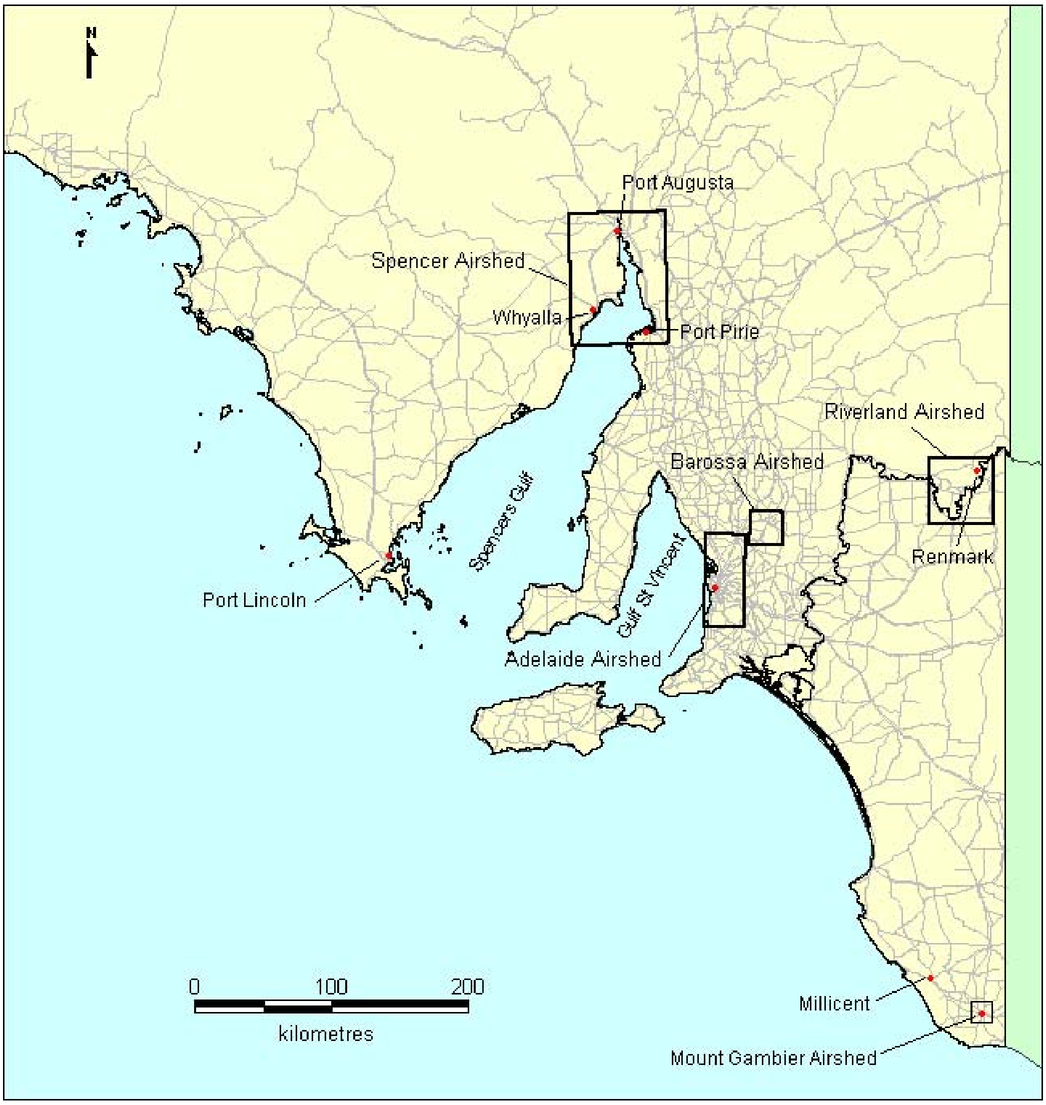
**NATIONAL ENVIRONMENT PROTECTION (AMBIENT AIR QUALITY) MEASURE**

# AMBIENT AIR QUALITY MONITORING PLAN FOR SOUTH AUSTRALIA




EPA South Australia

DEPARTMENT FOR environment and heritage

Government of South Australia

**Ambient Air Quality Plan for South Australia**

**August 2001**

**ISBN 1 876562 28 5**

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# SUMMARY

The Ambient Air Monitoring Plan for South Australia, developed under the National Environment Protection (Ambient Air Quality) Measure (Air NEPM), aims to establish, for each of the six Air NEPM pollutants, monitoring networks that meet the requirements of the Monitoring Protocol (part 4) of the measure. It will provide high quality information as a basis for evaluating air quality management performance against the standards in the NEPM.

The South Australian Environment Protection Agency (SA EPA) and its predecessors have operated a network of ambient air monitoring instruments for many years. Changes and additions to monitoring sites are needed to comply with the intent of the NEPM and to improve knowledge for the effective management of air quality in the future. The SA EPA is committed to having all proposed metropolitan networks in place as soon as possible in 2001.

Calculations based on the population formula in clause 14 of the NEPM and the population-based cut-off of 25,000 people suggest the need for only three performance monitoring stations in Adelaide. The SA EPA believes that, given the physical extent of the metropolitan area, this quantity will not provide an adequate description of transport and chemistry in the Adelaide airshed nor fully represent the population. Further, there exist country regions with significant populations where, due to local sources, it is advisable to carry out air monitoring for some of the Air NEPM pollutants. Thus, the SA EPA will undertake monitoring to a greater extent than the minimum required by the NEPM.

The South Australian ambient air quality monitoring system has been upgraded in recent years, particularly in order to monitor photochemical oxidants and their precursors. Initial design was based on the results of wind field modelling studies carried out by the CSIRO/Victorian EPA in conjunction with a rudimentary emissions inventory. The study report recommended that six stations be established around the central suburban areas and to the north as far as Gawler. Additional information provided by aircraft surveys carried out by Flinders University has led to a decision to include a further oxidant monitoring station in the southern metropolitan area along the Onkaparinga River Valley. That site is called Southern Metro in this Plan. It is intended to begin NEPM monitoring in December 2002 after selection in accordance with Australian Standards AS 2922-1987 and for generally representative upper bound (GRUB) exposure.

Results from the Flinders University aircraft studies have also provided information on emissions from the metropolitan area. Further analysis of the very large quantities of data from these studies is expected to refine estimates for emission rates and will provide corroborative estimates of emissions from large individual facilities that report to the National Pollutant Inventory (NPI). There may be scope for additional studies in the metropolitan area and possibly areas such as the Spencer Region airshed at the head of Spencer Gulf.

Network design will be refined as more information becomes available both from the monitoring system and from emission inventory data. The SA EPA is currently compiling emission inventories for the Adelaide metropolitan area and for several regional centres as part of the NPI program. Information from the initial metropolitan NPI database is included in this report.

Apart from extensive lead monitoring at Port Pirie and a limited presence at Port Augusta and Whyalla, regional centres of South Australia do not have ongoing monitoring networks. Since there are currently little useable monitoring or emission inventory data, the SA EPA

has scheduled a program of campaign monitoring at eight regional centres in rotation over the coming four years using mobile stations. These centres each contain significant pollutant sources of $PM_{10}$ and sulfur dioxide ($SO_2$). In regional centres, size selective inlet (SSI) samplers for particulate matter are operating at Port Augusta and Whyalla. These samplers are specifically located to monitor the impact of emissions from major industry in these towns.

There are no significant known sources of carbon monoxide (CO) in these cities and, apart from lead in Port Pirie, neither of these two parameters will be monitored in regional centres of SA. The other parameters—ozone ($O_3$), nitrogen dioxide ($NO_2$), sulfur dioxide ($SO_2$), particulates ($PM_{10}$) (with high volume sampler on a six-day cycle)—will be monitored along with meteorology as part of the mobile campaign program.

The results of this campaign monitoring should indicate any need for ongoing NEPM monitoring or whether additional long-term assessment can be carried out using emission inventory data and modelling. Campaign monitoring is summarised below in table S1-3. NEPM and campaign monitoring are subsets of the total air quality monitoring program summarised in tables 4-1 and 4-2 of the Plan.

It is uncertain at this stage whether the regions proposed are Type 2 regions, as defined by the Peer Review Committee (PRC), or whether the major population centres in those regions should be considered separately as individual regions within their own airsheds. This rotational campaign program will be used to evaluate the need for long term monitoring in these areas. Along with the gathering of emission inventory and meteorological data, the program will also allow assessment of whether performance monitoring is required for Air NEPM reporting in these regions.

In respect of instrumentation specified by the NEPM Monitoring Protocol, the current oxidant-monitoring network for the Adelaide airshed includes Airtrak monitors. These monitors are still considered as prototype instruments and cannot at this stage demonstrate equivalency with the Australian Standards method of monitoring cited in schedule 3 of the protocol. Recent analysis of the instrument performance has resulted in a decision by the SA EPA to replace this equipment with conventional ultraviolet ozone monitors and chemiluminescence nitrogen oxides analysers by December 2001. These analysers will comply with requirements of the Air NEPM.

The SA EPA will use the tapered element oscillating microbalance (TEOM) method for $PM_{10}$ monitoring as proposed by most other jurisdictions. This method does not currently meet the requirements of schedule 3 of the NEPM, but the SA EPA plans to demonstrate equivalence by applying the appropriate adjustment factor in accordance with PRC Guideline Paper 10 '*Collection and Reporting of TEOM $PM_{10}$ Data*'. The SA EPA considers the monitoring of the six pollutants under this Air NEPM as a subset of its overall air quality monitoring and management program over coming years.

The SA EPA is committed to providing NATA (National Association of Testing Authorities) accredited data for NEPM reporting purposes and plans to achieve NATA accreditation by July 2003.

Tables S1-1 and S1-2 show the proposed South Australian monitoring networks that are of relevance to the Air NEPM. Nominated performance monitoring stations (PMS) and NEPM parameters are shown against a coloured background. $PM_{2.5}$ and associated meteorological monitoring are also shown. More detailed information on current monitoring networks is provided in chapter four.

**Key to the following tables (S1-1 and S1-2)**

Pollutant methods for tables S.1.1 and S.1.2:

| | |
|---|---|
| Nitrogen dioxide | chemiluminescence |
| Lead | high volume sampler—total suspended particulate lead, analysis by atomic absorption spectroscopy |
| Carbon monoxide | infrared |
| $PM_{10}$ | tapered element oscillating microbalance |
| Sulfur dioxide | ultraviolet fluorescence |
| Ozone | ultraviolet photometry |

Meteorology:

MET standard suite of meteorological parameters measured at ten metres above ground:

- wind speed, wind direction and wind direction variance (sigma-theta)
- temperature
- barometric pressure
- total solar radiation

**Table S–1: Air NEPM monitoring sites—metropolitan Adelaide**

| **Station** | **$O_3$** | **$NO_2$** | **$PM_{10}$** | **CO** | **$SO_2$** | **Lead** | **Met** |
|---|---|---|---|---|---|---|---|
| Elizabeth[2] | PMS | PMS | PMS | Trend | Campaign | | MET |
| Gilles Plains | | | | | | PMS | |
| Hope Valley | | | PMS | | Campaign | | MET |
| Netley | Trend | Trend | PMS | | Campaign | | MET |
| Northfield[2] | Trend | Trend | Trend | | Campaign | Trend | MET |
| Kensington[1] | Trend | Trend | Trend | | Campaign | Trend | MET |
| Southern Metro | PMS | PMS | PMS | | Campaign | | MET |
| St John's Christies Beach | | | | | Trend | | |
| Hindley St | | | | Trend | | | |
| Parkside | | | | | | Trend | |

**Notes:**

1. The Kensington (TSP lead) and Kensington Gardens stations are 100 m apart for logistical reasons. They are, however, a similar distance from busy roadways so are regarded for practical purposes as the same site.
2. $PM_{10}$ monitoring will start at these sites late in 2002 as the TEOM instruments earmarked for these sites will be used for the $PM_{2.5}$ monitoring trials at Netley and Kensington.
3. The Southern Metro site will commence monitoring in December 2002

**Table S–2: Air NEPM monitoring—regional population centres**

| Station | $O_3$ | $NO_2$ | $PM_{10}$ | CO | $SO_2$ | Lead | Met |
|---|---|---|---|---|---|---|---|
| Pt Pirie 1<br>West Primary School | | | | | | HVS | |
| Pt Pirie 2<br>Oliver St | | | | | | HVS | MET |
| Pt Pirie 3<br>Frank Green Park | | | | | | HVS | |

**Table S–3: Campaign monitoring**

| Site | Year | Pollutants monitored |
|---|---|---|
| Metro - Gawler | 2001–2 | $O_3$, $NO_2$, $PM_{10}$, $SO_2$ |
| Port Pirie | 2000–1 | $O_3$, $NO_2$, $PM_{10}$, $SO_2$ |
| Mt Gambier | 2000–1 | $O_3$, $NO_2$, $PM_{10}$, $SO_2$ |
| Whyalla | 2001–2 | $O_3$, $NO_2$, $PM_{10}$, $SO_2$ |
| Pt Augusta | 2001–2 | $O_3$, $NO_2$, $PM_{10}$, $SO_2$ |
| Southern Wineries Area (Coonawarra SE) | 2002–3 | $O_3$, $NO_2$, $PM_{10}$, $SO_2$ |
| Barossa -Angaston, | 2003–4 | $O_3$, $NO_2$, $PM_{10}$, $SO_2$ |
| Riverland | 2003–4 | $O_3$, $NO_2$, $PM_{10}$, $SO_2$ |

# 1 INTRODUCTION

The Ambient Air Quality National Environment Protection Measure is a program leading each state towards nationally consistent air quality monitoring.

In June 2001, the SA Environment Protection Agency (SA EPA) delivered a monitoring plan to the National Environment Protection Council (NEPC) showing that monitoring in South Australia will be consistent with the national agreement. The plan contains information on the requirements of monitoring in populous regions of the state, the placement of air monitoring sites, instrumentation, data collection and handling and reporting. Details of National Association of Testing Authorities (NATA) accreditation and quality control systems are also given.

The SA EPA aims to have all monitoring stations installed by the end of 2001.

## 1.1 The NEPM context

On 26 June 1998, the National Environment Protection Council (NEPC), consisting of Commonwealth, State and Territory Ministers, made the *National Environment Protection Council (Ambient Air Quality) Measure* (hereafter referred to as the measure or Air NEPM). This measure established a set of standards and goals for six air pollutants and outlined the methods by which these pollutants are to be measured, assessed and reported. A formal requirement of the measure is the establishment of monitoring procedures and commencement of assessment and reporting, in accordance with the protocols of the measure, within three years of its commencement.

After making the measure, the Ministers resolved to establish a Peer Review Committee (PRC) to advise on jurisdictional monitoring plans. Under its terms of reference, the PRC has two complementary roles. First, the PRC is required to advise the NEPC on the adequacy of monitoring plans submitted by jurisdictions. Second, the committee provides advice on technical issues related to the consistent implementation of the measure's Monitoring Protocol. The PRC has developed a series of strategy papers that provide a basis for the preparation of individual monitoring plans (by jurisdictions) and for the assessment of monitoring plans (by the PRC). It should be noted that the monitoring conducted as part of the requirements of the measure may represent only a subset of the total ambient air monitoring program of some jurisdictions.

This document is the submission of the South Australian Government, through its Environment Protection Agency, on how it plans to monitor, assess, and report air quality for the purposes of the measure. The report is structured according to the format specified by the PRC, which includes consideration of the following:

- regions to be monitored
- monitoring requirements of each region, including physical and demographic characterisation, emissions, air quality, identification of pollutants not required to be monitored, and monitoring network
- siting and instrumentation
- accreditation
- reporting.

The monitoring described in the Ambient Air Monitoring Plan for South Australia is only part of that which is conducted in South Australia by the South Australian Environment

Protection Agency (SA EPA). Other stations are operated for a variety of reasons including air quality management, scientific research, compliance monitoring and public information. Such monitoring is included in tables in chapter four, which sets out the current ambient monitoring that takes place in South Australia.

