelaide at Northfield (north-east of the CBD) and Netley (west of the CBD) since late 1988. Two additional stations, set up during 2001 in order to meet the requirements of the monitoring plan, were located at Kensington and Elizabeth. An additional monitoring station, established at Gawler, was nominated as a campaign station. The performance monitoring sites nominated for O_3 in the 2001 plan are listed in Table 6. The nominated O_3 performance station monitoring site in the southern metro region (south of the city, along the Onkaparinga Valley) has not yet been established.

[27] TSP Pb monitoring in metropolitan Adelaide sites (Thebarton, Northfield, Gilles Plains, Kensington and Parkside) ceased in June 2003. Levels recorded in 2002 were approaching the limits of detection, with an annual average of 0.02 $\mu g/m^3$, or 4% of the NEPM standard.

Table 6. Summary of nominated O_3 performance stations

Monitoring site	Classification	Status
Elizabeth	PMS	Operational
Kensington	Trend	Operational
Netley	Trend	Operational
Northfield	Trend	Operational
Southern Metro	PMS	Non-operational

Current O_3 monitoring sites are positioned close to the CBD in Netley and Kensington, and further from the city at Elizabeth and Gawler, giving a reasonable distribution between inner and outer Adelaide sites. However, the inner sites are situated near the source of precursor emissions (mainly motor vehicles) and thus there is a possibility that O_3 concentration at these locations are somewhat suppressed by interactions with NO_x from the city (i.e. NO_x emitting sources such as vehicles).

While high levels of O_3 are a matter of particular concern in many parts of Australia, it appears from the 1979-2003 report (EPA 2004) that similar concentrations do not, and are unlikely to, occur in Adelaide. The NEPM goal for O_3 has not been exceeded in Adelaide at any site since 1986. A trend analysis completed for the *State of the Air report* (NEPC 2004a) suggests that Melbourne, Perth, Brisbane and Adelaide are close to or already meeting ozone standards, whereas Sydney records multiple exceedence days. A preliminary statistical analysis of 2002-2003 daily maximum ozone data from existing Adelaide monitoring sites indicates that some of the monitoring sites are highly correlated for O_3. For example, the value of correlation coefficient is close to 0.9 for Northfield, Netley and Kensington in the summer of 2002–2003. This indicates that regional meteorology probably has a dominant influence of over local events and sources at these sites. The findings imply that from the point of view of an efficient use of financial and human resources, the number of ozone monitoring stations in a monitoring network can be kept quite limited.

At Northfield (site located adjacent to a residential area in the grounds of a hospital in the northeast of Adelaide), the 99th percentile for 2002 was 0.042 ppm, which is 42% of the NEPM standard for one hour. In 2003, the 99th percentile was 0.045 ppm, 45% of the NEPM standard for one hour, and the maximum in 2003, of 0.068 ppm, is 68%. Before out-sourcing of monitoring operations in 1996, the 99th percentile was 0.039 ppm, which is 39% of the NEPM standard for one hour. According to a recently published report (EPA 2004), concentrations of O_3 at Netley and Northfield are consistently low with less inter-annual variability.

At Kensington, the 99th percentile for 2003 was 0.047 ppm, 47% of the NEPM standard for one hour and the maximum in 2003, of 0.074 ppm, is 74%. At both Elizabeth and Gawler, in 2003, the 99th percentile was 0.046 ppm, 46% of the NEPM standard for one hour.

O_3 is a secondary pollutant and is typically detected downwind from populated metropolitan areas during warm summer months. Assessment of O_3 concentrations in Adelaide will need to be maintained for the purpose of calculating the AQI (Elizabeth, Netley and Kensington are being used for this calculation), compliance with air quality standards and validation of air dispersion models. It is therefore proposed that monitoring for O_3 be continued at Netley, Elizabeth and Kensington, but discontinued at Northfield. The Netley monitoring site is located to the west of the city near the coast and is exposed to the urban plume (from Adelaide Hills and Adelaide plain) from both the offshore drift and sea breeze; it is thus at a strategic location for both providing information on exposure of the general population and validation of air dispersion models as well as for providing trends in ozone concentrations.

The studies carried out by Flinders University and Airborne Research Australia in 1996, and recent TAPM modelling carried out at the EPA, showed that on photochemically active days in the summer the pollutants are blown out to sea on the land breeze and returned to land through the Onkaparinga River Valley to Hahndorf in the Adelaide Hills. Thus, concentrations build up in the Adelaide plume, as it moves downwind, such that the highest concentrations are found on the fringe of Adelaide or to the south of the city. This would suggest that the highest concentrations would be found at urban background or suburban sites in the vicinity of the Onkaparinga River Valley and Hahndorf in the Adelaide Hills. It may be useful to establish campaign monitoring sites in these areas.

There is no monitoring of O_3 precursors such as VOCs at any of the current O_3 monitoring sites. The importance of VOCs as O_3 precursors has given rise to a need for information on these compounds to determine links between different pollutants and to fully assess O_3 formation. Therefore, it is proposed that VOC measurement be carried out at the Netley monitoring site.

O_3 has been measured in Port Pirie since May 2002 and there has been no exceedence of the NEPM standard (EPA, 2004). It is proposed that monitoring be discontinued at this site because of very low levels.

Nitrogen dioxide

Although there are major emitters of NO_x in Adelaide, such as power stations, the principal source (responsible for about 86% of the emissions) of nitric oxide (NO) and NO_2 (collectively known as NO_x), is road traffic (Ng 2004). As with O_3, long-term records are limited to two sites (Netley and Northfield) in metropolitan Adelaide. Both represent 'generally representative upper bound' sites (i.e. monitoring concentrations are considered to be generally representative of air quality experienced by residents) and meet criteria about population exposure. The five sites listed in Table 7 were nominated as performance monitoring stations for NO_2. Additional campaign monitoring for NO_2 began in 2002 at Gawler[28].

Table 7 Summary of nominated NO_2 performance stations

Monitoring site	Classification	Status
Elizabeth	PMS	Operational
Kensington	Trend	Operational
Netley	Trend	Operational
Northfield	Trend	Operational
Southern Metro	PMS	Non-operational

[28] Monitoring discontinued at this site in October 2004.

Continuous monitors are used at all sites, measuring concentrations of NO and total NO_x (NO_2 is by difference) based on the chemiluminescence produced by the sampled air in the instrument. At all sites, the levels are well below the NEPM standard of 0.12 ppm. NO_2 has also been measured at Gawler and Elizabeth since January 2002. There have not been any exceedences of the standard since these sites began operation.

According to the National Environment Protection Council Peer Review Committee *Screening Procedures* (Technical paper no. 4 (NEPC 2001a), the data for a long term site should be less than 75% of the standard for five or more years. At Netley, the 99th percentile for 2002 was 0.024 ppm, 20% of the NEPM standard for one hour, and the maximum in 2002 of 0.041 ppm is 34.2%. In 2003, the 99th percentile was 0.023 ppm, 19.2% of the NEPM standard for one hour, and the maximum in 2003 of 0.040 ppm is 33.3%. Similar low levels can be found at Northfield, Kensington, Elizabeth and Gawler (EPA 2004).

Monitoring results enable the EPA to confidently predict that the objectives for NO_2 are being, and will continue to be, met at existing monitoring sites if there is no change in fuel-emission status. It is well known that the spatial variability of secondary pollutants such as NO_2 and O_3 tends to be more homogeneous than for primary pollutants such as CO and SO_2. For example, concentration of a primary traffic pollutant such as CO will be high at roadside locations, while O_3 levels having high spatial uniformity will be lowest in near-road locations, due to scavenging by vehicle NO_x emissions. For this reason, optimisation of all parameters at one monitoring site is not possible. It is proposed that monitoring for NO_2 be continued at Netley, Elizabeth and Kensington in line with O_3, and discontinued at Northfield.

Based on the EPA (2004) review of ambient air quality monitoring in SA 1979-2003, the one-hour average of NO_2 at Port Pirie for 2003 was 0.003 ppm. This is very low compared to the averages at Northfield and Netley (in Adelaide) of 0.007 ppm and 0.009 ppm, respectively. It is proposed that monitoring of NO_2 at Port Pirie be discontinued.

Carbon monoxide

CO is produced in all combustion activities but the overwhelming proportion of emissions to air come from petrol engine exhausts. The number of vehicles idling in a street under calm conditions is generally the major factor influencing CO concentrations. In 2001, the EPA nominated two performance/trend monitoring stations for reporting to NEPC: the pre-existing Hindley Street site (established since 1988) and a new monitoring station established in 2002 in Elizabeth. The latter site was located within a school in a suburban area well away from arterial roads (~1 km) but where domestic wood-fired heaters are common.

There have been no exceedences of the standard at Hindley Street since 1997. This is mainly attributed to improvements in traffic flow and reductions in vehicle emissions. At Elizabeth in 2003, eight-hour averages of CO were within the range of 0-1.4 ppm, well below the NEPM standard of 9.0 ppm.

The existing set-up for CO monitoring is considered adequate when taking into account the National Environment Protection Council Peer Review Committee *Screening Procedures* (NEPC 2001a), using long-term measurement trends, and the emission inventory from National Pollutant Inventory (*www.npi.gov.au*) data showing Adelaide

CBD as an area of maximum CO emissions in South Australia. So there is no need to expand the monitoring program for CO. However, more people seem to be living in the city; therefore, additional campaign monitoring may be established at Rundle Street East (a place with lots of cafes and public crowds) for an initial period of 12 months to get an understanding of exposure of the population to CO concentration at this site.

Since CO is a primary pollutant, its ambient concentration closely follows emissions, which are overwhelmingly from petrol engine exhausts. It is proposed that the existing number of CO monitoring stations be reduced to one and that the Elizabeth site be discontinued.

Sulfur dioxide

In the 2001 monitoring plan, seven monitoring sites were nominated as performance monitoring stations for SO_2 (Table 8). Six sites (Elizabeth, Kensington, Northfield, Netley, Hope Valley and Southern metro) were proposed as campaign monitoring sites for an initial 12-month period. After that time the need for continued monitoring at these locations would be evaluated.

Until recently the EPA has been conducting Air NEPM monitoring of SO_2 in the ambient atmosphere at a variety of locations throughout the Adelaide airshed—Northfield, Kensington, Elizabeth and Christies Beach. Apart from Christies Beach (long-term monitoring site designed to monitor the impact of the Port Stanvac oil refinery in Adelaide), all monitoring has been in residential locations, without significant SO_2 sources nearby.