As a condition of licence to operate, additional ambient air monitoring is also required in South Australia of premises that are likely to be significant emitters of air pollutants. This monitoring may often be intended to measure source-related ambient peak concentrations under specific conditions, so would not usually be acceptable for NEPM performance monitoring.

## 1.2 Legislative basis in South Australia

The *Environment Protection Act 1993* (the Act) came into force in South Australia in 1995. It provides for the establishment of a six-member Environment Protection Authority, which is serviced by the Environment Protection Agency, a division of the Department for Environment and Heritage.

The Act includes harm to public health in its definitions of environmental harm—'material environmental harm' and 'serious environmental harm'—caused by pollution, whether actually or potentially harmful. For the purposes of determining potential for environmental harm, the NEPM standards are considered to represent concentrations below which public health is protected.

The Act also provides for the development, in consultation with the public and other interested parties, of Environment Protection Policies. Air quality is covered by the *Environment Protection (Air Quality) Policy 1994*. This policy provides the basis for regulation of industrial pollution and associated source-oriented monitoring and testing where required, but it does not provide for a program of ambient environmental air monitoring as discussed in this report.

National Environment Protection Measures automatically become Environment Protection Policies under the Act. Hence, the Air NEPM now forms the major legislative basis under the Act for ambient air quality monitoring for the protection of public health.

## 1.3 NEPM monitoring in South Australia's management plan

The standards in the Air NEPM provide a goal for managing air quality in terms of human health protection. Ambient monitoring and other assessment methods give the means of evaluating the management strategies implemented to achieve this goal. Monitoring is therefore an important part of effective air quality management.

The SA EPA considers monitoring of the six pollutants under this Air NEPM as a subset of its overall air quality monitoring and management program for the coming years. Important elements on which the overall State program focuses are emerging issues such as 'air toxics', which are likely to form the subject of future NEPMs. Recent and projected purchases of equipment, such as the digital optical absorption (DOAS) long-path monitors, reflect this approach in their ability to measure a much wider range of pollutants than conventional instruments can measure, including aromatic compounds such as benzene, toluene and xylenes. These instruments have United States Environmental Protection Agency acceptance of equivalence for sulfur dioxide, ozone, and nitrogen oxides; results from these instruments will be included in the annual reports for the NEPM but not as performance monitoring sites, as the method is not prescribed in the NEPM.

The SA EPA is also embarking on a long-term plan to use other monitoring tools for air quality management. These include emission inventory information, self testing of industry emissions under SA EPA licence requirements, mobile monitoring stations for regional areas, short-term air monitoring projects through a ‘hot spot’ monitoring program, and development of in-house regional modelling capabilities. Long-term management of air quality that involves these and other tools will assist formulation of a more defined State Ambient Air Quality Management Plan.

The Air NEPM requires that performance against national standards be measured at Performance Monitoring Stations (PMS) or be assessed by means that provide equivalent information. Such methods include emission inventories, wind field and dispersion modelling and inference from results in other comparable regions. Where these methods are used, an explanation of their application is provided, in accordance with the relevant PRC guidelines.

The minimum number of performance stations for a region is to be estimated according to a specified formula applicable for populations of over 25,000 people. Clause 14 of the NEPM, however, allows for establishment of further stations on the basis of local characteristics such as topography, weather, or emission sources (see sections four and ten of the NEPM).

South Australia proposes to report on some regional areas because major local emission sources may result in significant exposures for nearby populations. The need for regional stations is being investigated over the next four years using mobile monitoring stations. The SA EPA will establish monitoring stations or other reporting methods in regional centres according to the results of this study and the requirements of the Air NEPM.

In addition to the six pollutants for which standards have been set, the NEPC requires in NEPM-related future actions that $PM_{2.5}$ be monitored to establish data for future reviews.

Networks for some pollutants have developed historically from knowledge of local conditions or a need to protect specific populations, such as school children, from particular pollutants—for example, roadside lead emissions. In recent years, considerable work has been undertaken using modelling studies, inventories and aircraft monitoring programs. This work has formed the basis for designing metropolitan (and near metropolitan) networks, particularly for photochemical pollutants. In describing monitoring networks for each pollutant, the following information is included:

- location and site description
- monitoring objective(s), spatial scale and representativeness of air quality in the area
- area and population represented
- whether the station is also a trend station
- sampling and analysis methods
- operating schedule.

The report is set out as follows. Chapter two discusses the selection and identification of monitoring regions. Brief descriptions of topography, climate, meteorology, emissions and population distributions appear in chapter three. Chapter four considers siting and instrumentation. Quality assurance and control measures are outlined in chapter five. Chapter six discusses the reporting process as well as the collection and handling of data.

The appendices provide additional useful information to that required in the main body of the report. Relevant portions of the Air NEPM, particularly parts of the Monitoring Protocol, are reproduced in Appendix A. Appendix B reproduces the Peer Review Committee’s guideline paper no. 4, *Screening procedures*, which has been downloaded from the NEPC web site for readers' information. A summary of historical background, current monitoring, and air quality appears in Appendix C. Appendix D includes the emissions inventory, and the CSIRO/Victorian EPA modelling study is described briefly in Appendix E.

# 2 SELECTION OF MONITORING REGIONS

## 2.1 Identification of monitoring regions

The NEPM gives a very broad definition of the word 'region' and leaves the determination of regions and their boundaries to each jurisdiction. In order to provide guidance for jurisdictions, the Peer Review Committee (PRC) provided the following definition of a region:

> A **region** for the purposes of performance monitoring is a geographical area where the air quality (for a particular pollutant) is determined either entirely or in large part by the influence of a common collection of anthropogenic emission sources.

Under Clause 14 of the NEPM, performance monitoring may be required in regions with a population exceeding 25,000 people.

The PRC also adopted the following definitions of different region types:

- 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
- 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
- Type 3—a region with population in excess of 25,000 but with no significant point source or area-based emissions, so that ancillary data can be used to infer that direct monitoring is not required under Clause 14.

The PRC has adopted the use of Australian Bureau of Statistics (ABS) population figures, specifically the 'urban centre/locality' data, as the most objective estimates for identification of potential Type 1 regions. Relegation of a Type 1 region to Type 3 must be supported by arguments based on local knowledge. Identification of Type 2 regions is also reliant on local knowledge of emission sources and airshed characteristics. PRC guideline paper no. 2, *Selection of Regions* (Peer Review Committee 2000b), provides a discussion of the use of ABS data and issues to consider when classifying regions. This paper includes the following summary comment:

> In summary, whilst the ABS 'urban centre' population data may provide a transparent basis for a preliminary assessment of regions for NEPM monitoring, it is important to note that other considerations such as local knowledge of region/airshed population, emission sources, topography and dispersion should also be considered. In applying the formula that guides the number of monitoring sites needed on the basis of population, the actual population in the affected airshed should be estimated by integrating up the ABS data as appropriate. The changes in population that can result from this integration may be substantial. In some instances it may raise the population above the lower threshold where monitoring needs to be considered. Moreover, a narrow application of the ABS population data should not be used as a justification for a lower level of monitoring than would result from a consideration of an airshed concept.

As shown in tables 2.1 and 2.2 below, South Australia's population is largely concentrated in the Adelaide metropolitan area, to the extent that populations in the larger regional areas are in most cases less than the 25,000 cut-off established in clause 14 of the Air NEPM. It is also true, however, that some South Australian regional populations may be exposed to significant concentrations of one or more of the set pollutants. In keeping with the concept of equivalent protection for the population, measurements taking in regional areas as part of campaign monitoring will be reported under the measure.

**Table 2–1: Regional population based on 1996 census—Adelaide regional airshed**

| Region | Persons |
|---|---|
| Adelaide | 1,037,263 (72.67% of SA population) |

**Table 2–2: Regional population based on 1996 census—Spencer, Mount Gambier, Riverland and Barossa regions**

| Statistical area included in region | Region | Persons |
|---|---|---|
| | **Spencer** | **53,988** |
| Port Pirie (City) | | 15,699 |
| Port Augusta (City) | | 14,244 |
| Whyalla (City) | | 23,975 |
| | **Mt Gambier** | **34,294** |
| Mt Gambier (City) | | 22,037 |
| Mt Gambier (District Council) | | 5,010 |
| Millicent (District Council) | | 7,247 |
| | **Riverland** | **25,701** |
| Renmark (Municipal Council) | | 7,835 |
| Loxton (District Council) | | 6,836 |
| Berri (District Council) | | 6,752 |
| Barmera (District Council) | | 4,278 |
| | **Barossa** | **20,691** |
| Barossa (District Council) | | 4,991 |
| Angaston (District Council) | | 6,952 |
| Tanunda (District Council) | | 4,114 |
| Kapunda (District Council) | | 3,324 |
| Eudunda (District Council) | | 1,310 |

The Adelaide Region is clearly a Type 1 region as detailed in PRC guideline paper no. 2 *Selection of Regions* (Peer Review Committee 2000b). It is defined by the sea to the west and the Mt Lofty Ranges to the east and south, where the ranges meet the sea at Willunga. To the north, the airshed is open and, given suitable meteorological conditions, pollutants are able to move up the coast beyond Gawler. The population between Gawler and Port Pirie is low and, at this stage, it is not intended to monitor in the area north of Gawler or south of Port Pirie as part of NEPM monitoring.

This airshed contains 1,037,263 people based on statistical local areas; based on typical mixing heights, which give the boundary shown in figure 3.1, the population is 1,011,000 or 70.83% of the population of South Australia. Thus, monitoring in this area is designed to give representative monitoring of all criteria pollutants.

Regions containing significant population centres near major industrial pollution sources are the Upper Spencer Gulf (Port Pirie, Port Augusta, Whyalla), Mount Gambier, and the Riverland. They are considered to be potentially Type 2 regions as defined in PRC guideline paper no. 2 *Selection of Regions* (Peer Review Committee 2000b).

The Barossa Valley Region contains several relatively small population centres but no dominant industrial sources of the NEPM pollutants. Pollutants from the Adelaide Region can be transported towards the valley by the prevailing south-westerly winds. Modelling and previous investigational monitoring suggests that the Barossa Region may be affected by photochemical smog from the Adelaide Region and so would be represented by monitoring conducted at Gawler at the southern entrance to the valley. More comprehensive measurements are planned at Gawler to clarify whether the current conclusion is correct. No long-term measurements are planned within the valley itself but there will be some 'hot spot' monitoring of ozone, nitrogen oxides, benzene, toluene and xylenes as well as particulates.

The Upper Spencer Gulf holds a large steel works at Whyalla, a lead smelter at Port Pirie and the State's major brown coal power station at Port Augusta. Port Pirie is almost 100 km south of Port Augusta and 48 km across the gulf to the east of Whyalla. Nevertheless, recorded wind patterns of the area and visual observation of the distance travelled down the gulf by the fly-ash plume from Port Augusta indicate the potential for emissions from one centre to affect air quality in the others. The plan will determine through campaign monitoring whether the area does in fact constitute a Type 2 region.

Similarly, the Mount Gambier Region contains the majority of the State's large timber mills, creosote treatment plants and particle board plants, the emissions of which have been reported as affecting the residents of the city of Mount Gambier and the adjacent district council area. The population of the two statistical areas exceeds the 25,000 basis in the NEPM.

The issues in the Riverland Region are emissions from horticultural practices such as fruit drying and agricultural burning as well as wind-borne dust. The urban centres are 10–20 km apart, and there is no single major source of significance, so the purpose of the monitoring is to ascertain whether the area is in fact a Type 2 region and whether performance monitoring is required on an ongoing basis.

Thus, when the above information is considered in conjunction with PRC guideline paper no. 2 *Selection of Regions* (Peer Review Committee 2000b), the following regions are proposed as regions to be monitored for NEPM purposes:

- Adelaide airshed
- Upper Spencer Gulf—known as 'Spencer Region'—including Port Pirie for particulate lead
- Barossa Region
- Mount Gambier Region
- Riverland Region.

As stated, there is some uncertainty about the status of regions in South Australia. To determine this, campaign monitoring will be conducted for 12-month periods. Results from this monitoring will be used in combination with emissions inventories to determine if a performance monitoring site needs to be established. Details of this process are included in the body of this plan.

Some regional areas have been studied in the past because of the presence of specific pollutants from major industry. For example, concern about exposure of the local population to lead and sulfur oxides has prompted major studies in Port Pirie over two decades. Particulate matter and sulfur dioxide monitoring has been conducted for years at Whyalla and Port Augusta. Some areas, however, such as Mount Gambier and the Riverland, have had little or no ambient air monitoring and, subsequently, little is known of the nature and extent of air pollution in those areas. Work in this type of area will be exploratory. The SA EPA is planning a four-year program to evaluate the need for further monitoring in each of these Type 2 regions, using mobile monitoring stations; the program is to commence in 2000. Mount Gambier and Port Pirie will be the first areas to be serviced in the program.

Results from the Flinders University aircraft studies have also provided valuable information on emissions from the metropolitan area. There may be scope for additional studies in the metropolitan area, and possibly areas such as the Spencer Region airshed at the head of Spencer Gulf.

There are no other regions in South Australia where monitoring would be required for NEPM purposes, as they have populations much smaller than the 25,000 threshold and do not have major emission sources in their airsheds.

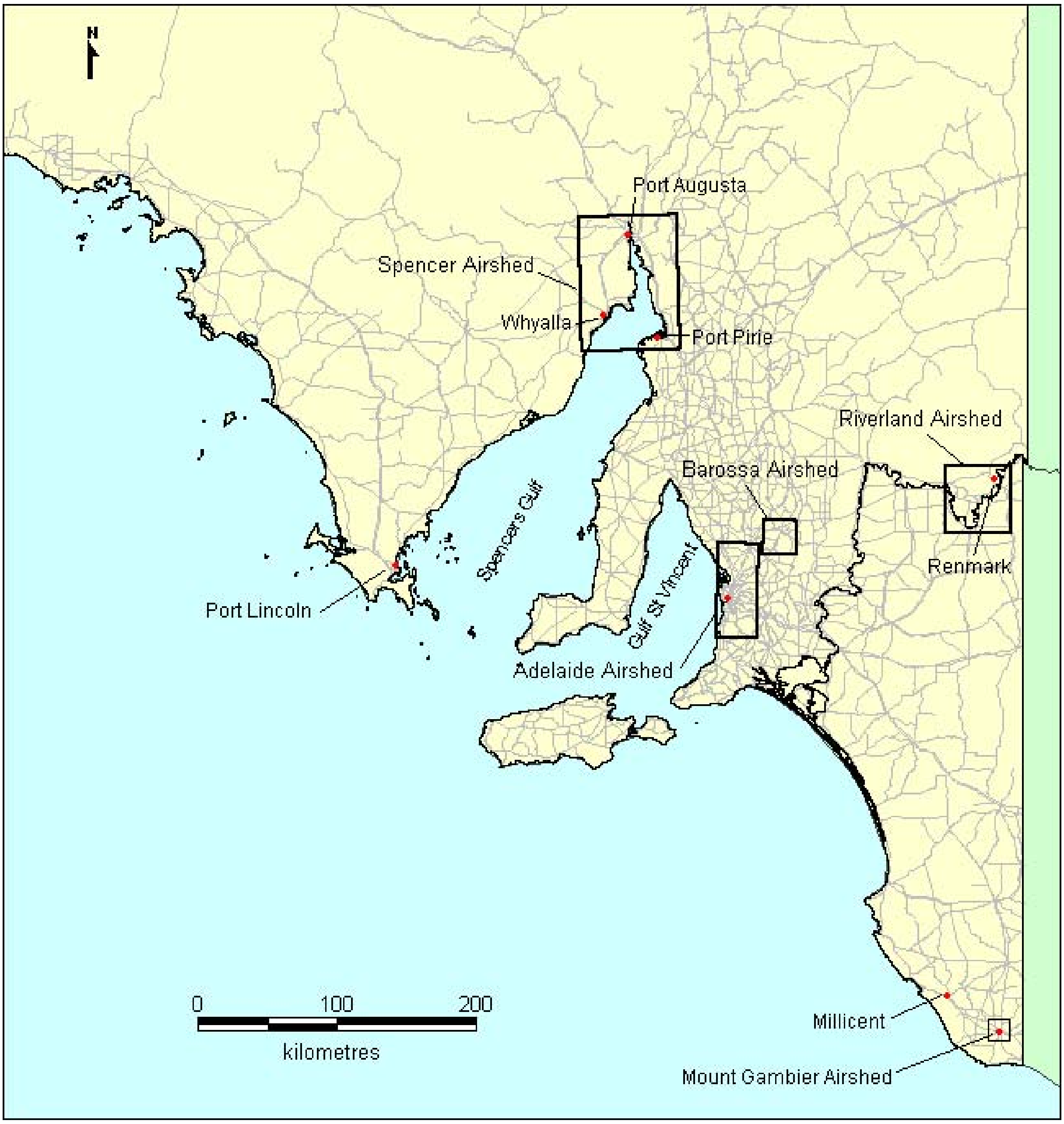


**Figure 2–1: Locations of South Australian regional centres relevant to the Air NEPM and showing airsheds as defined in this report**

# 3 MONITORING REQUIREMENTS OF REGIONS

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

> **NEPM Clause 14. Number of performance monitoring stations**
>
> (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 monitoring 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. (National Environment Protection Council 1998, original emphasis)

Sub-clauses (1) and (2) are self-explanatory. Sub-clause (3) provides to jurisdictions the opportunity to demonstrate that, for a given region, fewer monitoring stations than indicated by the formula are required (possibly zero). The Peer Review Committee (PRC) refers to this process as 'screening' and has prepared guidelines to ensure a reasonable degree of consistency and rigour in the screening assessments undertaken by jurisdictions. The guidelines identify a range of screening procedures that might be used for particular pollutants and assign an acceptance limit to each procedure reflecting the confidence attached to the procedure. The guideline document, entitled *Screening procedures* (Peer Review Committee 2000d), appears as Appendix B to this report and should be read in conjunction with the assessment of monitoring requirements which follows.