Table 8 Summary of nominated SO_2 performance stations and present status

Monitoring site	Classification	Status
Elizabeth	Campaign	Operational
Kensington	Campaign	Operational
Northfield	Campaign	Operational
Hope Valley	Campaign	Non-operational
Christies Beach, St Johns School	Trend	Operational
Southern Metro	Campaign	Non-operational

SO_2 concentrations in metropolitan Adelaide are of decreasing concern. The closure of Port Stanvac oil refinery, fuel switching[29] and other factors have brought about a significant reduction in SO_2 concentration. There were no exceedences of the NEPM standard (0.20 ppm as a one-hour average) and thus no exceedences of either the one-day (0.08 ppm) or yearly (0.02 ppm) NEPM standard during 2002-2003 at Elizabeth, Northfield, Kensington and Netley monitoring sites. At Christies Beach, there has been only one exceedence since 1996. It occurred in 2002 and was due to a severe plant malfunction.

Ambient SO_2 levels at all these sites have been low, well below 75% and 55% of the NEPM standard for SO_2 (Riordan and Adeeb 2004) and the results for Adelaide meet PRC criteria for screening out air pollutants. Government commitments to limit national SO_2

[29] SO_2 arises predominantly from fossil fuel combustion.

emissions, using a variety of control measures, will maintain the position. As a result monitoring of SO_2 has been reduced to one site, Northfield in metropolitan Adelaide, in order to maintain trend monitoring for the region.

The existing SO_2 monitor at the Oliver Street site in Port Pirie needs to continue monitoring emissions from the industrial area.

Particulate matter (PM_{10} and $PM_{2.5}$)

Within metropolitan Adelaide, motor vehicles contribute approximately 28% of particle loading, according to 2002-2003 emission inventory for South Australia (Ng 2004). These amounts are most concentrated in areas near busy roads, but a fraction of the finer particles, including PM_{10}, can persist for considerable distances into suburban residential areas. Wood-fired domestic heating is an important source in some areas of the suburbs in winter, particularly those close to or within the Adelaide Hills. In South Australia, measurements of particulate matter are focused on the PM_{10} fraction but $PM_{2.5}$ is also being measured at a small number of stations.

The EPA currently monitors for PM_{10} at four locations in Adelaide—Netley, Kensington, Elizabeth and Osborne (Penrice). The first three sites are representative of Adelaide's residential areas and Osborne (non-NEPM) is a peak monitoring site near industry. PM_{10} monitoring by using the continuous TEOMs began at Gawler (campaign site) in June 2002 and continued to 31 July 2003. Table 9 indicates nominated performance monitoring stations and current monitoring status.

Table 9 Summary of nominated PM_{10} performance stations and present status

Monitoring site	Instrument	Classification	Status
Elizabeth	TEOM	PMS	Operational
Kensington	TEOM	Trend	Operational
Netley	TEOM	Trend	Operational
Hope Valley	TEOM	PMS	Non- operational
Southern Metro	TEOM	PMS	Non-operational

PM_{10} monitoring began at Netley during 2001, using the TEOM method. In 2002, monitoring for PM_{10} using the continuous TEOMs began at Kensington. Until recently PM_{10} monitoring was also conducted at Thebarton (site decommissioned in 2003) and Gilles Plains (site decommissioned in October 2002), where samples were taken for a 24-hour period once every six days. Monitoring at these sites was not representative of broader air quality. For example, the Gilles Plains site is a non-performance station as it is near a roadway and reflects potential exposure for people who live next to roads rather than representing exposure of a broad range of the community.

As depicted in Table 9, the current PM_{10} network in Adelaide has a good geographic distribution. There are no obvious gaps in the data, except that to fulfil the requirements of 2001 monitoring plan, stations in the southern metro and Hope Valley are needed. The new setup would lead to more appropriate spatial distribution of the sites for PM_{10}, given the concentration of predicted exceedences within this part of metropolitan Adelaide.

PM_{10} monitoring in Port Pirie at Oliver Street and Port Augusta needs to be continued. At Whyalla, it is generally accepted that measurements of PM_{10} (which affect human health) are better indicators of suspended particulate matter in air than those provided by the currently used TSP. There have been quite a few exceedences of PM_{10} at the Walls Street and New Hummock Hill sites but not at the Civic Park site. Although there is community concern over dust in Whyalla, the particulate monitoring at the New Hummock Hill site is of limited use because this sampling is at the fence line (the boundary) rather than at a NEPM compliant location. It is recommended that TSP and PM_{10} monitoring be more thoroughly reviewed in Whyalla, with an aim of rationalising the monitoring sites while still addressing community concern.

Monitoring of $PM_{2.5}$ is limited to one site in west Adelaide (Netley), which is equipped with TEOM series 1400 with $PM_{2.5}$ size selective inlet. This station is enough to generate the necessary data for reporting on $PM_{2.5}$ as required by the Air NEPM. However, because of wood smoke particulate emissions, an additional campaign monitoring site for $PM_{2.5}$ needs to be set up in the Adelaide Hills.

A national fine particle composition study (Vic EPA 2004a) was conducted in four major Australian cities (Melbourne, Sydney, Brisbane and Adelaide) over a 12-month period to gain information on the variation of the composition of particles with season and location. The study collected information in both the $PM_{2.5}$ and $PM_{2.5-10}$ fractions of particulate matter. The sites chosen for Adelaide were Netley and Northfield. The results of this study have shown that PM_{10} levels at both Adelaide sites are dominated by the coarse fraction especially through summer months. The results also indicate that there are no significant differences in the composition of both $PM_{2.5}$ and $PM_{2.5-10}$ at the Netley and Northfield sites. The ratio of $PM_{2.5}$ to PM_{10} (i.e. 0.3—lowest of all Australian cities studied) was also the same at both sites.

Lead

Total suspended particulate Pb monitoring in metropolitan Adelaide sites (Thebarton, Northfield, Gilles Plains, Kensington and Parkside) ceased in June 2003. The levels recorded during 2002 were approaching the limits of detection, with an annual average of 0.02 $\mu g/m^3$, or 4% of the NEPM standard. This reflects the increasing use of unleaded petrol and reductions in the lead content of leaded petrol. The downward trend in Pb in metropolitan Adelaide in recent years is very pronounced (EPA 2003) and it is not no longer seen as a pollutant of concern in Adelaide.

Port Pirie is the only place outside the Adelaide metropolitan area where long-term monitoring for TSP Pb and PM_{10} Pb occurs. Currently, two stations sample for TSP Pb and a third samples for both TSP Pb and PM_{10} Pb. According to the Department of Health, 6-day 24-hour TSP sampling is not useful in determining exposure patterns to children (D Simon, Department of Health Adelaide, pers. comm. 2004). A wider discussion is needed on the future monitoring program in Port Pirie. The debate should involve the sampling type (e.g. PM_{10}, TEOM, HVS-TSP) and locations of monitors, over and above the NEPM site. The Department of Health also has concerns about the form of Pb, with oxides thought to be more bio-available than sulphides.

4.3 Monitoring pollutants of future concern

Air toxics

Air toxics are gaseous, aerosol or particulate pollutants (other than the six criteria pollutants) which are present in the air in low concentrations and have characteristics such as toxicity or persistence that make them a hazard to human, plant or animal life (EPHC fact sheet[30]). These compounds are emitted into ambient air from a wide range of sources, but roads, traffic, industrial processes and solvent uses are the main sources. On 16 April 2004 the NEPC made a new NEPM for Air Toxics (see *www.ephc.gov.au/news.html.#AS_NEPM*). It applies to the following air toxics:

benzene

formaldehyde

benzo(a)pyrene as a marker for PAH

toluene

xylenes (as total of ortho, meta and para isomers)

Under clause 3(i) Schedule 3 of the Air Toxics NEPM, jurisdictions are required to undertake an initial assessment of locations in order to identify Stage 1 sites that may be monitored for air toxic pollutants. This assessment must be undertaken in a time frame that ensures that Stage 2 sites can be identified within 12 months of the development of the Air Toxics NEPM.

Very limited information is available in South Australia on ambient concentrations of these compounds. To date, measurements have been undertaken on a local scale as a part of hotspot monitoring programs in the vicinity of industries with significant emissions—such as Castalloy[31] at North Plympton and Hensley foundry[32] at Flinders Park—and which are mainly located in non-urban areas. Some short-term baseline studies, largely in relation to a small number of traffic-related hydrocarbons, such as benzene, toluene and xylene, should be carried out in metropolitan Adelaide (preferably in heavily trafficked areas like Glen Osmond Road and Grand Junction Road) and at a background location (a site well away from roads). Furthermore, the importance of VOCs as O_3 precursors has given rise to a need for information on these compounds to fully assess O_3 formation and the links between different pollutants.

Dioxins and furans

The term 'dioxins' describes a group of highly toxic organochlorines that remain in the environment for a long time. These compounds can accumulate in the body fat of animals and humans, and tend to remain unchanged for long periods. This makes them a great environmental concern.

Dioxins are not manufactured intentionally but are by-products of combustion. They are formed by forest fires and industrial processes including waste incineration and

[30] http://www.ephc.gov.au/nepms/air/air_toxics.html

[31] Air quality monitoring, Hotspot No. 4, near the Castalloy Foundry, North Plympton, February 2003

[32] Air quality monitoring, Hotspot No. 3, Hensley Foundry, Flinders Park, October 2002

synthesis of chemicals. The major route for human exposure to dioxin is through our diet, in particular products high in animal fat such as milk, butter and eggs.

The National Health and Medical Research Council has determined an Australian monthly intake for dioxin of 70 pg TEQ[33]/kg of body weight. The National Dioxin Program has completed three years of study to improve our knowledge of dioxins in Australia (monitoring was carried out at the Netley site as part of the national study). The results of these studies are available from the Department of the Environment and Heritage web site at: *www.ea.gov.au/industry/chemicals/dioxins/index.html*.

The overall finding of these reports is that exposure of the Australian population to dioxins is extremely low by world standards from all of the sources researched. The level of dioxin in ambient air was measured in all capital cities and found to be very low when compared to other published data. However, dioxin in ambient air was measured at higher levels during winter months and chemical analysis showed that the increase was predominantly caused by the increased use of wood-fired combustion heaters. The low levels of dioxin recorded in the Adelaide airshed show no need for ongoing ambient monitoring for dioxin.

Australia recently became a signatory to the Stockholm Convention on Persistent Organic Pollutants. The convention sets out a range of obligations for countries to reduce and, where feasible, eliminate release of such pollutants, including emissions of persistent by-product organic pollutants such as dioxins. To meet these obligations it is expected that future management actions on dioxins will concentrate on identifying and controlling the sources of these emissions.