The following extract from a PRC guideline entitled *Monitoring strategy* provides the rationale for siting performance monitoring stations.

> In order to ensure equivalent protection for the overall population of a region, stations will generally be located so as to monitor the *upper bound* of the distribution of pollutant concentration likely to be experienced by portions of the population, while avoiding the direct impacts of localised pollutant sources. These *generally representative upper bound for community exposure (GRUB)* stations will be distributed to measure the upper bound concentrations in different portions of the populated area, reflecting different emission or dispersion regimes.
>
> An examination of the distribution of GRUB stations relative to the distribution of population and pollutant will determine the need for, and location of, additional stations to achieve *adequate representation of population-average concentrations.* (Peer Review Committee 2000c, emphasis added)

By using GRUB stations to monitor the ambient air across a region, we can be reasonably sure that, if the NEPM standards are met at those sites, most of the total population of the region will be exposed to air that meets the standards. In this way, the NEPC aim of equivalent environmental protection is assured.

## 3.1 Metropolitan Adelaide Region

### 3.1.1 Overview of the region

Figure 3.1 shows the topography of the Adelaide Region and its surroundings marked with the National Pollutant Inventory (NPI) boundary as a rectangle, and the Adelaide airshed as defined for this report shown by the dark line along the Adelaide Hills. The latter is based on typical mixing height of the airshed and the meteorology of the region.

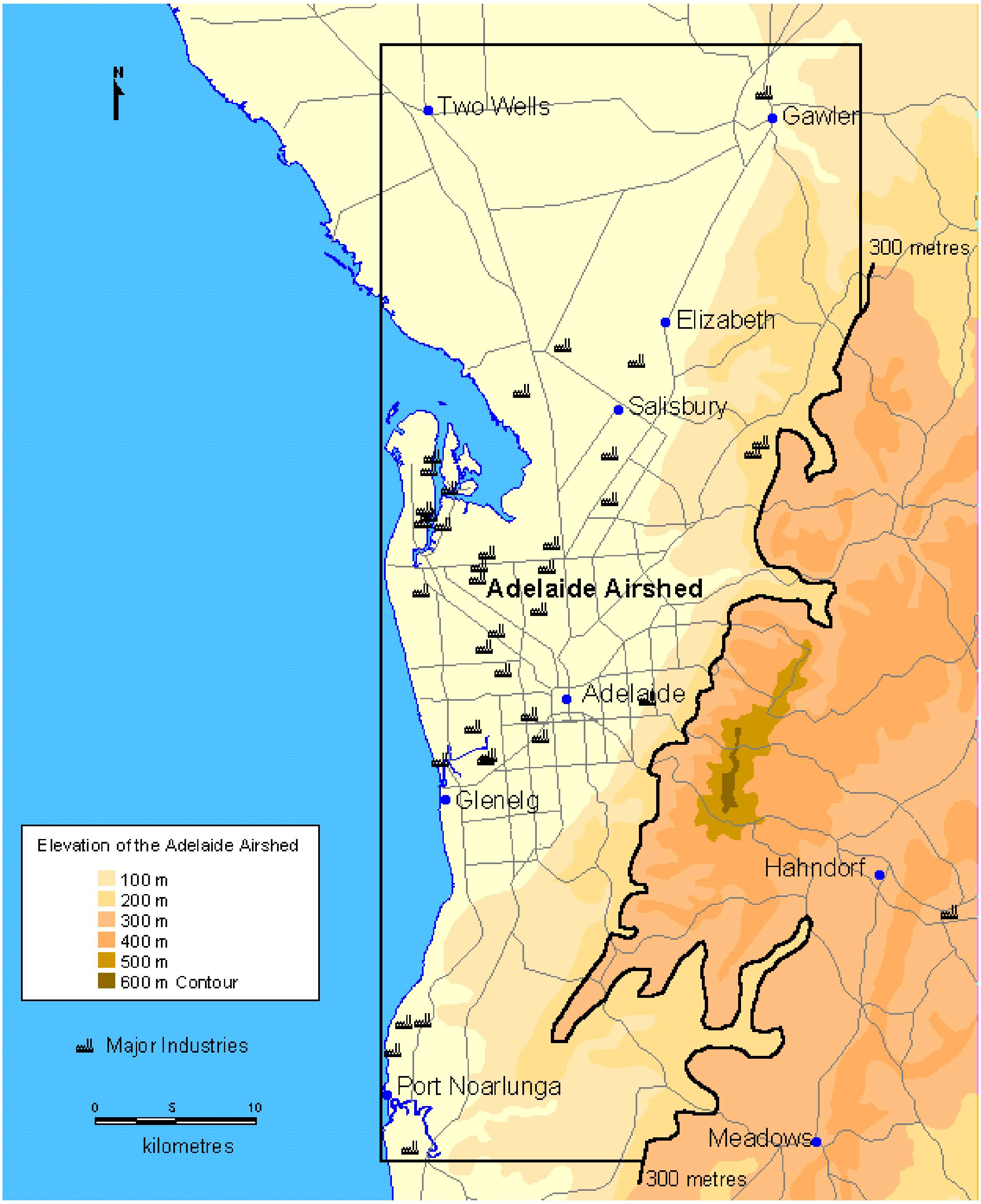


**Figure 3–1: Topography of Adelaide and surroundings showing the Adelaide airshed**

**Regional boundaries**

South Australia lies between the longitudes of 129°0′ and 140°45′ east, its northern boundary set at latitude 25°45′ south, within the temperate zone. It occupies some 984,000 $km^2$, or 13% of Australia's landmass. It is also one of the driest States: a large proportion of the State is arid or semi-arid landscape. As a result, most of its population is centred in Adelaide, the State capital (lat. 34°55′ south, long. 138°35′ east).

The Adelaide Plains are bounded on the east and the south by the Mount Lofty Ranges, and by Gulf St Vincent on the western side (see figure 3.1, which shows the location of the airshed within the State). That section of the Mount Lofty Ranges which falls within the Adelaide airshed is often referred to as the Adelaide Hills. The Adelaide Plains and particularly the Adelaide Hills receive some of the highest rainfalls in the State. Adelaide receives about 600 mm on average per year.

**Population and topography**

Of the State population of 1.4 million (1996 Census figures), about 1.025 million people live within the Adelaide metropolitan area. Some 95% of the population live within 50 km of the seashore, the highest percentage of any mainland State. If the near metropolitan town of Gawler is included as per figure 3.1, the area encompasses 1.037 million people, or 72.7% of the State total.

Within the greater metropolitan area, high population densities are found in some of the western suburbs, such as Fulham Gardens, Hilton and Cowandilla, eastern suburbs like Kensington, Beulah Park and Norwood, and the north-western suburbs of Semaphore, Largs Bay and Exeter. These older north-western suburbs have recently undergone subdivision and redevelopment of large housing blocks and former industrial land. Kensington and Netley monitoring stations will represent these areas.

The distribution of young children, both those less than four years and those of school age, is concentrated in the outer suburbs, particularly to the north in Paralowie, Elizabeth North and Salisbury North, and south of the central business district (CBD) in Trott Park, Seaford Rise, Woodcroft, Noarlunga Downs and Sheidow Park. These suburbs are developing areas that attract younger families to more suitable housing and land. Elizabeth and Southern Region monitoring stations will represent these areas.

In contrast, people 60 years and older are concentrated within a 12-km radius of the city centre. These areas are also represented by the Kensington and Netley stations.

Bounded on the east by hills of up to approximately 700 m (Mount Lofty) and on the west by the gulf, Adelaide has no significant topographic features in the metropolitan area that intrude upon the general diurnal wind patterns within the coastal plain.

**Industry**

The State's major heavy industries are located well outside the metropolitan region. Adelaide's 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 Le Fevre Peninsula and its port facilities. Port Stanvac oil refinery and the Mitsubishi foundry are in the south adjacent to the coast. 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. These areas also contain a range of smaller industries.

**Emissions**

The most recent detailed air emissions inventory for the Adelaide Region was completed for 1985 (Australian Environment Council 1988). Total aggregated emissions of nitrogen oxides, $PM_{10}$ and volatile organic compounds (VOCs) for Adelaide, based on the National Pollutant Inventory (NPI) database for South Australia, are shown in figures D.1 to D.6. Motor vehicles are a major source of these pollutants over most of the metropolitan area.

In South Australia, the data collection system of the NPI includes some questions relating to short-term emissions data, which will provide information more detailed than the annual means that form the bulk of the database. NPI estimates have been derived from specific industry profiles and aggregation of motor vehicle and other smaller scale emission sources, including domestic activities. Estimates of total emissions given in the first report of the NPI for Adelaide are shown in table D.1, as well as emission rates in kilograms per second.

The Flinders University aircraft study on photochemical smog (Isaac et al 2000; see also Appendix D) also provided estimates of emissions of carbon monoxide, nitrogen oxides, sulfur dioxide, total VOCs, lead and compounds, and $PM_{10}$ (see table D-2) from data collected during the 1997–98 summer. These estimates were calculated from crosswind concentration profiles through the Adelaide urban plume, using meteorological data to convert these profiles into total fluxes. The values in table D.2 show numerical differences between the two methods, particularly for nitrogen oxides, although the orders of magnitude are comparable. Carbon monoxide estimates show agreement within a factor of about 2, which is probably reasonable for a ‘first cut’, given both the lack of temporal data in the NPI and the limited time scale of the aircraft measurements.

**Meteorology**

Winds are typically characterised by easterly morning drainage from the hills, which tends to carry pollutants out over the gulf. Later in the day, a sea breeze recirculates pollutants back over the land. It became clear from the CSIRO/Victorian EPA modelling study just how extensive this circulation is; the urban plume travels considerable distances out over the gulf and Yorke Peninsula. The hills are a significant barrier to pollutant transport, and the effect of the sea breeze is to push the urban plume to the north-east over Elizabeth and Gawler and toward the Barossa Valley.

The SA EPA, in conjunction with Flinders University and Airborne Research Australia, has undertaken an airborne monitoring project. The aim was to examine the spatial generation and transport of pollutants in and beyond the metropolitan region, from the tip of the Fleurieu Peninsula south of Adelaide to Outer Harbor in the north (Clark et al 2000). That study also points to significant transport of pollutants on the sea breeze into the rural areas east of the Mount Lofty Ranges, and into the Adelaide Hills village of Hahndorf via the Onkaparinga River Valley. This transport was not anticipated by the CSIRO airshed model, primarily because of a lack of data for these areas.

**Air monitoring history**

Although the SA EPA and its predecessors have been monitoring ambient air quality for over two decades, it is only in recent years that a network has been developed, particularly for photochemical smog. Two oxidant-monitoring stations operated for approximately 20 years at the Air Quality Laboratories at Netley and at Northfield. The latter was located to allow for reaction time of morning CBD-bound traffic and other precursor emissions as they are carried by the summer prevailing wind.

Prioritising the management of air quality issues has meant that monitoring of other pollutants has generally occurred close to significant single sources or groups of similar source types, on the grounds that exposure of the public would be highest near those sources. The levels themselves have been below general air quality goals. This issue and the widespread introduction of more stringent controls on most sources have led to a conclusion that air pollution in Adelaide was a local or neighbourhood-scale concern rather than a regional issue.

Total suspended particulates (TSP) have been monitored long term using high volume samplers at more than ten sites throughout the metropolitan region, located predominantly next to arterial roads to investigate lead levels from leaded petrol. Other sites have usually been close to major industrial sources of dust. In the mid 1980s, a residential site was chosen in the eastern suburbs (Kensington) for comparison with the sites near industrial emissions in the western and north-western sectors. $PM_{10}$ particulate has been monitored for the past five years at four sites that are co-located with TSP units.

Beginning in 1970, sulfur dioxide monitoring was carried out at several sites in the metropolitan region, using wet chemical techniques. This ceased at all sites except near the refinery due to the reporting of extremely low concentrations, particularly after general transfer of industrial fuel use from oil to natural gas. Unlike the heavy fuel oil and industrial diesel fuel, natural gas contains negligible sulfur and emissions of sulfur dioxide reduced substantially with this change in use.

Carbon monoxide has been measured in the Adelaide CBD for over two decades in almost the same location during that time. Campaign monitoring of carbon monoxide at other locations next to major CBD streets and arterial roads has also been conducted. The conclusion from this monitoring is that it is only likely to approach health goals in narrow street canyons subject to high-volume, slow-moving traffic.

In 1996, the SA EPA commissioned a study by the CSIRO Environmental Consulting and Research Unit (ECRU) and the Victorian EPA of transport of urban pollutants around the Adelaide airshed. Although based on limited data, the study was able to provide the SA EPA for the first time with the basis for a systematic monitoring program within the Adelaide metropolitan area. The SA EPA has invested considerable resources in establishing a monitoring network according to the study recommendations, but recognises that the program may need further refinement as the data from the extended network provide better understanding of pollutant transport and the mechanisms that cause episodes of high pollution.

Additional studies by Flinders University, using aircraft, have provided further insights into pollutant transport in the Adelaide airshed (Clark et al 1998). The Flinders University airborne monitoring project also collected valuable data during the 1997–98 summer, even though the information is not directly comparable with NEPM standards. 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. For practical reasons, inventory flights for this study were limited to morning peak hour periods (0730 to 0930) and were confined to summer months, so the results cannot be seen as average values. Further, as Adelaide typically experiences a sea breeze in the afternoon/evening, late peak period emissions are not amenable to measurement by aircraft, given restrictions on aircraft operations (particularly low-flying operations) over built-up areas.

At this stage, interpretations are preliminary, as the study has generated a considerable volume of data that is still being analysed. The work has already provided, however, valuable descriptions of the recirculation of Adelaide's morning emissions in a sea breeze moving inland towards the ranges along the Onkaparinga River Valley, south of the city.

### 3.1.2 NEPM formula

The SA EPA has used the formula in clause 14 of the NEPM with 1996 population figures for the greater metropolitan Adelaide area, extending from Gawler in the north to Willunga in the south, to determine that three performance monitoring stations are required. The SA EPA considers that, at this time, ozone and particles would justify such attention within the metropolitan area.

In the case of ozone, however, the Air NEPM standard has been exceeded on isolated occasions, and results from the expanded system are suggestive of exceedences over a wider area than that previously monitored. Since South Australia is in the early stages of installing a systematic monitoring program, and because of the extent of the metropolitan area, the SA EPA considers that a greater number of stations would be more appropriate to develop a complete picture of the airshed. This approach is in line with recommendations of the CSIRO/Victorian EPA modelling study and the Flinders University aircraft study. Accordingly, the SA EPA has decided to establish six major stations, of which five are initially nominated as performance monitoring stations for ozone and nitrogen dioxide.

In regard to siting and operating performance monitoring stations, clause 13 of the NEPM requires the following:

> (1) To the extent practicable, performance monitoring stations should be sited in accordance with the requirements for Australian Standard AS2922-1987 (Ambient Air – Guide for Siting of Sampling Units). Any variations from AS2922-1987 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. (National Environment Protection Council 1998)

The locations of monitoring stations are thus being chosen on the basis of determining pollutant distributions in populated areas and understanding the likely exposures of people in the various areas where they spend most of their time. To facilitate this determination, the SA EPA is taking into consideration:

- meteorological patterns and their effects on pollutant transport
- relationships between population distributions and emission sources, including industry, vehicles and other sources
- practicalities of obtaining representative results, and likely adverse effects such as ensuring appropriate distances from roadways or other local sources
- local topography
- existing monitoring information, inventories, modelling and aircraft-based studies.

After consideration of clause 13(2) of the NEPM, the SA EPA has adopted the recommendations of the CSIRO/Victorian EPA modelling study and the Flinders University aircraft study report, but acknowledges that these studies can only provide an initial basis for network development. Further work will be needed over the next few years to evaluate the representativeness of the network in terms of population exposure, and the network may need to be modified in the light of such studies.

The population represented by a given station is a function of the area represented by the station and the population density within that area. Clause 17(2) requires that:

> (2) For each performance monitoring station in the jurisdiction or assessment in accordance with subclause 11(b) there must be:
>
> (a) a determination of the exposed population in the region or sub-region represented by the station (National Environment Protection Council 1998)

In practical terms, a station can be said to be representative of an area equivalent to a few kilometres diameter that is reasonably homogeneous. AS2922-1987 defines neighbourhood stations as those that are '… located in areas that typify a broad area of uniform land use, e.g. residential, industrial and commercial' (Standards Australia 1987). Although quite large areas of residential land might have fairly uniform concentrations, the interposition of nearby sources such as major roads or industrial plants may perturb this uniformity and require additional stations to allow accurate description of its air quality.

Topographical features may cause particular patterns in pollutant transport that can influence measured concentrations or break the airshed into distinct sub-regions. The Adelaide Plains, however, can be treated as fairly homogeneous for those pollutants that tend to be or become widely distributed and exert their effects on human health over significant distances. Oxidants and $PM_{10}$ particles fall into this category in urban regions but TSP lead does not, as the concentration of the coarse fraction decreases very quickly with distance from a source, such as a roadway. Carbon monoxide from motor vehicles also tends to be a localised pollutant since its *direct* effects on human health (as reflected by the standard) occur at relatively high concentrations that are usually not sustained well away from the source.

### 3.1.3 Photochemical oxidants (as ozone)

Ozone is a product of complex chemistry in the atmosphere driven by sunlight. It is formed ultimately from oxides of nitrogen and organic compounds under the action of solar ultraviolet radiation, and represents one of a group of compounds—usually the major component—collectively known as photochemical oxidants. The rate of formation and concentration in the atmosphere depends not only on emissions of precursors and the intensity of ultraviolet light, but also on other aspects of meteorology, such as wind speed and direction and wind patterns over quite large areas of an urban airshed and beyond. Precursor chemicals are emitted from industry, vehicles, domestic sources and even some natural sources. For example, vegetation, particularly trees, can be a major source of reactive organic materials.

**Review of data**

South Australia has continuous long-term data from only two sites, in suburbs to the north-east and west of the central business district (CBD). Conventional instrument measurements at Northfield and Netley are shown in Appendix C, figures C.1 and C.2. Annual four-hour maxima are consistently above 0.05 ppm, but have not breached the standard of 0.08 ppm since 1986.

Ozone is being measured using the Airtrak monitor at five sites. The Airtrak method is still considered a prototype and cannot at this stage demonstrate equivalency with either the Australian Standards method for monitoring photochemical oxidants (AS3580.6.1-1990) or that for nitrogen dioxide (AS3580.5.1-1993) cited in schedule 3 of the protocol. The SA EPA will replace these units with compliant monitors by December 2001. Corrected data from the Airtrak instruments are also shown in Appendix C; they suggest more frequent exceedences at locations other than Northfield and Netley.

Ozone monitoring studies have also been carried out further north at Gawler, the entry to the Barossa Valley, to give some sense of long-range transport of photochemical smog from the metropolitan area.

In recent years, the SA EPA has invested considerable effort in expanding the network in a systematic way to improve understanding of the chemistry of the Adelaide airshed and likely exposures of the population to ozone. In 1996, the CSIRO Division of Atmospheric Physics used the Lagrangian air dispersion wind field model with inventory data to determine the best locations for photochemical monitoring stations (refer to Appendix E). Although it was performed on very limited data, this modelling predicted that the urban plume could travel well out over Yorke Peninsula on the west side of Gulf St Vincent and over Spencer Gulf under favourable weather conditions. Appendix E provides a summary of the study and depicts screen snapshots of the development of the two representative smog episodes chosen for computer modelling.

Six stations were recommended as a result of the study. As already stated, the SA EPA has established stations at five of the six sites, which are shown in figure 3.2 superimposed on a population distribution map of the metropolitan area. To assess exposure of the population to ozone, sites have been positioned both close to the CBD in Netley and Kensington, and further from the central business district at Elizabeth and Gawler and at the proposed southern site. The inner sites are situated near the source of precursor emissions (mainly vehicles). This pattern will give a mix of sites positioned to measure peak and more representative levels and so determine the upper bound for ozone in the region. This approach is in line with the concept of generally representative upper bound (GRUB) sites. Consequently, data from these sites will allow an assessment of the upper bound to which the population is exposed. The results of the Airtrak data are reported in Appendix C, figures C.3 and C.4.

**Nominated performance monitoring stations and trend station/s**

On the basis of the studies undertaken to date and the results of monitoring, the SA EPA proposes to retain ozone monitors at four of the existing sites that track the photochemical reaction northward along the region to Elizabeth, and to establish a further station at a site south of the city, along the Onkaparinga Valley (Southern Metro), although the precise location has not yet been decided. The airborne studies carried out by Flinders University of South Australia and Airborne Research Australia found ozone concentrations in the order of 0.09 ppmv. Pollutants are blown out to sea on the land breeze (drainage winds) and returned to land through the Onkaparinga River Valley to Hahndorf in the Adelaide Hills. The study also found associated particles in the air parcel. Clearly, it is important both to maintain existing ozone monitoring and to establish an ozone monitoring station in the southern metropolitan area.

Amongst the significant findings of the Adelaide Photochemical Smog Study (Isaac et al 2000) are conclusions about the sites for ozone and nitrogen dioxide monitors:

> **Comparison of the meteorology recorded at the OEPA and BoM sites shows that the OPEA sites are broadly representative of the Adelaide urban area**. Temperatures at the OEPA site tend to be within 1 or 2 degrees of the nearest BoM site while wind speeds are generally somewhat less, suggesting the OEPA instrument mounting height is less than that for the BoM sites. This is also suggested by the wind direction comparison, which shows

that at times there are large differences between the directions reported from the OEPA and BoM sites, particularly during the early morning offshore flow when wind speeds are low. Data from the OEPA sites for sea breeze onset and propagation agree well with that from the BoM sites.

Comparison of the air quality data recorded by the aircraft and by the OEPA sites shows good agreement. Maximum NOx concentrations measured by the aircraft during the morning inventory flights with a well established offshore flow, about 150 to 200 ppb, agree to within 20 ppb with the morning peak recorded at Netley. This suggests that the AIRTRAK monitor at Netley is well placed to record the morning emissions of NOx as they are swept out to the Gulf. On afternoons with modest O3 concentrations, 50 to 60 ppb, the aircraft data agrees reasonably with the available monitoring data from Elizabeth and Gawler. More importantly, on these days the aircraft data does not show any signs of significant spatial variability in the O3 concentration over the urban and rural areas north of Adelaide. **The general agreement between the aircraft and the ground based monitors plus the lack of significant spatial variability on these days suggests that the OEPA stations are sited to provide data representative of the Adelaide area.**

**The highest O3 concentrations, ~110ppb, found over the plains to the north of Adelaide, and 106ppb in the Onkaparinga Valley were outside the area covered by the existing OEPA monitoring network.** To the north of Adelaide, the areas of high O3 concentration observed by the aircraft were very localised suggesting that significant concentrations occur in patches which may be missed by a network of ground based monitors. This is a limitation, not easily overcome, of any monitoring network and should be kept in mind when considering reported maximum concentrations as these may not be the highest values actually occurring.

**In general, the aircraft data indicates that the existing OEPA monitoring network is representative of the Adelaide area.**

**The NOx and VOC emission rates for Adelaide estimated from aircraft data agree well with the emission rates based on population density used by CSIRO in the preliminary modelling study. (Isaac et al 2000, original emphasis)**

The performance monitoring sites for ozone are listed in table 3.1 and their locations (except for the Southern Metro site) are shown in figure 3.2.

There is also a station currently operating at Gawler as part of a 12-month trial to evaluate the need for a long-term station in the area. Preliminary results suggest that the measurements in Gawler are of 'mature' photochemical smog, which has ceased producing further ozone. The SA EPA has yet to decide whether this station should continue in operation and, if it does, whether it will be nominated as a performance monitoring station. It is therefore not included in table 3.1.

**Table 3–1: Summary of nominated oxidant performance stations**

| | |
|---|---|
| Elizabeth | PMS |
| Kensington | Trend |
| Netley | Trend |
| Northfield | Trend |
| Southern Metro | PMS |

Among the nominated oxidant performance stations, Kensington, Northfield and Netley are nominated as trend stations. Northfield is a long-term station north-east of the CBD along a prevailing wind direction. Ozone has been measured at Northfield for nearly two decades, so there is a long and almost continuous data record. Kensington is a relatively new station in a quiet suburban area to the east of the CBD, well away from busy roads, and is considered to be very representative of residential exposure in the region. Netley is also a long-term station, monitoring ozone for approximately 15 years. It is located to the west of the city near the coast and is exposed to the urban plume from both the offshore drift and the sea breeze.

The other two nominated oxidant performance stations are Elizabeth and Southern Metro. Elizabeth is a newly established station in a residential area. The Southern Metro station will be located along the Onkaparinga Valley in accordance with the results of the aircraft study discussed above, but its exact positioning has not been finally decided. It too can be considered ideal as a trend station, but this nomination will depend on the arrangements that can be negotiated.

All of these nominated stations have been or will be sited in accordance with NEPM requirements.

### 3.1.4 Nitrogen dioxide

Nitrogen dioxide is both a recognised pollutant in its own right and a very 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.

**Review of data**

As with ozone, long-term records are limited to two sites in the Adelaide metropolitan area. Their results are shown in Appendix C, figure C.2. Airtrak data are in figure C.5 for the five sites indicated on figure 3.1. Annual one-hour maxima have remained slightly above 0.05 ppm for the past three years at Netley and Northfield, whereas the annual one-hour maximum concentrations at other sites are generally less than 0.04 ppm. At all sites, the levels are well below the NEPM standard of 0.12 ppm.

Nitrogen dioxide monitors will be sited with ozone monitors to assure that photochemically produced nitrogen dioxide as well as that emitted directly from vehicles are monitored. The Netley and Northfield sites are ideally placed as GRUB sites for nitrogen dioxide as illustrated in figure C.2 results, which are somewhat higher than those for other sites shown in figure C.5

**Nominated performance monitoring stations and trend station/s**

With the expansion of the oxidant monitoring network, nitrogen dioxide will be measured using chemiluminescence instruments at five sites and will also be measured by long-path ultraviolet/visible monitors at three sites. The five sites listed in table 3.2 are nominated as performance monitoring stations for nitrogen dioxide. Their locations are as shown for ozone in figure 3.2.

**Table 3–2: Performance monitoring stations for nitrogen dioxide**

| | |
|---|---|
| Elizabeth | PMS |
| Kensington | Trend |
| Netley | Trend |
| Northfield | Trend |
| Southern Metro | PMS |

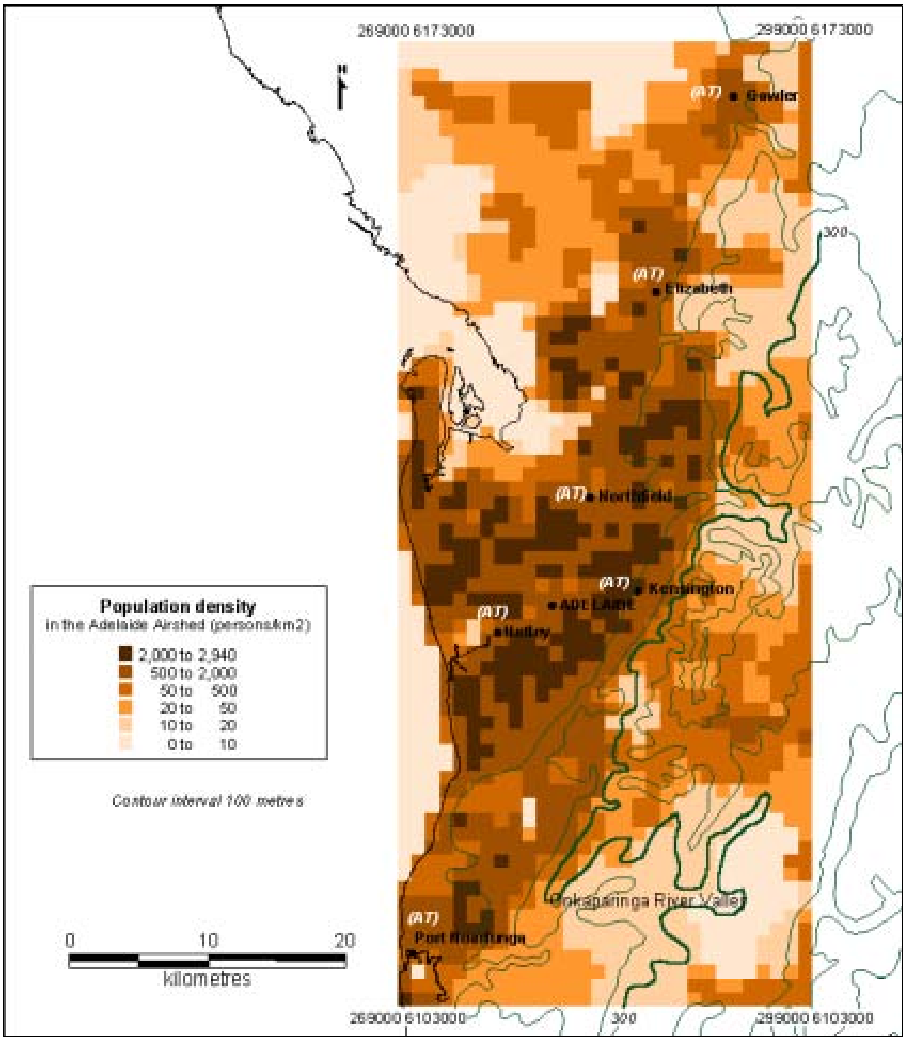


**Figure 3–2: Locations of ozone and nitrogen oxide monitoring stations in metropolitan Adelaide (eastern airshed boundary shown as black line)**

### 3.1.5 $PM_{10}$ and $PM_{2.5}$ particles

For the purposes of the Air NEPM, particles are addressed as $PM_{10}$ where the subscript numbers refer to an upper size cut-off for particle diameters in micrometers (µm). $PM_{2.5}$ particles are a subset of respirable particles within the $PM_{10}$ range, some of which are small enough to penetrate into the finest structures of the human lung. $PM_{2.5}$ particles are also largely responsible for light scatter or haze in the atmosphere.