4.4 Other intended monitoring sites

According to the ambient air quality monitoring program for South Australia (EPA 2001), a campaign monitoring program was planned to start in the Riverland in 2003, after an appropriate location had been chosen based on knowledge of the local meteorology, population, and industries. The site for the campaign monitoring in this area has not yet been selected.

The Riverland region includes the towns of Barmera, Berri, Loxton and Renmark. The towns (Figure 11) are located along the River Murray and the land is used for grazing, grape cultivation and citrus fruit growing. Fruit and grape growing and their associated industries include fruit drying using sulfur, and there are also diffuse sources of pollution associated with stubble burning on a seasonal basis. These widely dispersed sources could lead to occasional high particle loading in the area.

It is suggested that campaign monitoring should start in the Riverland region for SO_2 and PM_{10}, which will identify any hotspot areas (i.e. highest ground level concentrations) and indicate any need for ongoing monitoring. Alternatively, TAPM airshed modelling can be conducted to justify this screening in accordance with National Environment Protection Council Peer Review Committee Screening procedures (NEPC 2001a).

[33] toxicity equivalent quotient

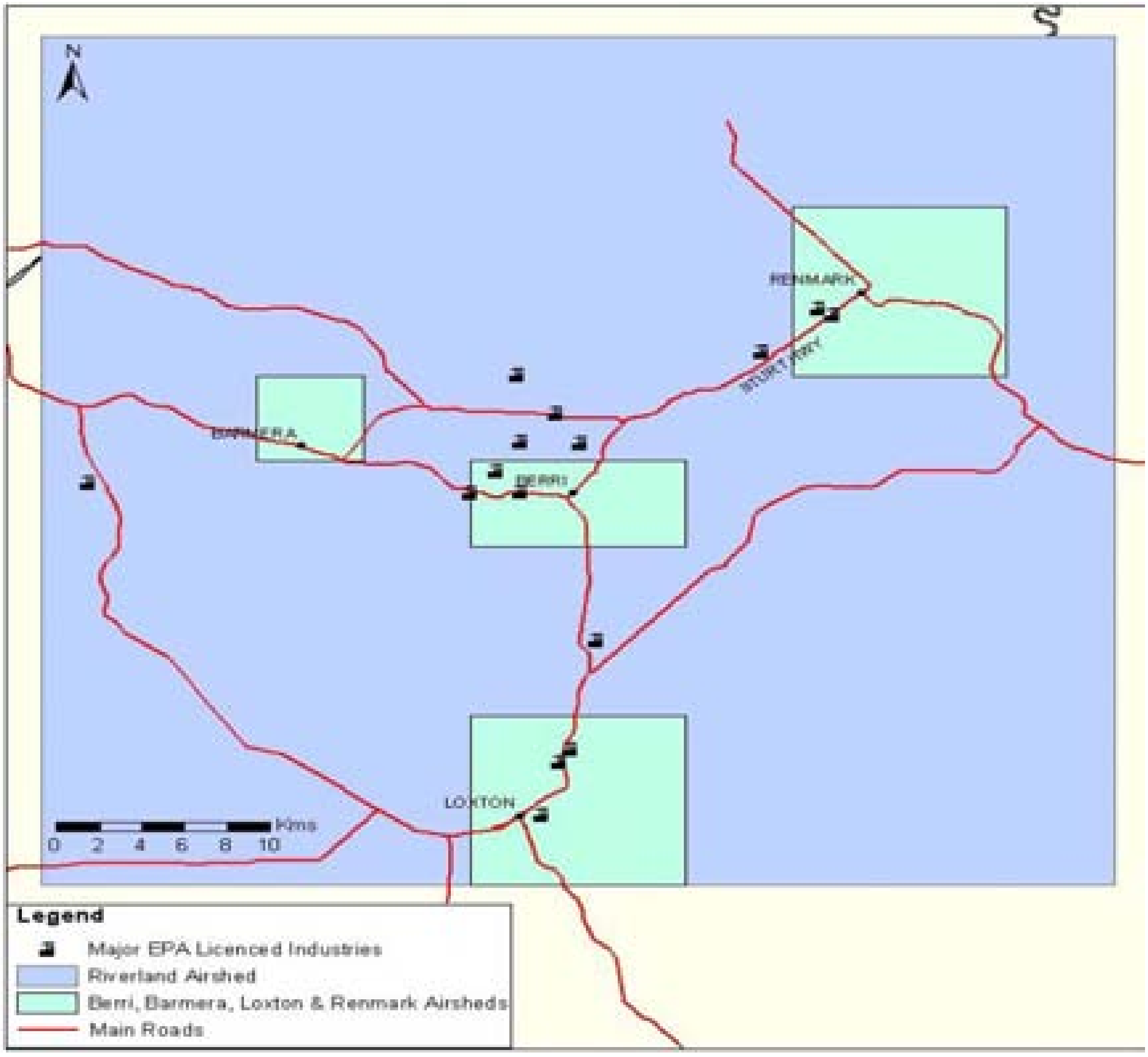

Figure 11 Riverland airshed with major EPA-licensed industries

4.5 Site metadata

A 'comprehensive and accessible' database environment (e.g. the Environmental Data Management System (EDMS)) needs to be used to make the collation and subsequent analysis of the air quality data more convenient and user friendly.

There is no detail about the meteorological parameters being measured along with air quality data in the present metadata reporting system. The current metadata system only involves the name of meteorological parameters (e.g. wind speed, wind direction, solar radiation) measured at the meteorological stations. There is no instrument calibration or quality assurance status for meteorological data. A list of the changes proposed in the current metadata collection system is described in Chapter 5.

4.6 Data quality, handling and reporting

To ensure that data collection and interpretation is reasonably representative of the state's air quality, sampling and analysis must be consistent with appropriate standards and quality control processes:

- Sampling and sample handling must be undertaken in a manner consistent with appropriate Australian Standards.
- Analysis should be undertaken, where possible, by a NATA-accredited laboratory.
- Data storage must be in a secure database (e.g. EDMS).
- Interpretation should be based on a rigorous statistical review of the data.

Data quality

There has been insufficient emphasis on data quality and consistency in the past, as identified by a recent audit of ambient air quality monitoring sites in Whyalla (Vic EPA 2004). Raw data by itself is of limited use. Although the time taken for data validation has reduced, the quality of monitoring data can be improved. There is some confusion as to which data is validated and which is not (data available on the internal shared drive is not identified as provisional or validated). This was evident at the time of the Whyalla audit in early 2004 (T Bardsely Vic EPA, pers. comm. 2004). Ideally, there should be only one source of validated data available for release to internal and external data users. The reason for having different levels of validated data is not clear. Any revised data should be e-mailed and notified as soon as possible. Proper quality assurance and quality control practices are necessary to ensure data integrity and to produce reliable and credible results. Further, data systems should be improved to automate data validation procedures, as much as possible.

Data management

Maintaining the current ambient monitoring program is expensive. It is therefore essential that the data produced provides value for the money spent. Inspection of the data reporting and formats in mid-2004 revealed:

- units of measurement not always clear
- inconsistent formats being used
- delays in validating data, particularly Pb
- validation dates not recorded so that performance indicators are difficult to quantify
- difficulty in finding and tracking historical data, mainly because there is no unified file naming scheme
- NO and NO_2 are measured simultaneously but both pollutants are not included in the same worksheet (both NO and NO_2 should be included in the same Excel worksheet with columns in the following order: date/time, NO_2, NO).

The EPA is responsible for the management of the South Australian air quality database and making sure that all data is systematically included in a database. Efforts are being made to place all the data in EDMS but the process is relatively slow.

Data reporting

As emphasised earlier, the purpose of monitoring is not merely to collect data but to produce useful information in appropriate formats for the public, scientists and regulatory bodies.

The current methods of reporting individual data to NEPC on an annual basis and reporting for SoE and AQI are set out in Chapter 3. This section reviews the adequacy of these reporting avenues from an overall South Australia perspective.

The EPA's web site provides useful information on current pollutant levels (through AQI describing air quality status) in the last 24 hours. The information is updated every day at 10 am and 6 pm. The following important issues need to be addressed:

- The site does not provide a download of hourly air quality datasets (validated or provisional) for all measured pollutants and for meteorological parameters. Thus the air quality database is not accessible on the internet and people looking for information about air quality monitoring cannot find data for the pollutants of interest, over a particular time period and at the location of interest.
- The link to a site information archive, which should include site photographs and some details of monitoring locations, is absent.
- There are no e-mail alerts of pollution events to local authorities or state organisations, or even within the EPA to other branches. Examples of such systems can be found in Department of Environment and Conservation in NSW and the Victorian EPA. Such systems are very cost-effective and greatly improve communication.
- The geographic locations of monitoring sites are not sufficiently clear. This is especially a problem when accessing data from outside the organisation.
- The annual report on air quality is a useful document but the time scale for production (over 12 months) is far too long for strategic planning, etc. At the moment, the EPA has a minimum level of data reporting in the form of monthly and annual summaries, involving simple statistics and graphical analyses that show both time and frequency distributions of the monitored data. The use of geo-spatial information systems (GIS) should be considered, particularly in combining pollution data with demography and dispersion patterns.
- The presentation of air monitoring data in various EPA reports (available on the internet) needs considerable improvement. Recommended improvements include adding narrative to interpret the data presented or explain its significance, giving reasons or cause of an exceedence of certain parameters (including where possible, the influence of natural events), and using pollution roses for visual depiction of the data.
- The problem with presenting simple statistics is that they do not adequately depict the complete picture. For example, maximum values are useful but provide no indication of how much higher they are from the average concentration. Box plots are used by the OECD for reporting a large amount of complex air quality information. They are a useful graphical representation of summary statistics and therefore should be encouraged for presenting air quality data for different monitoring sites and parameters.
- There is no regular reporting process for campaign monitoring sites (i.e. sites in operation for a period of 12 months). For example, the Gawler monitoring site has

been in operation since January 2002 but significant findings from this monitoring site have not been assembled and interpreted to date.

Air quality index survey highlights (October-November 2003)

During October-November 2003, a survey of South Australian Government departments and private companies sought to assess the effectiveness and usefulness of the AQI reporting process and gain opinions on its improvement. The survey questionnaire was put to officers of Department of Health, Transport Planning Agency, the Bureau of Meteorology (BoM), PIRSA, Planning SA, local government, Flinders University, selected industries in Adelaide, and EPA staff including regional EPA offices. It was also placed on the EPA web site on the air quality index page. The questionnaire sought information (apart from raising awareness) on all aspects of the AQI system, specifically with regard to the reporting of the current AQI in Adelaide, future issuance of forecasts or warnings, and several changes proposed for the future. The future changes related to the improvement of access to AQI, the quality of information provided to the public and increasing usage.