Particles arise from a range of sources, including fossil fuel combustion, industrial processes, fires, photochemical processes, and fugitive dust, although the latter falls mainly into the coarse fraction. According to NPI figures, motor vehicles contribute about 20% of particle loading within the Adelaide metropolitan area. These amounts are most concentrated in areas near busy roadways, 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, particularly those close to or within the Adelaide Hills.

A standard has been set for $PM_{10}$, which is widely measured in Adelaide and South Australian regional centres. The Air NEPM has not set a standard for $PM_{2.5}$ but it does recognise the potential importance of these particles for human health. In passing the NEPM, NEPC required under future actions relating to the NEPM that $PM_{2.5}$ be monitored to provide extended data sets for future evaluation.

**Review of data**

Appendix C figures C.8a to C.8d show the results of $PM_{10}$ measurements in terms of the number of exceedences of the annual standard of 50 $\mu g/m^3$. Osborne and Port Adelaide represent locations of high industrial activity, and the Thebarton and Gilles Plains sites are close to arterial roads. Adelaide's dry climate has a significant effect on the number of days that the standard is exceeded; even at Gilles Plains, on average, two days per year are over the standard.

**Nomination of performance monitoring stations and trend station/s**

The Air NEPM Monitoring Protocol specifies that particles be measured gravimetrically as mass concentration using high-volume samplers (HVS) with size selective inlets (SSI). This method is not practical on a *daily* basis for most organisations. The SA EPA operates several of these samplers for $PM_{10}$ but only on the traditional six-day cycle. The new stations will use tapered element oscillating microbalance (TEOM) monitors, which provide essentially continuous measurements for $PM_{10}$. The TEOM will also be used for some $PM_{2.5}$ measurements in Adelaide. Nephelometers can be used as an indicator of fine particles, approximating $PM_{2.5}$, but they do not measure mass concentration directly. The issue of equivalence of TEOM monitors with HVS has been addressed by the PRC in guideline paper 10, *Collection and Reporting of TEOM $PM_{10}$ Data* (PRC, May 2001).

The metropolitan $PM_{10}$ monitoring system is a mix of high-volume samplers with size selective inlets and TEOM instruments. Four of the five TEOM units will be co-located with the ozone monitoring stations listed above. The SA EPA also nominates these as performance monitoring stations for particles, as marked in table 3.3. SSI instruments operating at the three sites shown in table 3.3 are located at specific roadway sites and are therefore not representative of broader air quality. Nephelometers will be operated at two of the nominated performance stations to monitor visibility and as an indicator of $PM_{2.5}$ particulates.

Section 3.1.1 suggests that there is a significant proportion of the population living in houses along major roads that may be exposed to particulate concentrations not typical of 'representative residential areas'. A study by the Department of Environment and Planning in 1988 found that approximately 64,800 people lived adjacent to the 630 km of arterial roads managed by Transport SA in Adelaide. This represents 6.4% of the population of Adelaide. There may be a case for data from one or two sites near roadways to be monitored to reflect potential exposures for such people. Gilles Plains is proposed as a non-performance monitoring station to fill this role.

The two TEOMs shown monitoring $PM_{2.5}$ at Kensington and Netley will be installed for an initial period of a year to evaluate the need for long-term monitoring at these sites. The instruments to be used for this study are those earmarked for relocation to Elizabeth and Northfield, so commencement of $PM_{10}$ monitoring at these sites will be delayed for 12 months. Kensington and Northfield are nominated as trend stations for $PM_{10}$ because they are well-established stations considered to be representative of residential areas.

**Table 3–3: Current and proposed particle monitoring stations in metropolitan Adelaide (nominated performance monitoring stations are shaded)**

| Station | $PM_{10}$ | $PM_{2.5}$ | |
|---|---|---|---|
| Elizabeth | TEOM | | PMS |
| Gilles Plains | SSI | | |
| Hope Valley | TEOM | NEPH | PMS |
| Kensington | TEOM | TEOM (12 mths) | Trend |
| Netley | TEOM | NEPH<br>TEOM (12 mths) | |
| Northfield | TEOM | | Trend |
| Pt Adelaide | SSI | | |
| Southern Metro | TEOM | TEOM | PMS |
| Thebarton | SSI | | |

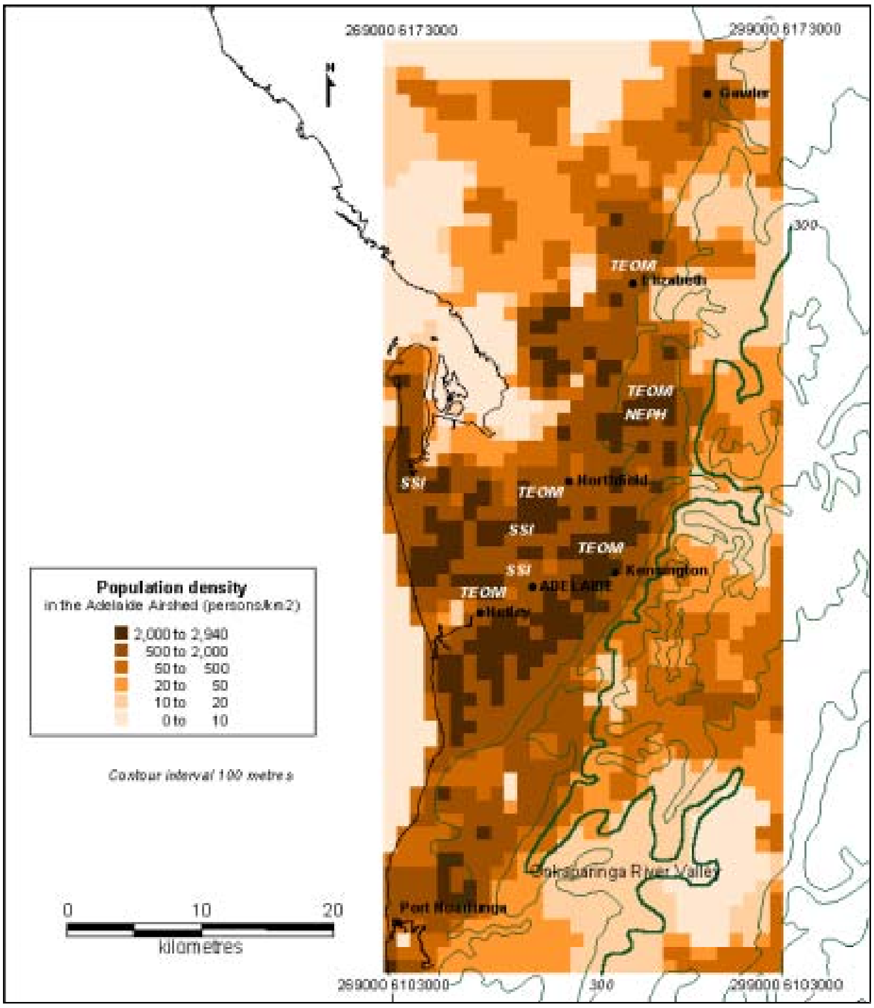


**Figure 3–3: $PM_{10}$ and $PM_{2.5}$ monitoring stations in metropolitan Adelaide (eastern airshed border shown as black line)**

### 3.1.6 Carbon monoxide

Carbon monoxide is produced mainly by motor vehicles in urban areas and is generally higher in areas of high traffic, particularly where long idling times occur. Public health considerations for carbon monoxide are confined mainly to neighbourhood scales. Solid fuel domestic heaters have been suggested as a potentially significant source in suburban areas.

**Review of data**

In Adelaide, carbon monoxide has been monitored continuously in a relatively narrow busy street within the central business district (CBD). This monitoring is regarded very much as an upper bound station but it is seen as appropriate for carbon monoxide (see Appendix C where the results are graphed in figure C.6). The number of exceedences has decreased dramatically since 1994 with improvements in traffic flow and reductions in vehicle emissions.

**Nomination of performance monitoring stations and trend station/s**

The PRC considers carbon monoxide to be a special case in terms of monitoring requirements due to its limited spatial effect and the principal sources of this pollutant. It details issues specifically relating to carbon monoxide in its guideline paper no. 4, *Screening procedures* (Peer Review Committee 2000d). For continuity reasons and since it is a known upper bound station, the existing CBD site is proposed as a performance monitoring station. The SA EPA also proposes to monitor carbon monoxide at Elizabeth, within a school in a suburban area well away from arterial roads (~1 km), but where domestic wood-fired heaters are common. The two nominated stations are shown in table 3.4 and figure 3.4.

The Adelaide CBD is seen as an area of maximum carbon monoxide emissions, as can be seen from emission inventory data (figure D.1). The high density of vehicle emissions and the canyon effects of tall buildings create the maximum ambient concentrations that could be expected in the Adelaide airshed. Current levels are below the standard at this peak site. The Elizabeth site is included as a site representing exposure of the total metropolitan population outside the CBD and where residential exposure to CO is characterised by domestic wood fires and dispersed vehicle emissions. It is not proposed to have three monitoring stations as the SA EPA will be monitoring maximum and GRUB levels and the CBD is the only area likely to achieve levels approaching the standard. The proposed number of sites is considered adequate when taking into account the PRC guideline *Screening Procedures* (PRC, 2000d), using long term measurement trends, and the emissions inventory for NPI showing spatial distribution of emissions (figure D.1). It is expected that this can be confirmed with 12 months of results at Elizabeth and application of screening procedure A.

**Table 3–4: Performance monitoring stations for carbon monoxide**

| | |
|---|---|
| Adelaide CBD – Hindley St | PMS/trend |
| Elizabeth – Elizabeth Downs School | PMS/trend |

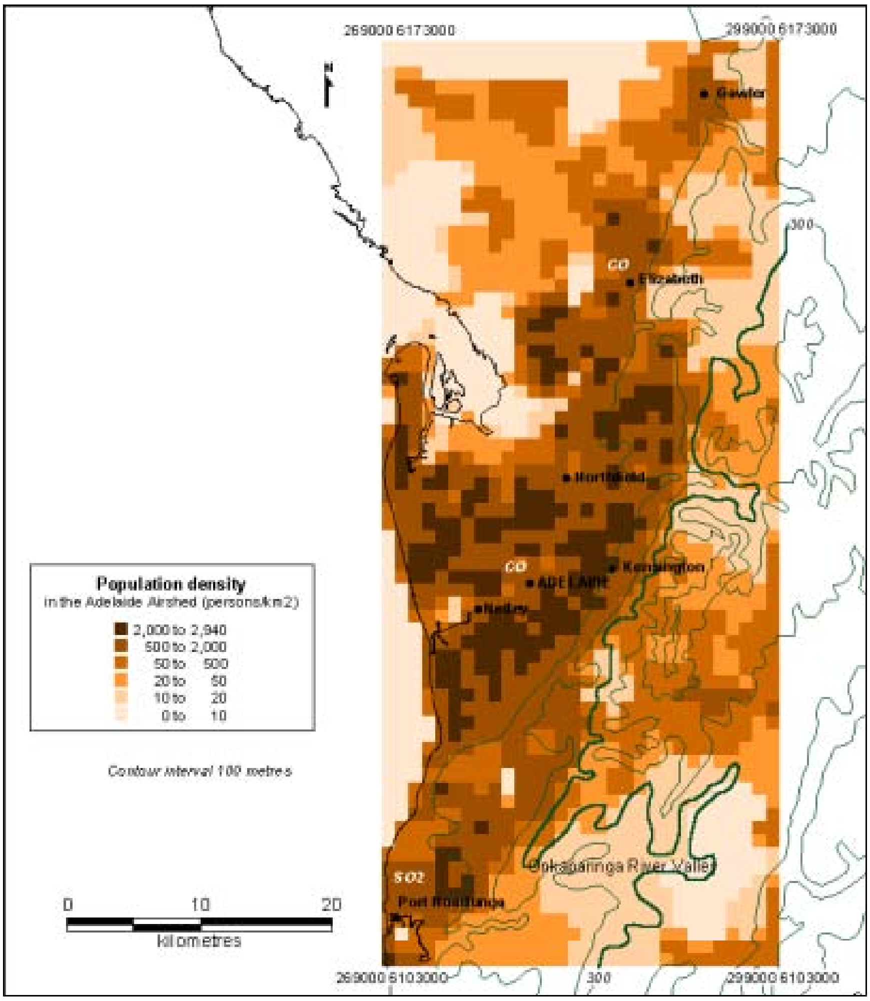


**Figure 3–4: Carbon monoxide and sulfur dioxide monitoring in metropolitan Adelaide (eastern airshed shown as black line)**

### 3.1.7 Sulfur dioxide

**Review of data**

Sulfur dioxide 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. Prior to 1976 there were high levels in the Port Adelaide region, close to a now-demolished power station burning high-sulfur oil and a sulfuric acid plant, also now demolished. The data for Christies Beach is presented in Appendix C, figures C.7a–d.

**Nominated performance monitoring stations**

The monitoring network is shown in table 3.5 below and in figure 3.4 above. Of these stations, only that at Christies Beach has been in operation for a long time. Located in a residential area along the Christies Creek Valley, this is a long-term station designed to monitor exposure from refinery emissions in residential areas along the valley and nearby areas. On this basis, the SA EPA regards it as a PMS representative of nearby populations.

Four of the nominated stations will utilise ultraviolet fluorescence, which meets the current requirements of AS3580.4.1-1990 as specified in schedule 3 of the Air NEPM. The other two sites will be equipped with long-path monitors. These monitors have United States equivalent method designation EQSA-0495 for sulfur dioxide. At this stage, the SA EPA intends to carry out campaign monitoring to measure sulfur dioxide at Elizabeth, Kensington and Northfield for an initial 12-month period, after which the need for continued monitoring at these locations will be evaluated.

**Table 3–5: Monitoring network for sulfur dioxide showing nominated performance monitoring stations**

| | | |
|---|---|---|
| Christies Beach, St Johns School | UVF | Trend |
| Elizabeth | UVF (12) | Campaign |
| Hope Valley | LP | Campaign |
| Kensington | UVF (12) | Campaign |
| Netley | LP | Campaign |
| Northfield | UVF (12) | Campaign |
| Southern Metro | UVF | Campaign |

### 3.1.8 Lead

The predominant source of airborne lead in Australian capital cities is petrol-engined vehicles. Current knowledge suggests that lead is not a pollutant of concern in the Adelaide metropolitan area. The reduction of lead in petrol and the advent of exhaust catalysts on vehicles have decreased urban lead concentrations markedly over the last 15 years. The recent removal of leaded petrol from the marketplace means that, in areas where there are no significant industrial sources, levels should continue to decrease. The criterion suggested by the PRC (PRC Guideline Paper No 9, *Lead Monitoring*) for discontinuing lead monitoring, once measured levels are consistently below the detection level of the current method, will be used for review of data. It may mean that lead monitoring will be discontinued at some sites.

**Review of data**

As shown in Appendix C, figures C.9a–d, the SA EPA has monitored lead at a number of sites within the metropolitan area for many years and so has an extensive historical database. Most sites have, however, been positioned specifically to measure impacts of heavy traffic along major roads on susceptible populations such as school children. There have been some relatively recent changes to the network that provide for monitoring at several sites more in line with the requirements of the Air NEPM while the capability for evaluating more localised impacts is retained. The SA EPA currently operates a mix of total suspended particulate (TSP) lead sampling, in accordance with schedule 3 of the NEPM, and $PM_{10}$ lead sampling. $PM_{10}$ lead monitoring is always carried out in conjunction with TSP lead monitoring. So there is a considerable body of comparative data for the two methods in two metropolitan sites and three regional sites.

The graphs in Appendix C clearly demonstrate that the fall in airborne lead reflects the fall in lead added to petrol. All sites, despite some being next to high traffic arterial roads, record levels well below the NEPM standard. Moreover, since October 2000, lead has no longer been added to petrol supplied in South Australia by the refiners supplying more than 90% of that petrol grade.

**Nomination of performance monitoring stations and trend station/s**

In view of the disappearance of the overwhelmingly predominant source of urban airborne lead, the Peer Review Committee (PRC) adopted the approach suggested in its guideline paper no. 9, *Lead monitoring* (Peer Review Committee 2000i). Roadside monitoring of lead is considered appropriate, rather than monitoring at normal GRUB sites, and should continue until lead is consistently below the current level of detection using the standard method of analysis. Such levels are likely to occur within two years—much sooner than the ten-year NEPM time frame for compliance with the standards.

The SA EPA proposes to follow that guideline; proposed sites are shown in table 3.6 and figure 3.5. Certainly the Kensington and Northfield sites are residential areas and, as such, are appropriate performance monitoring and trend sites as they are well away from major roads and therefore considered to be representative of general exposure for the bulk of residents in the area.

However, it can be argued, in regard to traffic-related emissions, that there is a proportion of people who live in houses alongside busy roads and that there needs to be *some* monitoring that is reflective of their exposure. While TSP lead decreases very quickly with distance from roadways, $PM_{10}$ lead and respirable particles generally can be expected to penetrate much further into residential areas. Accordingly, the SA EPA proposes the Gilles Plains station as a performance monitoring station.

It is of note that the Kensington Gardens site is actually in the same locality as the Kensington station discussed above but, for logistical reasons, is separated from it by about 100 m. The two stations are, however, about the same distance away from busy roadways, so they are regarded for practical purposes as the same site. TSP Lead is the only Air NEPM parameter measured at Kensington Gardens.

**Table 3–6: TSP lead monitoring network showing nominated performance monitoring stations**

| | | | |
|---|---|---|---|
| Northfield | HVS | PMS | Trend |
| Kensington | HVS | PMS | Trend |
| Gilles Plains | HVS | PMS | |
| Parkside | HVS | PMS | Trend |
| Thebarton | HVS | | |

Note: Due to the removal of leaded petrol from the market, results from these stations will be evaluated regularly to determine the need for continued lead monitoring.

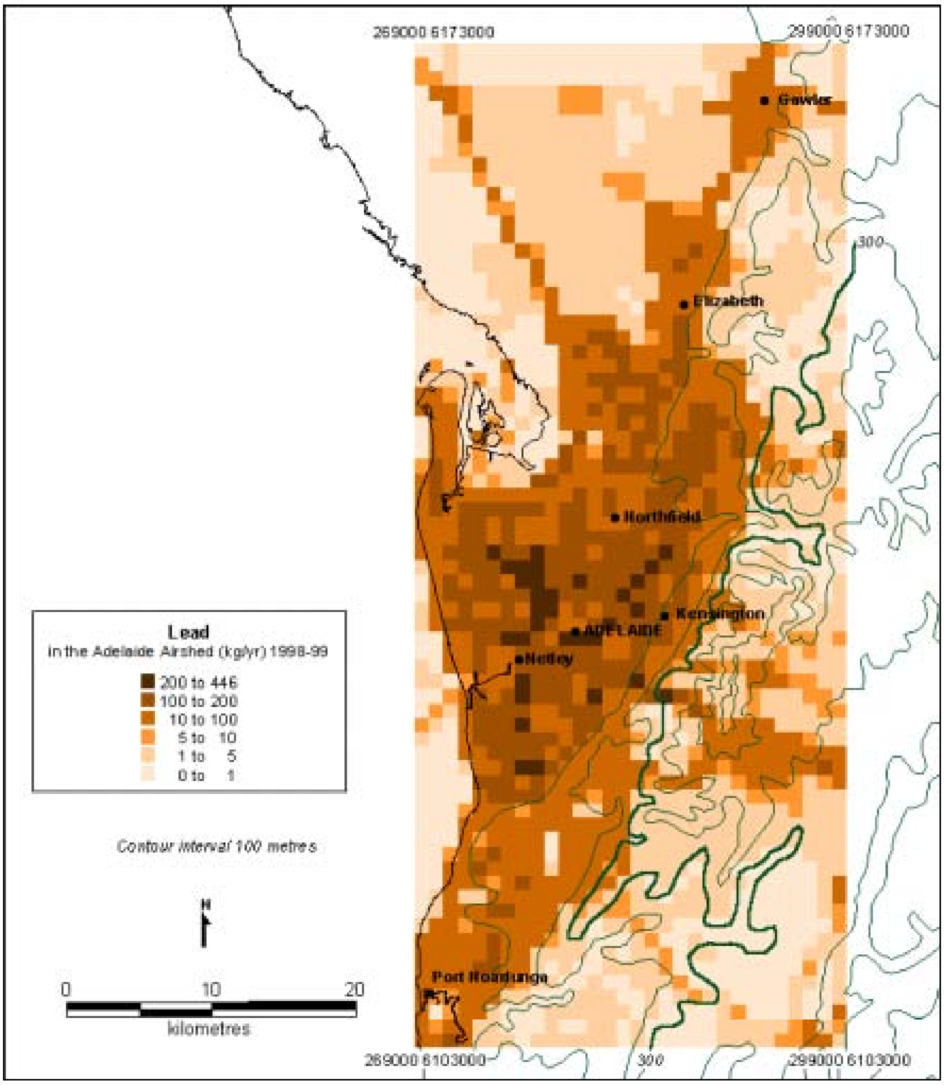


**Figure 3–5: TSP lead monitoring in metropolitan Adelaide (eastern airshed border shown as black line)**

### 3.1.9 Summary of NEPM networks in metropolitan Adelaide

Performance and trend stations as described in the previous sections are summarised in table 3-7 below. In this table, the coloured areas indicate proposed performance monitoring stations for the parameters shown. As previously noted, the SA EPA considers that sulfur dioxide is unlikely to be present at significant concentrations in most suburban stations and will decide on whether monitoring should be continued after a year of campaign monitoring. The complete network, including non-NEPM sites, is depicted in table 4-1 showing current and proposed air quality monitoring sites

**Key to table 3-7**

Pollutant methods for table 3-7:

| | |
|---|---|
| Nitrogen dioxide | chemiluminescence |
| Lead | high volume sampler—total suspended particulate lead, analysis by atomic absorption spectroscopy |
| Carbon monoxide | infrared |
| $PM_{10}$ | tapered element oscillating microbalance |
| Sulfur dioxide | ultraviolet fluorescence |
| Ozone | ultraviolet photometry |

Meteorology:

MET standard suite of meteorological parameters measured at ten metres above ground:

- wind speed, wind direction and wind direction variance (sigma-theta)
- temperature
- barometric pressure
- total solar radiation

**Table 3–7: Current and proposed NEPM ambient air quality monitoring sites in metropolitan Adelaide**

| Station | $O_3$ | $NO_2$ | $PM_{10}$ | CO | $SO_2$ | Lead | Met |
|---|---|---|---|---|---|---|---|
| Elizabeth[2] | PMS | PMS | PMS | Trend | Campaign | | MET |
| Gilles Plains | | | | | | PMS | |
| Hope Valley | | | PMS | | Campaign | | MET |
| Netley | Trend | Trend | PMS | | Campaign | | MET |
| Northfield[2] | Trend | Trend | Trend | | Campaign | Trend | MET |
| Kensington[1] | Trend | Trend | Trend | | Campaign | Trend | MET |
| Southern Metro | PMS | PMS | PMS | | Campaign | | MET |
| St John's Christies Beach | | | | | Trend | | |
| Hindley St | | | | Trend | | | |
| Parkside | | | | | | Trend | |

**Notes:**

1. The Kensington (TSP lead) and Kensington Gardens stations are 100 metres apart for logistical reasons. They are, however, a similar distance from busy roadways so are regarded for practical purposes as the same site.

2. $PM_{10}$ monitoring will start at these sites late in 2002 as the TEOM instruments earmarked for these sites will be used for the $PM_{2.5}$ monitoring trials at Netley and Kensington.

## 3.2 Spencer Region

### 3.2.1 Overview of the Spencer Region

**Regional boundaries**

This region is being investigated as potentially a Type 2 region because it includes the three industrial centres of Port Augusta, Port Pirie and Whyalla, all situated around the head of Spencer Gulf some 250 km north of Adelaide. The region is bounded on the east by the Flinders Ranges and on the western side of the gulf by hills of the Middleback Range; these ranges channel the wind pattern in a predominantly north–south direction. The region is physically open-ended to the north and south, but for air pollution and NEPM monitoring purposes, the urban centres are considered to be the ends of the region.

**Population and Topography**

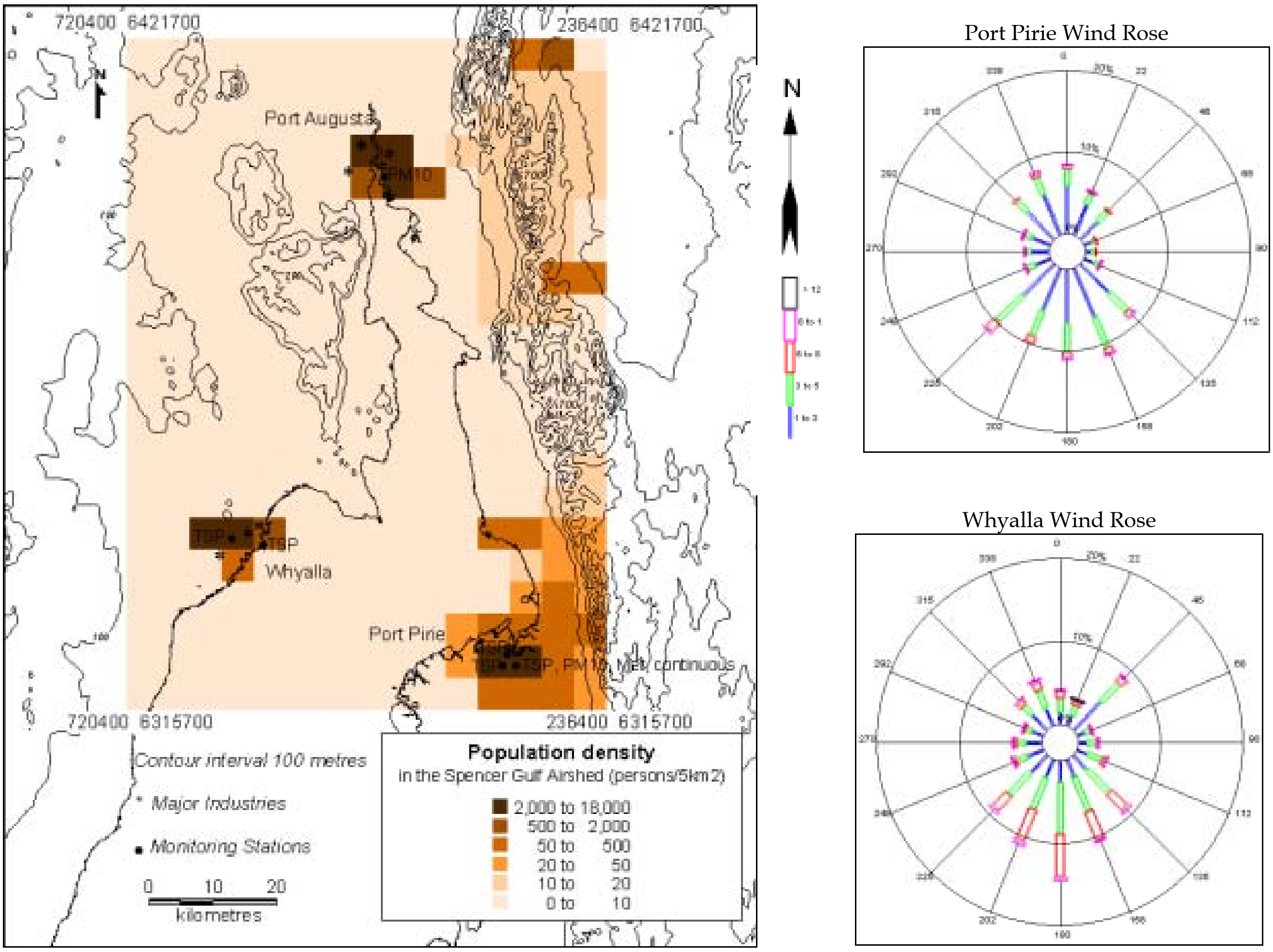


**Figure 3–6: Topography, population density and wind roses for the Spencer Region**

Port Augusta has a population of about 14,000, considerably less than the 25,000 cut-off specified in the Monitoring Protocol. It straddles the northernmost point of Spencer Gulf, with the original settlement on the eastern side. The terrain of the city is flat; the coastline has extensive saltbush and samphire flats. The Flinders Ranges are some 12 km to the east.

Port Pirie is the site of the world's largest pyrometallurgical lead smelter and the focus of extensive studies of lead and sulfur dioxide over the past 30 years or so. It has a population of 14,000 with an additional 1500 (approximately) in the district council area adjacent. Like Port Augusta, Port Pirie has no dominant topographic features apart from the interface with Spencer Gulf. In this case, it is the Pirie River, a tidal estuary that is effectively the city's northern boundary.

Whyalla is a city of about 24,000 people at present. Before the shipyard closed in 1968, the population exceeded 30,000. It is located on the western side of Spencer Gulf, with the early settlement close to the major industry and the newer development extending westward away from the coastline. There are some hills near the coastline that affect local wind flows but overall the land rises gently from the coastline to the Middleback Range west of the city plain. The steel plant is the primary industrial source in the town, especially of particulate materials. The SA EPA currently measures particles at two sites using high-volume samplers, but at only one of these (Hummock Hill) is the $PM_{10}$ fraction measured. As the steel plant is the major focus of monitoring, the particles are analysed for iron and manganese content.

**Industry**

Port Augusta city centre is about 6 km north of South Australia's major coal-fired power generation facilities. In the 1960s, sulfur dioxide ($SO_2$) concentrations affected the town as a result of emissions from the relatively low chimneys of the Playford Power Station (240 MW electrical output). Since the commissioning of the Northern Power Station (500 $MW_e$) in 1983 with its 200-m chimney, $SO_2$ has no longer been a problem.

The silver, lead and zinc smelter at the northern end of the city of Port Pirie began operations in 1889, smelting ores from the mines at Broken Hill. Systematic improvements have been incorporated into the processes over the years but particularly since introduction of clean air legislation in 1972. The port is also a major grain handling terminal receiving crops for export from the Mid North agricultural area of the State. There are no other major industrial sources.

The major industry at Whyalla is an integrated steelworks consisting of an ore pellet plant, blast furnace, basic oxygen steel-making furnace, continuous caster and rolling mills. There are also coke ovens, a lime kiln and ancillary services on site. Other industries in the city are smaller in scale, whether associated with the steelworks industry or not.

**Emissions**

Particulate matter is the common pollutant of concern in all three centres and consists of brown coal fly-ash, heavy metals, and iron oxides discharged through tall chimneys from industrial processes. In addition, sulfur oxides are emitted at all three locations: the emissions from Port Pirie are the most significant. Table D.5 summarises the emissions from the National Pollutant Inventory (NPI) for the region and shows the dominance of industrial sources.

**Meteorology**

Port Pirie has a grassland climate with a mean maximum temperature for the area in 2000 between 24 and 27°C. The rainfall for 2000 for the area was between 400–600 mm. The winds were from a southerly direction for 55% of the year and northerly for only 35% of the year. Drainage flows from the Flinders Ranges and some gulf breezes from the west were less frequent. It is suggested that the winds have been directed up the gulf due to the presence of the ranges on either side of Spencer Gulf. In summer, the formation of a thermal internal boundary layer (TIBL) has been found by CSIRO when the agency studied behaviour of the plume from the 205-metre smelter chimney (the 'Tall Stack'). This formation has resulted in incidences of unusually high but localised concentrations of sulfur dioxide ($SO_2$) in a section of the city.

Whyalla has a grassland climate with a mean maximum temperature for the area in 2000 between 24–27°C. The average yearly rainfall for the area in 2000 was between 200–300 mm.

Winds were predominantly southerly for approximately 60% of the year and, similar to Port Pirie's wind structure, have been dominated by the southerlies making their way up Spencer Gulf. Local winds behave similarly to those in Port Pirie with drainage flows from the ranges to the west and gulf breezes from the east.

No analogous monitored wind data are available for Port Augusta but the pattern can be considered to be generally similar to those of Whyalla and Port Pirie, with some modification due to Port Augusta's location relative to Spencer Gulf. Given the topography of the site, the potential for formation of a TIBL is also suggested, which is consistent with recorded observations of behaviour of the Playford Power Station plume during investigations for the planning of the Northern Power Station.