Of the respondents, 70% were from state government departments, while 10% were from industry, 10% from environmental consultancies and 10% from universities. No responses were obtained from local governments in South Australia. The detailed results from the survey are attached in Appendix C.

The findings of the survey indicate that the AQI would be of more interest if it forecast conditions for the next day. An AQI in a forecast mode would be a good health measure to alert hospitals and people suffering from asthma, hay fever and lung complaints. Respondents were also asked to name a maximum of three air pollution issues they believed were of highest public concern in their communities; responses were not totally exclusive. The most frequently cited concern was particulate matter (both PM_{10} and $PM_{2.5}$). The other frequently cited concerns were emissions from smokey cars and trucks (automobile source emissions) and photochemical smog (ozone or urban smog).

4.7 Critical analysis of monitoring program

The current monitoring system is relatively dynamic, with new sites added as needed and old sites discontinued when they are no longer useful. Changes are likely to occur within any monitoring program. However, a clear understanding of how, when and why changes are made is lacking. This problem was fully highlighted in PM_{10} and TSP measurements at Whyalla. The site at Hummock Hill was relocated to its current position on 12 May 2000 due to a construction at the old location. Before then, the Old Hummock Hill site was located some 70 metres from the OneSteel[34] site. The changes were not properly documented and data analysis for an EPA dust monitoring report did not take into account the discontinuity in monitoring data due to site relocation. The rationale for making changes should be documented and available for review before implementation.

As mentioned earlier, the current monitoring network is not flexible enough to incorporate changes in the sources and nature of air pollution. Furthermore, it does not fulfil some of its supposed objectives. Community residents also feel that the air quality

[34] OneSteel Manufacturing Pty Ltd operates the steelworks north-east of Whyalla on the upper shores of the Spencer Gulf.

data provided by the EPA through its network of monitoring stations does not necessarily reflect the poor quality of the air they breathe.

The operation division of EPA has raised concerns on several occasions that the current monitoring does not fulfil their specific needs to monitor different pollutants in the vicinity of licensed industries or in those areas where local 'hotspots' of pollution actually exist—for example, a recent case of community complaints about odour in the vicinity of Kilburn (north-west of Adelaide) where a number of industries co-exist. These local air quality issues need proper scientific assessment using a combination of approaches like emission inventory, problem-specific monitoring and air quality modelling.

The costs (both capital and non-capital) of the current monitoring program are high, mainly due to the need to purchase and install continuous monitors and associated data logging instrumentation and other infrastructure at many sites. Operational expenses for maintaining the sites on a continuous basis are substantial. As all resources are bound in the current ambient monitoring program, it is almost impossible to do special investigations and assessment in areas of real concern and in those areas where air quality problem actually exist. The overall goal of a monitoring program should be to ensure that the maximum information can be derived from minimum efforts.

An efficient and cost-effective way is to run a monitoring program in conjunction with other objective assessment techniques including modelling, emission measurement inventories and mapping. Practically speaking, project-specific monitoring should be initiated for those pollutants that could pose a potential threat to public health and the environment. The need for, scope and type of air quality monitoring to be performed should be determined on a case-by-case basis. This could include intensive monitoring periods (e.g. for a period of two months), careful design of the project-specific monitoring (i.e. field measurements) and inexpensive non-automated monitoring methods like passive samplers. Passive samplers are specifically suited to baseline and screening studies for assessing the spatial coverage of various pollutants and can provide a more complete assessment of air quality in areas of concern.

Since some NEPM pollutants are formed through secondary atmospheric reactions (e.g. O_3), it is not possible to understand the role and contribution of precursor compounds to their production without actually characterising their chemical precursors. Further, it is hard without this information to assess options for effective emission control strategies to minimise their formation. The current monitoring network for O_3 does not include any measurement of hydrocarbon data. On the basis of the analysis presented in Section 4.2 of this report, it is reasonable to conclude that routine air quality monitoring in SA is driven mainly by regulatory NEPM requirements. The current monitoring arrangement does not provide enough scientific data for initiating air quality management and emission control strategies in the airshed.

It is also reasonable to conclude, on the basis of analysis presented in Section 4.2, that the current monitoring program has historically focused on determining the state of the environment as defined by established air quality criteria pollutants. It does not necessarily focus on those parameters that help us to understand the processes that lead to that environmental state.

5 Proposed changes in the monitoring program

Proposed changes to the monitoring program include discontinuation of measurements of some pollutants at sites where the requirements for screening (NEPC 2001a) are met. Also included are suggestions for establishing new monitoring sites (e.g. Adelaide Hills) and measuring new pollutants (e.g. air toxics, VOCs, size-resolved chemical composition). Table 10 shows the current and proposed monitoring program for compliance assessment required under the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM); Table 11 indicates other main suggested changes in the overall monitoring program, such as new sites and new monitoring parameters.

Table 10. Current and proposed number of monitoring sites from the existing monitoring network for compliance assessment required under the AAQ NEPM.

Pollutant	Current number of sites		Proposed number of sites	
	Metropolitan Adelaide	Regional centres	Metropolitan Adelaide	Regional centres
NO_2	**5**[a]	**1**	**3**	**0**
SO_2	**1**	**1**	**1**	**1**
CO	**2**	**0**	**1**	**0**
PM_{10}	**4**	**5**	**4**	**5**
O_3	**5**[a]	**1**	**3**	**0**
Pb	**0**	**4**	**0**	**4**

a Monitoring at Gawler discontinued in October 2004

Table 11. Other key proposed changes in the air quality monitoring program

Pollutant	Metropolitan Adelaide		Regional centres	
	Location	**Duration**	**Location**	**Duration**
NO_2	South of the Adelaide city	Campaign (12-months)	-	-
VOCs	Netley	Campaign (12-months)	-	-
CO	Adelaide Hills	One winter initially	-	-
PM_{10}	South of the Adelaide city	Campaign (12 months)	Mount Gambier	Campaign (12 months)
	Adelaide Hills	One winter initially	Riverland region	Campaign (12 months)
	Birkenhead	Permanent	-	-
O_3	South of the Adelaide city	Campaign (12 months)	-	-

Pollutant	Metropolitan Adelaide		Regional centres	
	Location	Duration	Location	Duration
SO_2	-	-	Riverland region	Campaign (12 months)
$PM_{2.5}$	Adelaide Hills	One winter initially	Mount Gambier	One winter initially

5.1 Ozone

- Consideration needs to be given to installing a monitoring station in the south of the city to fulfil the commitments made in the 2001 Air Monitoring Plan.
- Most of the O_3 stations also monitor NO_2 at present. To fully understand the complex relationship between O_3 and its precursors, measurement of VOCs at least at one of the O_3 station (at Netley) is recommended.
- The NEPM goal for O_3 has not been exceeded in Adelaide at any monitoring site since 1986. It is proposed that monitoring for O_3 be continued at Netley, Elizabeth and Kensington, but discontinued at Northfield. The general locations for Netley, Elizabeth and Kensington have been chosen because they are in key locations for assessing O_3 and O_3 precursor transport from the CBD. In addition, the data from these sites is currently used for calculation of the AQI in Adelaide.
- It is recommended that monitoring for O_3 be discontinued at the Port Pirie site.

Points raised in the Adelaide workshop

If further monitoring sites are to be established (even for short periods such as one or two summer seasons), then the most appropriate locations would be downwind of the fastest growing regions[35] in the Mount Lofty Ranges (e.g. Mount Barker) to measure concentrations in the transport corridors as identified by aircraft studies.

5.2 Nitrogen dioxide

- There is no need to expand the monitoring program for NO_2. However, a monitoring station is needed in the south of the city to comply with the requirements of the 2001 monitoring plan. It is proposed that a campaign monitoring station should first be established and the decision about establishing a permanent monitoring site should be made based on initial results.
- It is recommended that monitoring for NO_2 be continued at Netley, Elizabeth and Kensington in line with O_3, and discontinued at Northfield.
- NO_2 monitoring in Port Pirie is not required as levels are very low.

Points raised in the Adelaide workshop

The Adelaide workshop also noted that NO_2 is fairly well covered in Adelaide and adding extra sites would not add much value to the program.

[35] Some of the developments are large enough to increase local traffic flows and this will affect local air quality.

5.3 Carbon monoxide

- CO monitoring at Elizabeth should be discontinued as levels are very low.
- Adding CO monitoring to an Adelaide Hills station in winter would provide useful information about this pollutant as CO is also associated with wood-smoke.

Points raised in Adelaide workshop

The Adelaide workshop noted that CO levels in the city at Hindley Street have been consistently low. Due to the change in the living style of people (more people seem to be living in the city now), current monitoring site could be relocated at Rundle Street East (a place with lots of cafes and public crowds). This should be placed for a period of 12 months to get an understanding of exposure of the wider population to CO concentration at this site. One alternative is to set up a second site for about 12 months at Rundle Street as a campaign monitoring site.

5.4 Sulfur dioxide

- SO_2 monitoring in Port Pirie needs to be continued.

5.5 Particulate matter (TSP, PM_{10} and $PM_{2.5}$)

- There is a growing interest in $PM_{2.5}$ concentrations but there is no NEPM requirement for widespread monitoring. It would be useful to develop a better understanding of $PM_{2.5}$ in South Australia to help inform future policy directions. The EPA should therefore consider encouraging further monitoring for $PM_{2.5}$ in the Adelaide Hills, especially in winter months. Monitoring there would allow characterisation of the effects of domestic heating on fine particulate concentrations in the area.
- While monitoring stations have been upgraded and new sites assessed to comply with the Air Quality Monitoring Plan for South Australia (EPA 2001), monitoring at the proposed southern metropolitan and Hope Valley sites for PM_{10} has not started, leaving gaps in data coverage in the southern part of Adelaide. Monitoring should commence at these sites as a matter of priority.
- Very few studies in South Australia have examined the size distribution of particles and relative contributions of different sources to PM_{10} or $PM_{2.5}$, or the seasonal variation in source contributions. The studies conducted have been mostly of short duration and small sample size, and have not adequately documented temporal and seasonal variation. For making informed decisions on particulate matter sources, additional special studies such as 'source apportionment' on particles, particle numbers, chemical speciation and size distribution are recommended for a variety of locations in Adelaide and other regional centres. Such measurements are both costly and difficult to undertake. Studies can determine the relative contribution of each of the major sources to the overall ground level particulate matter concentrations, taking into account the dispersion of the emissions and 'typical' weather parameters. At this stage, it is recommended that the duration of such studies should be for a period of one year. A sampling site should be located at Mount Gambier, where fine particles have been shown to be exceeding NEPM standards (e.g. Adeeb 2003). A related area is the formation of secondary organic aerosol, produced by the oxidation of both anthropogenic and biogenic VOCs. The formation

of these aerosols is poorly parametrised in models. An understanding of the size-resolved chemical composition of Adelaide particles would move towards addressing this issue.