**Air Monitoring History**

At Port Augusta, dust fall monitoring was conducted for many years. Now, the SA EPA maintains a $PM_{10}$ station at the Port Augusta Hospital that uses a high-volume sampler with size-selective inlet. The power station operators have monitored sulfur dioxide for at least ten years on the western side of the city in the approximate location of the maximum ground level predicted by computer modelling of the Northern Power Station emissions.

Port Pirie is the only place outside the Adelaide metropolitan area where long-term monitoring for TSP lead and $PM_{10}$ lead occurs. The SA EPA has had a presence in Port Pirie for three decades and, since 1983, has operated lead monitoring stations in collaboration with the SA Department of Human Services. Currently, two of these stations sample for TSP lead and a third samples for both TSP lead and $PM_{10}$.

Since 1989, TSP and $PM_{10}$ have been measured at Whyalla. The latter is monitored 500 m south of the steelworks pellet plant on Hummock Hill (east of the CBD), while TSP is monitored in a residential suburb of Whyalla 4.5 km west of the pellet plant.

### 3.2.2 NEPM formula

With a combined population of 53,988 in the region, the NEPM formula indicates that one performance monitoring station is required in the Spencer Region; should the proposed investigations indicate that it constitutes a type 2 region then the SA EPA will reevaluate the monitoring requirements. Campaign monitoring is planned for each of the three cities.

### 3.2.3 Photochemical oxidants (as ozone)

**Review of data**

No data for ozone are available for the region.

**Screening analysis**

Formation of photochemical smog is unlikely to occur in the region at concentrations above the 0.03 ppm encountered in similar-sized rural centres not affected by long-range pollutant transport from major cities.

Campaign monitoring will be conducted at a generally representative upper bound (GRUB) site in each city (see section 3.6). This approach is consistent with screening procedures A and F in the PRC guideline paper no. 4, *Screening procedures* (Peer Review Committee 2000d); the results will be assessed using both procedures to determine the need for performance monitoring in the long term.

**Nominated performance monitoring stations and trend station/s**

No performance stations are currently proposed. The mobile stations will be located at a site to be selected in Port Pirie in the first year of the regional campaign monitoring program, and in Whyalla and Port Augusta in the second year of the program. This is intended to commence in 2001. Results will be used to assess the need for ozone performance monitoring.

### 3.2.4 Nitrogen dioxide

**Review of data**

There are no data available for nitrogen dioxide for this region.

**Screening analysis**

Screening procedure F in the PRC guideline paper no. 4, *Screening procedures* (Peer Review Committee 2000d), which compares Spencer Region centres with the metropolitan Adelaide Region, can be applied. On the basis of the emissions, topography, and meteorology of Spencer Region, both industrial and traffic emissions are far greater in Adelaide, but the concentrations of nitrogen dioxide in Adelaide are well below the NEPM standard.

Nevertheless, campaign monitoring at a GRUB site in each city will be conducted (see section 3.6). This approach is consistent with screening procedure A since the results will be assessed with emissions inventory and meteorology to determine the need for performance monitoring in the long term.

**Nominated performance monitoring stations and trend station/s**

As stated above, no performance station is nominated at this time but, in the event that the proposed campaign monitoring indicates the need for permanent monitoring, appropriate sites will be selected.

### 3.2.5 Particulate Matter—$PM_{10}$

**Review of data**

$PM_{10}$ monitoring has been carried out on the normal six-day cycle in Whyalla since 1989, Port Augusta since 1994 and Port Pirie since 1984. Although they are not directly comparable with the NEPM Monitoring Protocol, the results indicate a strong seasonal variation, with high values in summer due primarily to wind-borne dust. Results range from 40 $\mu/m^3$ to well above the 50 $\mu/m^3$ standard for 24-hour samples. Data are presented as graphs in figures C.8e–g.

**Nominated performance monitoring stations and trend station/s**

Monitoring data are available from sampling one day in six. This sampling indicates that there may be a need for continued monitoring. To allow a full and proper assessment, campaign monitoring at a GRUB site in each city will be conducted (see section 3.6). This approach is consistent with screening procedure A in the PRC guideline paper no. 4 *Screening Procedures* (Peer Review Committee 2000d): the results will be assessed with emissions inventory and meteorology to determine finally the need for performance monitoring in the long term.

### 3.2.6 Carbon monoxide

**Review of data**

There are no data available for carbon monoxide for the Spencer Region.

**Screening analysis**

Carbon monoxide is primarily a pollutant associated with high volumes of very slow moving vehicle traffic in street canyons of large cities. The other potential source is widespread use of solid fuel fires for domestic heating. Neither source applies in this region. According to emission inventories calculated for the NPI (tables D.1 and D.5), carbon monoxide emissions per capita are about 75% of those in the Adelaide Region. As the temperate climate does not have the prolonged or low temperature winters of other southern States that lead to significant use of solid fuel heaters, high levels of carbon monoxide are not expected.

The SA EPA will await the outcome from campaign monitoring by Queensland EPA of CO in the Toowoomba region in Queensland (population 83,000). It is expected that application of screening procedure F in *Screening Procedures* (PRC, 2000d) will screen out the requirement to monitor CO in the Spencer Region.

**Nominated performance monitoring stations and trend station/s**

No performance or trend sites are nominated for CO in the Spencer Region.

This approach is consistent with screening procedure A (PRC, 2000d) as the results will be assessed with emissions inventory and meteorology to determine the need for performance monitoring in the long term.

### 3.2.7 Sulfur dioxide

**Review of data**

The SA EPA has no relevant long-term $SO_2$ data for the region. Previous monitoring was located at sites predicted to give peak values from the source discharges rather than for general population exposure. Results reported to the SA EPA for Port Augusta confirm the modelling study predictions for the Northern Power Station in that measured levels of sulfur dioxide are well below the NEPM Standard. Campaign monitoring of sulfur dioxide was conducted at Whyalla near the pellet plant as part of investigations into the improvements needed to reduce emissions to acceptable levels. Sulfur dioxide was monitored extensively at Port Pirie by the SA EPA before and for several years after installation in 1979 of the 205-metre chimney designed to disperse $SO_2$. Changes to the process since 1990 have led to an increase in emissions. They are now monitored by the company in the chimney and at strategic sites to manage the impact that occurs under specific weather conditions on a localised scale.

**Nominated performance monitoring stations and trend station/s**

Campaign monitoring at a GRUB site in each city will be conducted for a one-year period (see section 3.6). This approach is consistent with screening procedure A of the PRC screening guideline paper (PRC, 2000d). The results will be assessed with emissions inventory and meteorology to determine the need for performance monitoring in the long term.

### 3.2.8 Lead

**Review of data**

Extensive monitoring of lead has been undertaken at Port Pirie at a variety of sites over the past 30 years. The sites were chosen for industrial source management rather than general community exposure. The longest history of results comes from a site only 200 m from the works boundary; others were chosen to coincide with the predicted site of maximum concentration from the tall chimney discharge. The Oliver St site is in a residential area and is therefore useful in assessing general community exposure.

**Screening analysis**

In the absence of any major single lead source in Port Augusta and Whyalla, the only likely source of lead is motor vehicle emissions. With the application of screening procedure F, a comparison of these cities with metropolitan Adelaide leads to the conclusion that monitoring is not necessary in these two cities.

Lead particles of $PM_{10}$ size and smaller are the only lead particles transportable over the tens of kilometres between Port Pirie and Port Augusta or Whyalla. This fraction is emitted both from near ground level and from the tall stack. The results in Port Pirie show how rapidly concentration drops with distance from the smelter, as fugitive releases from near ground level do not travel more than 3 km. The concentrations due to the tall stack in Port Pirie are lower than the NEPM standard and therefore are unlikely to result in levels more than 40% of the NEPM standard in either Whyalla or Port Augusta. Recent short term monitoring in Whyalla has confirmed low levels of lead. PRC screening criteria B and D (Table 1, PRC 2000d) therefore indicate that lead monitoring is not required in Whyalla or Pt Augusta.

**Nominated performance monitoring stations and trend station/s**

None are planned for Whyalla or Port Augusta. Two sites have been chosen in Port Pirie based on its meteorology and the location of the residential areas relative to the smelter. They are at the centroids of the principal residential areas downwind from the smelter according to local wind roses. Additional monitoring, not related to the NEPM, is being conducted to evaluate the emission reduction programs implemented by the smelter.

## 3.3 Mount Gambier Region

### 3.3.1 Overview of the Mount Gambier Region

**Regional boundaries**

The northern extent of the Mount Gambier airshed is unclear due to an absence of topographical features that would form a natural boundary, and of detailed meteorological data and atmospheric dispersion modelling. To the south and west of the city, the coast ranges from 14–20 km away. For the purposes of the NEPM monitoring program, the area shown in the map (figure 3.7) is considered to contain the Mount Gambier airshed.

Mount Gambier, in the State's South East, has a population of about 22,000 people in the city itself, with 5000 in the adjoining district, while Millicent some 45 km away has a population of 7247.

Mount Gambier city spreads up the slopes of the extinct three-cratered volcano, Mount Gambier, which reaches 190 m above sea level. The surrounding area is gently undulating countryside, much of which has been cleared of native eucalypt forest and replanted with pine plantations.

**Industry**

The region's industry is centred strongly on timber and timber products. Within Mount Gambier, there are two panel board plants, notable for their discharge of 'blue haze'. This haze is an aerosol of fine carbonaceous particles with associated condensation products characteristic of *Pinus radiata* woodchip drying. It includes a broad range of terpenoid oils, which create a characteristic odour that can be irritating.

Under some weather conditions, the city can also receive sulfur dioxide and associated organic emissions from a pulp and paper facility at Millicent.

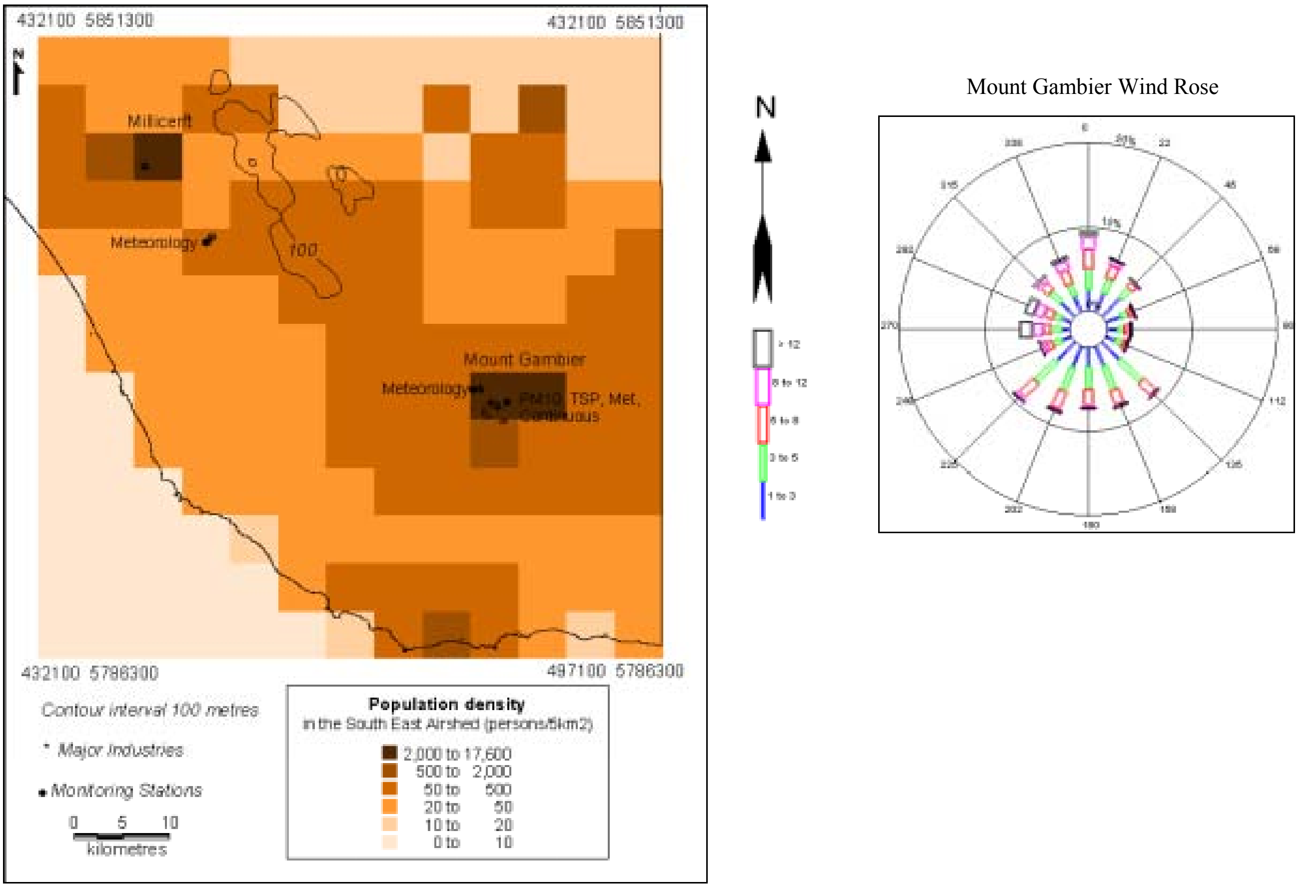


**Figure 3–7: Topography, population density and wind rose for the Mount Gambier Region**

## Emissions

The emissions summarised from the National Pollutant Inventory (NPI) are shown in table D.4 of Appendix D. These are quite similar to those from the Spencer Gulf Region for non-industrial sources. There is a large wood processing industry in the area which may contribute to the particle concentrations in the region.

Millicent, north west of Mt Gambier City, has a large wood pulp processing facility which in the past has emitted significant amounts of sulphur dioxide. Recent upgrades to the plant are likely to reduce these levels.

'Hot spot' and campaign monitoring initiated in August 2000 will clarify the need for ongoing monitoring.

## Meteorology

Mount Gambier is classed as having a temperate climate, with the mean maximum temperature for the area in 2000 being 18–21°C. The average yearly rainfall is 600–900 mm.

The winds have been found to be predominantly southerlies, ranging from south-easterly to south-westerly approximately 50% of the year. North to north-westerlies have been recorded for approximately 35% of the year. The presence of Mount Gambier, an extinct volcano, produces some local drainage flows from the east. The stronger winds are usually north to north-westerly in nature.

**Air monitoring history**

The SA EPA installed a mobile monitoring station in Mount Gambier in September 2000 as part of its regional monitoring evaluation program. The station measures ozone, nitrogen oxides, $PM_{10}$ particles using TEOM and a high-volume sampler, and sulfur dioxide.

### 3.3.2 NEPM formula

The number of performance stations required for the Mount Gambier Region is one based on clause 14(1) of the measure.

**Review of data for all NEPM pollutants**

Initial results for September to December 2000 show $PM_{10}$ average of about 20 µg/m$^3$ with quite high short-term concentrations. The ozone one-hour average has not reached 0.04 ppm and is generally below 0.03 ppm—much lower than the NEPM standard of 0.10 ppm. Likewise, sulfur dioxide is barely above the limit of detection. Although generally very low, nitrogen oxides show one-hour peak values of up to 0.05 ppm, which is a value still less than half the NEPM standard of 0.12 ppm hourly average.

### 3.3.3 Screening analysis

Lead is not monitored as part of the current program. The screening procedure F in the PRC guideline paper (see Appendix B) can be used to compare the region with Northfield station in the metropolitan Adelaide Region. The basis of comparison is the similarity of urban form and the emission inventory for lead (table D-5), which indicates no major industrial sources, and the phase-out of leaded petrol. Northfield's lead concentrations (Figure C-10c) are well below the NEPM standard, so airborne lead in the Mount Gambier Region is likely to be even further below the NEPM standard. Performance monitoring is not warranted here.