- TSP measurements have been carried out on the normal six-day cycle in Whyalla (Hummock Hill and Civic Park) since 1989. As the emphasis on particulates has shifted to the PM_{10} and smaller size fractions, measurement of TSP should be rationalised in the existing monitoring program. A wider discussion is needed with the Department of Health and the resident community in Whyalla on future PM_{10} monitoring at New Hummock Hill monitoring site, whose data is not comparable to NEPM standard.
- It is suggested that a permanent PM_{10} monitoring station be established at Birkenhead, along with provision for meteorological monitoring.

Points raised in Adelaide workshop

- PM_{10} monitoring stations in Port Pirie and Port Augusta need to be continued.
- It would be useful to start monitoring on a short campaign basis (e.g. in winter) in areas where large developments are proposed—e.g. PM_{10} monitoring in new growth areas (both industrial and residential) of Mount Barker, Barossa Valley and Murray Bridge for winter months on a rotational basis.

5.6 Lead and other trace elements

- The existing industrial monitoring stations (at Port Pirie) for measuring lead levels associated with emissions from industry need to be continued. A wider discussion is needed with the Department of Health on the future lead monitoring program in Port Pirie.
- The current position with other trace elements (e.g. zinc, cadmium, nickel) is unclear. At this stage it is recommended that monitoring of heavy elements be kept under review pending development of a NEPM for these elements.

5.7 Air toxics

- No long-term measurements of air toxics are being carried out in South Australia at the moment. However, as a result of the new directive on air toxics, South Australia could be required to monitor benzene, toluene, formaldehyde, xylene and benzo(a)pyrene as a marker for PAH (ng/m^3). The decision to start monitoring will be based on a desktop assessment of sources and likely locations of these pollutants.
- Short-term baseline studies, largely in relation to a small number of traffic-related hydrocarbons such as benzene, toluene and xylenes, should be carried out in metropolitan Adelaide, preferably in heavy trafficked areas like Great Junction Road and at a background location (i.e. a site well away from roads, such as in Kensington). The decision to start monitoring should be based on a detailed desktop assessment of sources and likely locations of these pollutants.
- Air toxics assessment should be prioritised towards those areas like Mount Gambier and the Adelaide Hills where monitoring has identified high concentrations of small

particulates that are likely to be associated with air toxics (such as from combustion sources).

5.8 Other intended monitoring sites

- To fulfil the requirements of the 2001 monitoring plan, it is suggested that a campaign monitoring site be established in the Riverland region for SO_2 and PM_{10}.
- Two cities, Whyalla and Mount Gambier, have populations close to 25,000 and, in the near future, the populations may exceed the minimum required for establishment of a NEPM PMS site. It is proposed that a desktop assessment be carried out on potential air pollutants arising out of this population increase.

5.9 Site metadata

It is proposed that, in addition to the information already being collected (Chapter 3), monitoring site metadata should include the following supplementary information:

- specified monitoring objectives (e.g. determining maximum concentration levels or compliance with NEPM standards; population exposure in high density areas where air quality is suspected to be poor; determining impact from an industrial source or construction site; determining background levels of concentrations)
- site elevation—estimated height of site's ground level above sea level (m)
- housing—monitors are located within an air-conditioned portable monitoring shed with the sampling inlet extending out of the roof; ambient temperature setting in °C
- main topographical features that surround the site—buildings, trees, waterbodies, etc.
- description of sources—in case of line sources, road sources that surround the site (e.g. type of road (arterial or non-arterial), distance from site, direction from site, alignment, traffic density or average vehicles per day); in the case of point sources, distance from the site and direction from monitoring site; in the case of area sources, descriptive information about area sources that surround the site
- changes to the monitoring stations—changes may arise from results of campaign monitoring if it is decided that further performance sites are needed, or can involve installation of a new monitor or monitoring shed, decommissioning of the site or site re-location due to development in the area
- % of valid data—the proportion of valid data collected from installation until the finish date
- distance between meteorological stations and monitoring site in km
- regional meteorological characteristics that influence the site's air quality—e.g. shielded from south-east wind flows by a 3-storey office buildings or a house
- micro-met characteristics: meteorological considerations such as the shielding of the monitor by surrounding structures—out-growth of trees, temporary construction activities, wall of a house

All stations should comply with the Australian Standard for siting and should not be shielded.

5.10 Data quality, handling and reporting

Data quality

Currently there is no appraisal of the actual compliance of the monitoring program with standard operating procedures. Obtaining NATA accreditation for instrument operation and data reporting would be one step towards assuring that the data is of the highest quality, and would enable an estimate of the uncertainty of the data. Most of the issues relating to data quality will be addressed through NATA accreditation for measurement and data reporting. Therefore, attaining accreditation should be a priority. In view of problems identified from time to time in the current monitoring system, it is also suggested that the EPA should:

- ensure that all measurements, including automatic calibrations and calibration checks, maintenance and servicing of monitors, and exposure and analysis of samplers be undertaken in accordance with relevant Australian Standards
- ensure that all gases used for the purpose of calibrating and checking the zero and span response of automatic monitors are certified to a traceable standard and maintained at a stable concentration
- aim to obtain an independent assessment of the quality of measurements made in Adelaide (this could be through periodical external audits of the ambient air monitoring network and associated data review and management systems)
- improve the time for validation of data and production of reports
- evaluate the current QA/QC system for the monitoring laboratory on an annual basis in order to ensure that the data is representative of ambient or exposure conditions and measurements are accurate, precise and consistent over time. QA reporting can include equipment evaluation and selection, routine site operations, network design, management and training systems; QC evaluation can include a description of network audits, inter-site calibrations, and presence or absence of calibration and traceability chains.

Data management

Data management needs to ensure that:

- the database be secure (preferably in EDMS) but readily available for read-only access by other government agencies, industry, community groups, local council and the community
- the system be easy to use, preferably through a simple GIS-type interface—users can use a map to identify areas of interest and answer a few simple questions to obtain the data required
- the system be able to present data in tables, graphs and reports in a variety of formats so that trends can be easily determined and comparisons made with other sites

- there is a secure off-site copy of the validated air monitoring database (e.g. in the existing WinCollect software), as well as an in-house secure copy and an in-house current raw year database.

Assessment and review

It is recommended that a rigorous triennial (once every three years) review be conducted that critically assesses the ambient air quality monitoring program to determine if it is still appropriate (relevant to monitoring objectives), whether the parameters being monitored are sufficient and relevant, whether the sampling frequency is optimal and whether new areas of environmental significance need to be included. The review should be based on the data collected over the previous year, or years, and should be undertaken in consultation with the other agencies involved (e.g. Department of Health, TSA and BoM).

Data reporting

Air NEPM requirements for reporting as specified in the PRC guideline for annual reports (NEPC 2002) are adequately addressed by the annual report to NEPC.

While the EPA's web site provides useful information on current pollutant levels (through the AQI describing air quality status in the last 24 hours up to 17:00) and data statistics, an important issue needs to be addressed—the site needs to provide a download of hourly air quality datasets for all measured pollutants and meteorological parameters.

Points raised in Adelaide workshop

The key issues identified and various suggestions arising out of the Adelaide workshop were as follows:

- Air quality forecasting for South Australia is essential.
- On-line data access is required.
- Meteorological data compatible with current air models should be provided. There should be two formats for air quality data: one in Excel and the other compatible for use in air quality models.
- Monitoring data collected by industry (after proper quality control and assurance) should be combined in the EPA ambient air quality database. The Industry Monitoring Assessment Group within the EPA is already in the conceptual stages of developing manuals for assessment of ambient air data supplied by industry. The final plan is to include this data in the monitoring modules called ELMO/GENI that are operated by EPA Information Technology Business Services.
- Storage and maintenance of air quality data in EDMS should be arranged on a priority basis.
- The geographic locations of monitoring sites are not clear, especially when accessing data from outside the EPA. GIS maps would be useful.
- E-mail alerts of pollution events should be issued to local authorities or other state organisations or even within the EPA to other branches.

5.11 Air quality index reporting

- One of the concerns raised in the AQI survey results was a need for increasing the accessibility of the AQI on EPA's web site. It is recommended that steps be taken to place the AQI on the EPA web site (not the Department for Environment and Heritage site).
- Of the respondents, 96% were of the view that the AQI would be of more interest if it forecast conditions for the next day. For health purposes, knowing what has happened is not particularly useful. Predictive forecasts are needed, as in other Australian states like NSW and Victoria.

5.12 Monitoring by external agencies and partnership

Points raised in Adelaide workshop

- Consideration needs to be given to including industrial monitoring sites in the SA ambient air quality network. In addition to the EPA's monitoring sites, there are also numerous long-term monitoring sites established and run by industry for compliance reasons and many have been running for several years. Generally, these stations are located specifically to monitor unique point source conditions (which limits the representative range of the station). The decision to incorporate such data should take into account important issues like quality assurance, quality control, and data formats compatible with SA ambient air monitoring programs, and should be made in consultation with the EPA Industry Monitoring Assessment Group.
- When considering industry ambient air monitoring data, the EPA should provide guidelines to allow such data to be useful to the EPA.
- The potential of joint funding of sites or the operation of monitoring programs needs to be explored, so that authorities can pool resource

5.13 Air quality modelling

Ambient air pollution monitoring is a very effective way of assessing changes in air quality over time and in ensuring that policy objectives are met. However, it is an expensive tool in the sense that it is clearly impractical to monitor at every point of interest and for an ever-increasing variety of air pollutants (e.g. air toxics). Air quality models fill the gaps and allow an assessment to be made of air quality in locations where no monitoring is or can be undertaken. Observations are made at a few locations and may therefore not be very representative of larger areas. In contrast to monitoring, modelling has predictive capabilities as well and can forecast air quality conditions for the next day and thus it is possible to give advance warning of any possible exceedence of air quality standards to the public.

The Air NEPM also recognises that direct air monitoring is one of a range of tools for air quality assessment and management. Clause 11 of the Air NEPM states:

> *For the purposes of evaluating performance against the standards the concentration of pollutants in the air:*
>
> - *is to be measured at performance monitoring stations; or*

- *is to be measured by other means that provide information equivalent to measurements that would otherwise occur at a performance monitoring station (NEPC 1998).*

The tools available other than monitoring are modelling and air emission inventories. Air quality modelling provides a link between measured air quality and emission estimates and thus can be used to improve an air monitoring program and emission inventories. For example, air quality dispersion models describe how pollutants are spread and mixed in the atmosphere. Mathematical procedures are used to calculate pollutant concentrations, taking into account emission rate (mass of a pollutant emitted over time) and dilution rate (the volume of surrounding air into which pollutant is being released and mixed per unit time).

The main limitations of monitoring data are that it:

- only represents air quality at certain locations, and problems arise with visualising spatial distribution of air pollution
- describes present and perhaps historic air quality but says nothing about future air quality.

Forecast models may play an important role in providing timely information to the public in case of smog episodes or exceedence of particulates.

Modelling undertaken previously in 1996 (based on data from two sites and a rudimentary emission inventory) helped in locations and expanding monitoring sites in Adelaide.

The EPA purchased the CSIRO's 3-dimensional prognostic model, called The Air Pollution Model, or TAPM in early 2002. A statistical evaluation of the TAPM for a well-defined, high ground-level ozone period in Adelaide, 17–31 Dec 2002, was undertaken recently (Adeeb, 2004). The results indicated that TAPM predicted the meteorological and ozone pollution situation reasonably well for the simulation period. As a next step in the project, EPA will use TAPM to determine the relative impact of various sources (source categories, emissions from different regions) and emission reduction scenarios.

In 2004, the EPA contracted the CSIRO to investigate and detail the extent of the risks, resources, costs and any other relevant issues in the implementation and ongoing use and maintenance of the Australian AAQFS. The study demonstrated that the implementation of AAQFS in South Australia has the potential to provide the EPA with a significant upgrade in its current air quality forecasting/modelling capability (Cope and Hess 2004). Such a system (if implemented) would include the ability to generate short-term forecasts for key air pollutants subject to reporting under the Air NEPM, in addition to wind-blown dust and bushfire smoke.

Points raised in Adelaide workshop

It was suggested during the Adelaide workshop that a network of EPA modellers (e.g. one in each state) is needed, who would be involved at the local level and who would work collaboratively with the CSIRO and BoM in ongoing development of the forecasting system. This pooling of resources and expertise has the potential to enhance the whole system on a national basis. Further TAPM modelling of Adelaide airshed by the EPA will enable refinement of the approaches related to monitoring sites, and identification of the relative importance of major sources in air quality management.

6 Bibliography

Adeeb, F 2004, *Evaluation of the Air Pollution Model TAPM for Adelaide—Case study* (17–31 December 2002), Environment Protection Authority, Adelaide. *www.epa.sa.gov.au/pdfs/modelling.pdf*.

Adeeb, F 2003, *Ambient Air Quality Monitoring—Mount Gambier, September 2001–August 2002*, Environment Protection Authority, Adelaide. *www.epa.sa.gov.au/pdfs/aq_mtgambier.pdf.*

Adeeb, F, Mitchell, R and Hope, L 2003, *Future air quality monitoring for lead in metropolitan Adelaide*. Report to the National Environment Protection Council. Environment Protection Authority, Adelaide *www.epa.sa.gov.au/pdfs/lead_aq_report. pdf*.

Australian Bureau of Statistics 2003, *Regional Population Growth, Australia and New Zealand 2001-02*, Catalogue No. 3218.0, ABS, Canberra (Issued 3 April 2003).

Australian Bureau of Statistics 2003, *Population by Age and Sex, Australian States and Territories, June 1997 to June 2002*, Catalogue No. 3201.0, ABS, Canberra (Issued 27 March 2003).

Best, P 2004, Causal factors for apparent deterioration of dust levels at Hummock Hill, Whyalla, Katestone Environmental, Report number KE0402228.

Ciuk, J 2001, *National Pollutant Inventory, Aggregate Air Emissions Study, 1998/1999. Summary Report, Adelaide and Regional Air shed*, Environment Protection Authority, Adelaide. *www.epa.sa.gov.au/pdfs/npi_air.pdf*.

Clark, NJ, Hacker, JM, and Mitchell, RM 1998, Aircraft observations of Adelaide air quality, *Proceedings of the 14th International Clean Air and Environmental and Environment Conference*, Melbourne, October 1988, Clean Air Society of Australia and New Zealand, Sydney.

Cope, M and Hess, D 2004, *Scoping study for air quality forecasting*, Prepared by CSIRO and Bureau of Meteorology Research Centre for South Australian Environment Protection Authority.

Cugley, J 1995, *Ambient Water Quality Monitoring for South Australia, Issues and Requirements*, Department of Environment and Natural Resources, Adelaide.

Environment Australia 2002, *Review of data on heavy metals in ambient air in Australia*, Technical report no.3.

ENVIRON 2003, *Draft Whyalla Air Quality Assessment and Health Implications for OneSteel Manufacturing Pty Ltd*; report prepared for OneSteel.

EPA 1998, *State of the Environment Report for South Australia 1998- summary report*, Department for Environment, Heritage and Aboriginal Affairs, Adelaide. *www.environment.sa.gov.au/reporting/reports/ser_summary/index.html*

EPA 2003, *State of the Environment Report for South Australia 2003—executive summary,* Environment Protection Authority, Adelaide. *www.environment.sa.gov.au/soe2003/key_findings.pdf*.

EPA 2000a, *Strategic Priorities for 2002–2004,* Environment Protection Authority, Adelaide.

EPA 2001, *Ambient air quality monitoring plan for South Australia*, Environment Protection Authority, Adelaide. *www.epa.sa.gov.au/pdfs/airnepm/pdf*.

EPA 2002, *Mapping Our Future, Strategies and Directions 2002-2005*, *A guide to the way forward for South Australia's Environment Protection Authority,* Environment Protection Authority, Adelaide.

EPA 2004, *Ambient Air Quality Monitoring, South Australia, 1979-2003,* Environment Protection Authority, Adelaide. *www.epa.sa.gov.au/pdfs/aq_report.pdf*.

EPHC nd, Air toxics, Environment Protection and Heritage Council. *www.ephc.gov.au/nepms/air/air_toxics.html*.

Fox, DR 2004, *Statistical Analysis of Whyalla Air Quality Monitoring Data*, Australian Centre for Environmetrics, Report 01/04.

Henry, RL, Bridgan, HA, Wlodarczyk, J, Abramsom, R, Adler, JA, and Hensley, MJ 1991, Asthma in the vicinity of power stations: II. Outdoor air quality and symptoms, *Pediat. Pulmonol*, 11: 134-40.

Hibberd, MF, Gilbert, AJ, Isaac, PR, Noonan, JA, Patterson, GR, Rothwell, KR, Scott, GO and Young, SA 1996, *Port Pirie Air quality investigations—relating emissions to impacts,* Final report to Pasminco metals, BHAS.

NEPC 1998, *National Environment Protection Measure and Impact Statement for Ambient Air Quality,* National Environment Protection Council, Adelaide. *www.ephc.gov.au/*.

NEPC 2001, *Checklist for monitoring plans (National Environment Protection Council (Ambient Air Quality) Measure, Technical paper no. 1*. *www.bom.gov.au/bmrc/csr/prc*.

NEPC 2001a, *Screening procedures, National Environment Protection (Ambient Air Quality) Measure*, Technical Paper No. 4. *www.bom.gov.au/bmrc/csr/prc*.

NEPC 2001b, *Selection of regions, (National Environment Protection Council (Ambient Air Quality) Measure, Technical paper no. 2*. *www.bom.gov.au/bmrc/csr/prc*.

NEPC 2001c, *Accreditation of performance monitoring (National Environment Protection Council (Ambient Air Quality) Technical paper no. 7.* *www.bom.gov.au/bmrc/csr/prc*.

NEPC 2001d, *Collection and reporting of TEOM PM_{10} (National Environment Protection Council (Ambient Air Quality) Technical paper no. 10*. *www.bom.gov.au/bmrc/csr/prc*.

NEPC 2001e. *Data collection and handling (National Environment Protection Council (Ambient Air Quality) Technical paper no. 5*. *www.bom.gov.au/bmrc/csr/prc*.

NEPC 2001f, Issues Paper—*The need for a $PM_{2.5}$ standard in Australia*, NEPC, Adelaide. *www.ephc.gov.au/pdf/Air_Variation_PM25/issues_paper.pdf*.

NEPC 2002, *Annual Reports (National Environment Protection Council (Ambient Air Quality) Technical paper no. 8.* *www.bom.gov.au/bmrc/csr/prc*.

NEPC 2002a, *Impact Statement for $PM_{2.5}$ Variation*, NEPC, Adelaide. *www.ephc.gov.au/pdf/Air_Variation_PM25/draft_variation_is.pdf*.

NEPC 2002b, *Discussion paper—Setting a $PM_{2.5}$ standard in Australia*, NEPC, Adelaide. *www.ephc.gov.au/pdf/Air_Variation_PM25/discussion_paper_PubCons.pdf*.

NEPC 2003a, *Annual Report (2002-2003),* National Environment Protection Council, Adelaide. *www.ephc.gov.au/pdf/annrep_02_03/152_156_App_6_AAQ_SA.pdf*.

NEPC 2003b, *Variation to the National Environment Protection (Ambient Air Quality) Measure*, NEPC, Adelaide. *www.ephc.gov.au/pdf/air_variation_PM25/PM2_5_variation.pdf*.

NEPC 2003c, *Impact Statement for the National Environment Protection (Air Toxics) Measure*, National Environment Protection Council, Adelaide. *www.ephc.gov.au/pdf/air_toxics/air_toxics_is.pdf*.

NEPC 2003d, *National Environment Protection (Air Toxics) Measure: Draft NEPM for public Consultation*, National Environment Protection Council, Adelaide. *www.ephc.gov.au/pdf/air_toxics/draftnepm_at.pdf*.

NEPC 2004, *Review of the Practicability of a 10 Minute Sulfur Dioxide Standard—Issues Paper. www.ephc.gov.au/pdf/air_SO2_review/SO2_issues_paper.pdf.*

NEPC 2004a, *Preliminary Work on Ozone for the Review of the Ambient Air Quality NEPM- Draft Issues Paper*, NEPC, Adelaide.

Ng, LY 2004, *Update of South Australian aggregated emissions data, prepared by EPA Victoria for Environment Protection Authority of South Australia.*

Physick, WL, Cope, M, Ischtwan, J and Morrell, A 1995, *Preliminary modelling for network design in the Adelaide air shed,* CSIRO and EPA Victoria, Melbourne.

Riordan, D and Adeeb, F 2004, *Air quality monitoring for sulfur dioxide in metropolitan Adelaide,* Environment Protection Authority, Adelaide. *www.epa.sa.gov.au/pdfs/so2_report.pdf*.

UNEP/WHO 1994a, GEMS/AIR Methodology Review Handbook Series, Volume 1, *Quality Assurance in Urban Air Quality Monitoring,* United Nations Environment Programme, Nairobi, and the World Health Organization, Geneva.

Vic EPA 2004, Audit of the Whyalla ambient particle monitoring network operated by the Environment Protection Authority, South Australia.

Vic EPA 2004a, *Fine Particle Composition in Four Major Australian Cities*—Draft final report, Environment Protection Authority, Victoria.

WA EPA 2003, *Annual summary of ambient air quality monitoring in Western Australia*, *2002*, Technical Series 115, Department of Environment, Perth, Western Australia.

World Health Organization 2002, *Guidelines for Air Quality*, WHO, Geneva. *www.who.int/peh/air/airqualitygd.htm*.

APPENDIX A. Characteristics of air pollutants

Carbon monoxide (CO)

Sources

In Adelaide, almost 85% of all CO emissions are a result of motor vehicle exhaust (Ciuk 2001). Power generation and domestic solid fuel heaters are other significant sources. CO may also be formed in the atmosphere by the oxidation of methane.

Health effects

Exposure to high levels of CO may result in increased incidence and duration of angina pectoris (chest pain sometimes leading to heart attack), visual impairment, reduced motor skills, poor learning ability, difficulty in performing complex tasks and low birth weight (NEPC 1998).

The main threat to health from exposure to CO is the formation of carboxyhaemoglobin, which substantially reduces the capacity of the blood to carry oxygen and deliver it to the tissues.

Sulfur dioxide (SO_2)

Sources

At normal temperature and pressure SO_2 is a gas but dissolves in water to give an acidic solution that is readily oxidised to sulfuric acid (H_2SO_4).

SO_2 has never been a pollutant of concern in metropolitan Adelaide, except near certain industrial facilities and in the vicinity of Port Stanvac oil refinery, some 30 km south-west of the CBD. The decommissioning of the oil refinery has now removed a major source of SO_2.

Health effects

SO_2 is a highly soluble irritant gas that is quickly absorbed in the moist environment of the upper or lower airways. SO_2 appears to reduce the diameter of airways and airflow by acting on cells that cause inflammation, constriction and create mucus.

As levels of SO_2 are low in Australian cities (because of low sulfur content in Australian fuels), only a few studies have been conducted to demonstrate the human health impacts associated with SO_2 levels. Cross-sectional studies conducted in NSW in the Hunter and Illawarra region (Henry et al. 1991) found no association between annual average levels of SO_2 and the prevalence of asthma in children. High short-term peaks of SO_2 are not widely experienced by the Australian population, with high levels only experienced close to sources (NEPC 2004).

SO_2 may cause damage to buildings, materials, aquatic systems and vegetation, including crops. Australian studies indicate that some crop yields may be affected by prolonged exposure to SO_2 at concentrations of 0.05 ppm or greater in the growing season, and some trees may suffer leaf damage at concentrations at or above 0.08 ppm.

Nitrogen dioxide (NO_2)

Sources

NO_2 is an important participant in the generation of photochemical oxidants. It is formed during combustion processes (including those that occur in motor vehicles), stationary engines, and industrial processes such as in boilers and furnaces.

Biogenic sources of NO_2 are lightning and the oxidation of ammonia—a very small component of total NO_2 emissions in urban areas. Motor vehicles account for about 72% of total Adelaide emissions of NO_x (Ciuk 2001).

Health effects

NO_2 irritates the lungs and may lower immunity to respiratory infections. Exposure to high levels of NO_2 causes severe lung injury. NO_2 has been demonstrated to increase the effects of exposure to other pollutants such as O_3, SO_2 and respirable particles (NEPC 1998). At high concentrations, in excess of those currently measured around the Adelaide metropolitan region, NO_2 can cause reduced growth and visible injury in plants.

Lead (Pb)

Sources

Outside the major local point sources, such as lead smelting facilities, the predominant source of airborne Pb in Australian capital cities is petrol-engined vehicles. Lead compounds were added to petrol as octane extenders. Unleaded petrol (ULP) was introduced in 1985 for use in catalyst-equipped cars. The normal replacement of vehicles with one designed to use ULP has automatically reduced the use of leaded petrol, total Pb emissions and therefore the Pb concentration in ambient air. Current knowledge suggests that Pb is not a pollutant of concern in the Adelaide metropolitan area. Lead monitoring was discontinued at some sites in 2003.

Health effects

Pb ranks as one of the most serious environmental threats to human health, especially in urban areas. Exposure can occur through a number of pathways including ingestion and inhalation. Pb affects several physiological processes including the blood-forming reproductive, nervous and renal (kidney) systems.

Ozone (O_3)

Sources

O_3 is usually not directly discharged to the air since it is formed from pollutants such as NO_x and VOCs. O_3 levels depend on the rates of emission of these 'precursor' pollutants, which are normally associated with motor vehicle operation, fuel combustion and industrial processes.

Because sunlight plays a major role in O_3 production, maximum O_3 levels generally occur in the summer months between noon and early evening.

Health effects

Symptoms of exposure to O_3 include irritation of the airways and minor lung function changes in both healthy and susceptible individuals. There is evidence of a small increase in mortality and hospital admission associated with exposure to O_3, primarily cardio-vascular diseases and mainly among those aged 65 and older.

O_3 also affects vegetation and ecosystems, decreasing yields of commercial crops and lowering the aesthetic value of national parks.

Particulate matter (TSP, PM_{10}, $PM_{2.5}$)

Sources

Unlike individual gaseous pollutants, which are single, well-defined chemical substances, particulate matter is composed of a wide range of materials arising from a variety of sources These can be broadly classified into three categories:

- Primary combustion particles—particles emitted directly from combustion processes such as domestic fires, motor vehicle engines, power generation boilers and industrial combustion plants. Primary combustion particles are generally less than 1 μm in diameter.
- Secondary particles—particles formed by chemical reactions in the atmosphere. They include sulfate, and nitrate formed by the oxidation of NO_2 and SO_2. They are generally less than 2.5 μm in diameter.
- Coarse particles—these particles arise from non-combustion sources such as resuspended dust from constructive activities, road traffic, wind blown dust, soil erosion processes and sea-salt, or are biological particles such as pollen. These particles are generally larger than 2.5 μm in diameter.

The relative contribution of each source type varies from day to day and on a seasonal basis, depending on meteorological conditions and quantities of emissions from mobile and static sources (e.g. higher PM_{10} emissions during winter months from domestic fires). Thus, it is important to bear in mind the different source categories and their relative contribution to PM_{10} concentrations when assessing air quality in an area.

Concentrations of PM_{10} are also strongly influenced by meteorological conditions. When temperatures are cooler, more people use solid fuel burners to heat their homes, leading to an increase in particulate concentrations in the air. Further, under certain weather conditions, an inversion layer can develop naturally which traps the particulate matter close to the ground, thus increasing the concentration.

Health effects

PM_{10} (particulate matter in air which is less than 10 μm in diameter) has been identified as a health concern because the fine particles in the air can enter the lungs and aggravate existing health problems such as asthma and bronchitis.

Ambient $PM_{2.5}$ (particles less than 2.5 μm in diameter) consists mainly of particles from combustion processes. They are suspected to be the prime carriers of toxic substances and are small enough to penetrate the small airways. $PM_{2.5}$ particles have been connected to cardiovascular and respiratory morbidity and mortality.

APPENDIX B. Attendees at the meeting (including facilitator)

Anne Leonard	EPA
Bruce Nauman	EPA
Beth Curran	BoM
Christopher Powell	EPA
Chris Harris	EPA
Doug Johnston	EPA
Donna Riordan	EPA
Dennis Linard	EPA
Edmond Verhoef	EPA
Farah Adeeb	EPA
John Cugley	EPA
John Nairn	BoM
Max Browne	EPA
Monica Nitschke	Department of Health
Rob Mitchell	EPA
Rocco Zito	University of South Australia
Tom Whitworth	EPA

APPENDIX C. Air quality index survey highlights

1. **Survey question**: Are you aware of the AQI on the EPA web site?

Response

Choices	% Response	% non-EPA Response
Yes	**78.0**	**65.0**
No	22.0	35.0

2. **Survey question**: Is it easy to find at its current web location?

Response

Choices	% Response	% non-EPA Response
Yes	**69.6**	**60.0**
No	30.4	40.0

3. **Survey question**: How often do you access the AQI?

Response

Choices	% Response	% non-EPA Response
Every day	4.34	3.30
Several times a week	4.34	3.30
Once a week	8.7	6.8
Once a month	**52.2**	**48.9**
Never accessed before	30.4	37.7

4. **Survey question**: How useful is the AQI?

Response

Choices	**% Response**	**% non-EPA Response**
Very useful	0.0	0.0
Useful	**56.5**	**50.2**
Slightly useful	34.8	30.7
Not useful at all	8.7	19.1

5. **Survey question**: Currently, the AQI is updated twice daily? Do you think this is appropriate?

Response

Choices	**% Response**	**% non-EPA Response**
Yes	**74.0**	**68.0**
No	13.0	12.0
Do not know	13.0	20.0

6. **Survey question**: How often would you like the AQI updated?

Response

Choices	**% Response**	**% non-EPA Response**
More frequently (every hour)	**43.5**	**33.5**
Less frequently (than the current practice of twice a day	4.3	3.5
Once a day	13.0	11.3
Once a week	0.0	0.0
Current update (twice a day) is sufficient	13.0	10.5
Not at all	8.7	21.0
Do not know	17.4	20.2

7. **Survey question**: Should the AQI be reported in the following media (can choose more than one)?

Response

Choices	% Response	% non-EPA Response
TV	**38.0**	**45.0**
Radio	22.0	15.0
Newspaper	36.0	30.0
Others (specify)	Web site is O.K (2%)	-
Do not know	2.0	10.0

8. **Survey question**: Should the AQI report be released to the media?

Response

Choices	% Response	% non-EPA Response
Only if there are exceedences	21.7	32.7
All the time	**74.0**	**65.0**
None of the above	4.3	2.3
Do not know	0.00	-

9. **Survey question**: Currently, the AQI describes air quality as 'very good', 'good', 'fair', 'poor', and 'very poor'. Is this clear (in conveying the air pollution conditions)?

Response

Choices	% Response	% non-EPA Response
Yes	**74.0**	**68.3**
No	26.0	31.7
Do not know	0.0	0.0

10. **Survey question**: If the AQI descriptors are changed to 'low', 'medium', and 'high', would that be useful?

Response

Choices	**% Response**	**% non-EPA Response**
Yes	17.4	12.0
No	**69.5**	**60.0**
Do not know	13.0	18.0

11. **Survey question**: Do you think that the current report of the AQI by eastern, northern, western and southern Adelaide regions is appropriate?

Response

Choices	**% Response**	**% non-EPA Response**
Yes	**69.5**	**60.0**
No	17.4	20.0
Do not know	13.0	20.0

12. **Survey question**: If the current practice of reporting the AQI by four Adelaide zones changes to reporting the AQI of the individual air monitoring stations located throughout South Australia, do you think it would be more appropriate?

Response

Choices	**% Response**	**% non-EPA Response**
Yes	**61.0**	**55.0**
No	17.0	12.0
Do not know	22.0	33.0

13. **Survey question:** Do you think it would be worthwhile to have a national air quality index (via web-link to capital cities) on the EPA web site?

Response

Choices	% Response	% non-EPA Response
Yes	**83.0**	**75.0**
No	13.0	10.0
Do not know	4.3	15.0

14. Survey question: Would the AQI be of more interest if it forecast conditions for the next day?

Response

Choices	% Response	% non-EPA Response
Yes	**96**	**80.4**
No	4.0	19.6
Do not know	0.0	0.0

15. Survey question: Can you name a maximum of three air pollution issues you believe are cause of public concern?

Response

Air Pollution Issues	% Responded	% non-EPA Response
Particles (both PM_{10} and $PM_{2.5}$)	13.3	23.0
Emissions from smoky cars and trucks	11.9	9.0
Industrial Pollution	9.0	10.0
Photochemical smog	7.5	10.0
Ozone	7.5	6.0

Health risks due to fine respirable particles	7.0	5.4
Pollutants that are asthma triggers	7.0	9.3
Pollen counts and fungal spores	**6.0**	5.0
Poor visibility caused by air pollution	6.0	5.0
Oxides of nitrogen (NO_2, NO_x)	4.2	2.0
Sulfur dioxide	3.0	1.0
Odour	3.0	2.0
Dust storms	3.0	2.0
Green-house gases	3.0	3.0
Smoke from wood fires	1.5	3.0
Ozone hole in the stratosphere	1.5	1.5
Carbon monoxide	1.5	1.0
Australia's failure to ratify Kyoto Protocol	1.5	1.5
Smoking, non-smoking places	1.3	-
Air toxics-benzene	1.3	1.3

16. **Survey question**: Do you have any other comments on improving the current AQI?

Comments made during the AQI Survey

1. Air Quality Index (AQI) should be updated in real-time.
2. AQI report should be released to the media, if it is predicted to be an exceedence.
3. For health purposes, knowing what has happened is not particularly useful. Predictive forecasts are needed, such as what CSIRO proposes for Sydney air shed.
4. Current report of the AQI by eastern, northern, western and southern Adelaide regions is appropriate. However, many people live in the Adelaide Hills now and a monitoring station in the hills would be useful. It might help people realise the impact of wood fires in the winter.
5. More air quality stations are required to get meaningful data for the AQI.
6. AQI should be reported in the media only if forecast is for 'Poor' air conditions.
7. It would be worthwhile to have a national air quality index (via web-link to capital cities) on the EPA web site. However, the indices must be matched in terms of how the data is reported. Better still, report only raw data and let people interpret it.
8. Need real data to be shown at all time. Because it allows review of instrument-online data and also to see the drift in the instrument over a 24-hour re-calibration period.
9. All past data (validated or unvalidated) should be downloadable from the EPA web site—perhaps grouped by station in monthly batches (available within 30 days of the event).
10. When forecasting the AQI for next day, link to predicted weather conditions and encourage commuters to use public transport, share rides, cycle or walk.
11. AQI web site should have link to hospital statistics to show effects of poor air quality.
12. Currently, the AQI describes air quality as 'very good', 'good', 'fair', 'poor', and 'very poor'. These are fairly vague terms. If these terms are used, specific figures should be provided.
13. At the moment, it is not possible to get ozone (smog) details, which can be a precursor for asthma.
14. The EPA should canvas all avenues of media to promote a better understanding of air quality.

15. All Australian EPA jurisdictions having AQI descriptors should have a common set of terms.

16. The southern monitoring site at Noarlunga is not yet operational. When operational this site will serve population >170,000 in the southern region, so the present AQI fails to report the southern region at all.

17. SA country regions monitored by the EPA (Port Pirie and Port Augusta, Whyalla) should have AQI similar to Adelaide.

18. For easy access an AQI symbol (Click) should be on atmosphere page.

19. There is a need to standardise air quality terms.

20. At present AQI gives previous day. However, by giving a next day forecast this would:

    1- Be a good health measure to alert hospitals and people suffering asthma, hay fever and lung complaints.

    2- Enable better media profile for air quality in SA. For example, on nightly TV weather forecast and in winter periods of high use of wood combustion heaters could, say, predict……..Fair AQ next day………………Asthma suffer alert.

21. When there are significant levels of haze apparent to the observer, it would be useful if an explanation could be provided sometimes, e.g. dust haze, aerosols due to sea spray.

22. AQI seems like a useful and user-friendly site pitched at the right level, however, it needs to be better advertised and marketed, as I am sure the wider community would be interested but may be unaware.

23. AQI can be released to newspapers in a way similar to Western Australia. For example, it is advertised for different pollutants at different monitoring stations. Bar graphs represent the highest contaminants recorded at the four measuring stations. A level above 10 is classed as pollution.

APPENDIX D Monitoring methods

Particulate matter PM_{10} using the TEOM method

The tapered element oscillating micro-balance (TEOM) is an approved equivalent method (AS 3580.98) for the continuous measurement of PM_{10}. The TEOM draws in ambient air through a Teflon-coated borosilicate glass filter at a constant flow rate of 3 litres of ambient air per minute. Mass is determined from the measured change in frequency at which the element attached to the filter is oscillating. The TEOM instrument uses an impacting mechanism to separate particles and measures PM_{10} as an equivalent aerodynamic diameter. The final mass concentrations are expressed as micrograms of particulate matter per cubic metre of ambient air sampled ($\mu g/m^3$).

The ambient air quality measure technical paper no. 10 (NEPC 2001d) describes how all continuous PM_{10} data obtained from TEOM can be adjusted for ambient temperature. The adjustment is applied if the daily average temperature falls below 15°C. The first adjustment accounts for temperatures of 5-15°C. The second adjustment accounts for temperatures less than or equal to 5°C. If the temperature is greater than or equal to 15°C then no adjustment is made. For further details see *www.rupprechtandpatashnick.com* and *www.ephc.com*.

Particulate lead (Pb) by high volume sampler

Lead in particulate matter is determined using Australian Standard AS 2800 (1985), which involves collection of total suspended particles (TSP), followed by analysis for lead using atomic absorption spectroscopy techniques. High volume air samplers are run for 24 hours on a six-day rotational cycle. The sampler draws air through a filter paper in an evenly distributed pattern at a known constant flow rate for 24 hours. Before loading, and after exposure, the filter papers are kept in a controlled environment at 21°C and less than 35% humidity for six days. The filter papers are weighed before and after exposure using a high precision four-place balance. The resulting increase in the weight of the filter paper is the total airborne particulates in the volume of air sampled (flow rate x time). The flow (Q) is automatically controlled to within ±1 standard cubic metre per hour.

Collected particles on the filter are analysed for Pb (Australian Standard AS 2800) using a nitric acid extraction method. The high volume sampler conforms to Australian Standard AS 2724.3 and siting requirements AS 2922.

Carbon monoxide by non-dispersive infrared analyser

CO is measured using a non-dispersive infrared analyser of the gas filter correlation type. A pre-filtered air sample is drawn through a sample cell. Infrared radiation is passed through the sample cell and a CO-free reference cell. The detector measures the infrared light absorbed by CO in the sample. By comparing the light intensity received by the detector through the cell with a similar cell containing reference gas, the concentration of CO is determined.

The analyser complies with Australian Standard AS 3580.7.1. For details of siting, operation and calibration of the carbon monoxide analyser, refer to Australian Standards AS 2922 and AS 3580.7.1 at *www.thermo.com/subsid/tmo1.html*.

Ozone by ultraviolet absorption photometry

Measurement of O_3 concentration in air uses the principle of absorption of ultraviolet light by O_3. An ultraviolet photometer can determine the O_3 concentration of an ambient air sample passed through an absorption cell by measuring the attenuation of ultraviolet light with a wavelength of 254 nm. The concentration of O_3 is directly related to the magnitude of the attenuation.

For details of siting, operation and calibration of the O_3 analyser, see Australian Standards AS 2922 and AS 3580.6.1. Also, see *www.thermoei.com*.

Nitrogen dioxide by chemiluminescence

At some sites, concentrations of NO_2, NO and total NO_x are measured using the principle of chemiluminescence, involving a gas phase reaction with O_3. For NO_2, the sample passes through a catalytic converter where the NO_2 is reduced to NO in the presence of O_3, producing a quantity of light for each NO molecule produced. The light can be measured using a photomultiplier tube. With the volumes of sample gas and excess ozone controlled, the light level in the reaction chamber is proportional to the concentration of NO_2 in the gas sample. Within the analyser separate measurements are made of total NO_x (= NO + NO_2) and NO, thus NO_2 can be calculated by the difference i.e.$NO_2 = NO_x - NO$.

For details of siting, operation and calibration of the NO_2 analyser, see Australian Standards AS 2922, AS 3580.5.1, AS 3580.2.1 and AS 3580.2.2, and *www.monitorlabs.com*.

Sulfur dioxide by fluorescence

SO_2 concentrations are measured by the fluorescent response of the SO_2 molecule to ultraviolet radiant excitation. SO_2 molecules are irradiated by light in the far-ultraviolet region (214 nm wavelength) and fluoresce with a secondary emission, also in the UV region. The emitted UV light has a well-defined frequency, with light output proportional to the concentration of SO_2 molecules present. Results are expressed in parts of SO_2 per million parts of sampled ambient air (ppm). For details of siting, operation and calibration of the SO_2 analyser, see Australian Standards AS 2922, AS 3580.4.1, AS 3580.2.1 and AS 3580.2.2. Also see *www.thermoei.com*.