Carbon monoxide ($CO_2$) is a pollutant primarily associated with high volumes of very-slow-moving vehicle traffic in street canyons of large cities. This situation does not exist in Mount Gambier. According to emission inventories, carbon monoxide emissions per capita are approximately the same as those in the Adelaide Region. Carbon monoxide levels are not expected to exceed the standards since the aspect is generally open. The SA EPA will await the outcome from campaign monitoring by Queensland EPA of CO in the Toowoomba region in Queensland (population 83,000). It is expected that application of screening procedure F in *Screening Procedures* (PRC, 2000d) will screen out the requirement to monitor CO in Mt Gambier Region.

Results for ozone and sulfur dioxide obtained since August 2000 easily comply with the NEPM. It is likely that screening procedure A will be applicable at the completion of the campaign.

### 3.3.4 Nominated performance monitoring stations and trend station/s

None are nominated at present. The current site is part of the campaign-monitoring program. It has been selected on the basis of general meteorology of the region and the relative location of the general residential population and industry. The SA EPA will make a decision on the need for permanent monitoring in Mount Gambier once the 12-month period of data has been obtained, but current results indicate that performance monitoring for $PM_{10}$ will be necessary.

## 3.4 Riverland Region

### 3.4.1 Overview of the Riverland Region

**Regional boundaries**

The boundary used for the NPI region in figure 3.8 is considered to encompass the regional airshed, although the extent of the airshed boundary itself is not clear. For the purposes of evaluating air quality under the NEPM, the area surrounding the towns of Renmark, Berri, Barmera and Loxton is proposed to comprise a Type 2 airshed as defined by the PRC. Loxton is 25 km SSE of Barmera and 20 km south of Berri. Renmark is 20 km north-east of Berri.

The SA EPA has little meteorological data that can be used in computer modelling of the emissions obtained through the NPI to verify the boundaries of the airshed. Unlike the Spencer Region, there is no significant industrial source. The proposed monitoring plan is intended to clarify this issue.

**Population and topography**

Together, the towns of Barmera, Berri, Loxton and Renmark have a population of 25,741 although none individually contains more than 8000. They are all located along the Murray River close to the border with Victoria. The river system is the dominant feature of the topography, which is essentially flat grasslands. The land is used mainly for grazing, grain growing, and citrus fruit and grape cultivation. The fruit and grape growing and their associated industries include sulfur drying of fruit. While some information is available from inventories, the SA EPA does not currently have any monitoring facilities in place in the region. Monitoring using a mobile station over a period of a year is scheduled to commence in 2003. Decisions about further monitoring will be based on an evaluation of data from that survey.

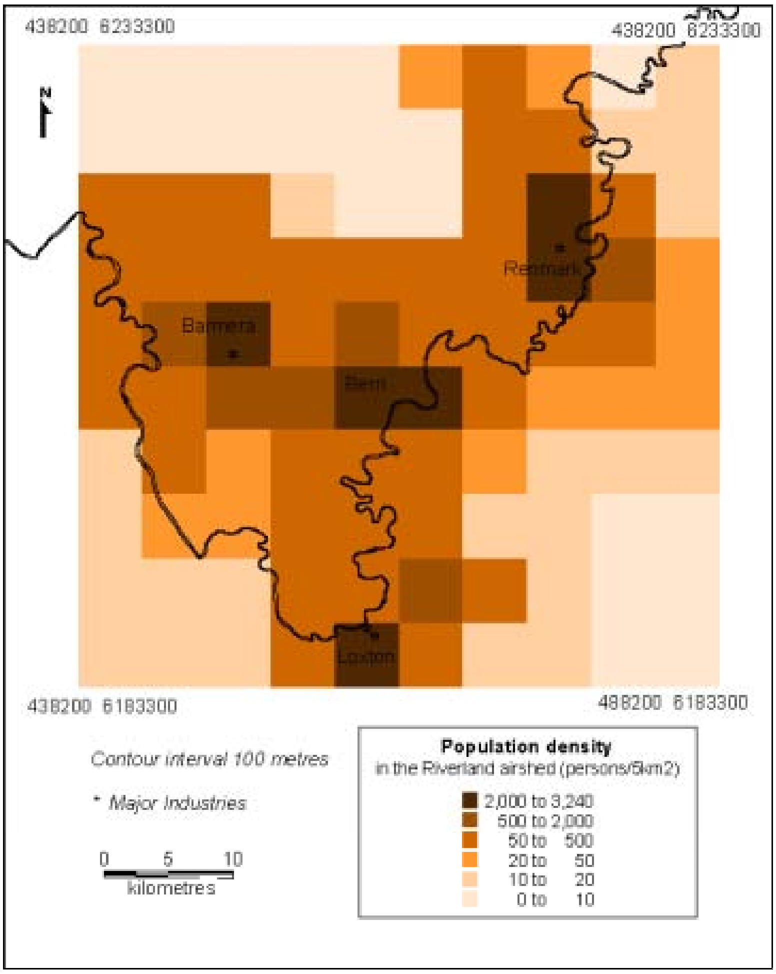


**Figure 3–8: Topography and population density for the Riverland Region**

### Industry

There are no large industries whose emissions are likely to be dispersed broadly across the region, except for diffuse sources associated with agricultural burning on a seasonal basis.

### Emissions

The principal emissions, as obtained from the National Pollutant Inventory (NPI), are listed in table D.5 of Appendix D. Emissions from non-industrial sources are generally lower than other regions. It is expected that industrial use of sulphur dioxide in localised areas are the only likely problem. Campaign monitoring will clarify the ground level concentrations and clarify any need for ongoing monitoring.

### Meteorology

The Riverland is classed as having a grassland climate with a mean maximum temperature for the area in 2000 of 24–27ºC. The average yearly rainfall for the area in 2000 was 300–400 mm. Towns adjacent to the river are likely to experience overnight drainage airflows strongly influenced by the river's presence, and pollutant transport patterns will be similarly influenced.

**Air monitoring history**

No ambient monitoring has been conducted in any of the Riverland towns.

### 3.4.2 NEPM formula

The number of performance stations required for the Riverland Region is one based on clause 14(1) of the measure.

**Review of data**

The SA EPA has no data relating to pollutants listed in the NEPM.

### 3.4.3 Screening analysis

It is not proposed to measure lead in the 12-month monitoring program planned for the region. The emission inventory for lead indicates no major industrial sources. This, together with the phase-out of leaded petrol, means that the screening procedure F in the PRC guideline paper (PRC, 2000d) can be used to compare the region with the metropolitan Adelaide Region. Adelaide's vehicle fleet is greater in proportion to its population than that in the Riverland Region, yet its lead concentrations are well below the NEPM standard. Airborne lead in the Riverland region is therefore likely to be well below the NEPM standard so performance monitoring is not warranted here. In addition, the lower number of vehicles, the flat and open topography, and its per capita carbon monoxide emissions, similar to those of Adelaide, suggest that carbon monoxide levels will not exceed the standards. Consequently, carbon monoxide will not be monitored as part of the campaign monitoring as the SA EPA will await the outcome from campaign monitoring by Queensland EPA of CO in the Toowoomba region of Queensland (population 83,000). It is expected that application of screening procedure F in *Screening Procedures* (PRC, 2000d) will screen out the requirement to monitor CO in the Riverland Region.

### 3.4.4 Nominated performance monitoring stations and trend station/s

No performance monitoring sites are currently nominated. The sites for the monitoring campaign planned for 2003 have not yet been selected. Their location will be chosen based on knowledge of the local meteorology, population, and industry centres, the protocol of the NEPM and the relevant Australian Standards. The need for further monitoring will be assessed using the results of campaign monitoring and emission inventories.

## 3.5 Barossa Region

This region is considered not to be any of the three region types defined by the Peer Review Committee (PRC) in its guidance of selection of regions for NEPM monitoring. There are no significant point source or area-based emissions within the region of sufficient magnitude to result in pollutant concentrations greater than 60% of the NEPM standards.

The Barossa Region is included in the monitoring plan because the SA EPA considers it is possibly subject to impact from the transport of pollutants—principally photochemical oxidants—from the metropolitan Adelaide Region. Some details of the region are provided to explain this conclusion.

### 3.5.1 Overview of the Barossa Region

**Regional boundaries**

Gawler is seen as the southern end of the Barossa Region but is not actually within it, although it is a useful position to ascertain the impact from the Adelaide plume (Physick et al 1995). There are low hills on the east and west of the three major towns of Angaston, Nuriootpa, and Tanunda. The National Pollutant Inventory (NPI) region includes the towns of Kapunda and Eudunda at the northern extremity; the latter is approximately 40 km from the 'triangle towns' of Angaston, Nuriootpa and Tanunda, which are not more than 20 km apart.

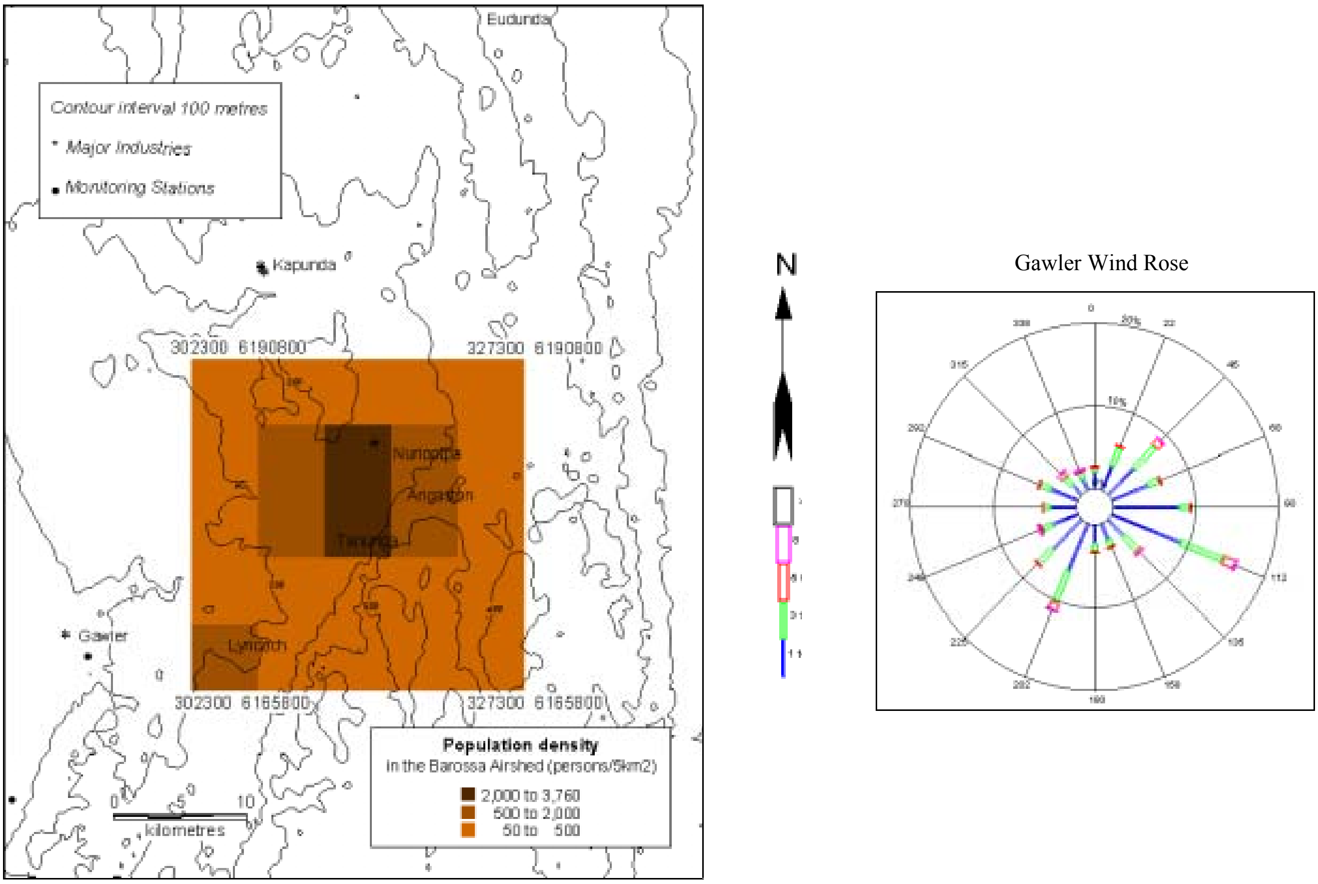


**Figure 3–9: Topography, population density and wind rose for the Barossa Region**

### Population and topography

The total population of the five towns is only 20,691; the individual town populations appear in table 2.2. The topography is shown in figure 3.9, which depicts the valley area and the NPI region boundary.

### Industry

The principal industry is winemaking, using grapes grown in the valley itself and from other areas. Angaston has a quarry nearby, supplying limestone to a soda ash plant in Adelaide, and a cement works, both of which are sources of particulate matter.

### Emissions

Table D.6 in Appendix D summarises the data obtained from the NPI, which includes the major industries and other aggregated sources of emissions.

**Meteorology**

The SA EPA has no detailed meteorological data. The general pattern is likely to be similar to that of Adelaide—that is, influenced by a daily south-westerly sea breeze but with evening cold air drainage winds flowing to the South Para River, which passes through the valley.

**Air monitoring history**

No ambient air monitoring has been conducted within the valley itself. Some monitoring of ozone and nitrogen oxides has been conducted at Gawler to investigate transport of pollutants from metropolitan Adelaide Region. The results indicate low values of both pollutants. The NPI emissions inventory table D-4 shows extremely low total emissions of carbon monoxide, sulfur dioxide and nitrogen dioxide. The campaign monitoring will address the latter two; however, application of screening procedure F indicates that carbon monoxide is not warranted.

**Nominated performance monitoring stations and trend station/s**

At this stage, no performance monitoring stations are planned. Apart from lead, all NEPM pollutants will be monitored at Gawler for a trial period of 12 months, after which the need for additional monitoring within the valley will be assessed in conjunction with the emissions inventory data for the region. The SA EPA has purchased the CSIRO air pollution dispersion model TAPM, and will use a combination of available data to model the regional air quality and, hence, to evaluate the need for additional monitoring.

## 3.6 Mobile campaign monitoring surveys and emissions inventories

In South Australia, the approach to the National Pollutant Inventory (NPI) includes asking questions relating to short-term emissions data to provide information beyond the annual means, which form the database. Emission inventories are being compiled in regional areas (see figure 4.5) as part of a needs analysis. The two mobile monitoring stations will both be deployed on rotating 12-month schedules at these centres over the next five years. So each of these regional centres are scheduled to be monitored for at least one year, as shown in tables 3-8 and 3-9, to determine whether they will need long-term monitoring:

**Table 3–8: Mobile campaign monitoring surveys**

| Scheduled Year of Commencement | Regional Centres | |
|---|---|---|
| 2000–1 | Port Pirie | Mount Gambier |
| 2001–2 | Whyalla | Port Augusta |
| 2002–3 | Southern wineries area | |
| 2003–4 | Barossa–Angaston | Riverland |

Parameters monitored at each of the above listed sites will be as follows:

**Table 3–9: Parameters monitored at mobile campaign monitoring stations**

| Station | $O_3$ | $NO_2$ | $PM_{10}$ | CO | $SO_2$ | Lead | $PM_{2.5}$ | Met |
|---|---|---|---|---|---|---|---|---|
| As listed above | UVP | CH | SSI | | UVF | | | MET |

**Key to tables 3-8 and 3-9:**

Pollutant methods:

| | |
|---|---|
| CH | chemiluminescence |
| HVS | high volume sampler—total suspended particulate lead, analysis by atomic absorption spectroscopy |
| IR | infrared |
| SSI | $PM_{10}$ size selective inlet used with high volume sampler six-day cycle |
| UVF | ultraviolet fluorescence |
| UVP | ultraviolet photometry |

Meteorology:

MET standard suite of meteorological parameters measured at ten metres above ground:

- wind speed
- wind direction and wind direction variance (sigma-theta)
- temperature
- barometric pressure
- total solar radiation

# 4 SITING AND INSTRUMENTATION

## 4.1 Current Adelaide metropolitan and regional monitoring network

The current metropolitan network is a combination of long-established monitoring sites and several stations established as a result of recent modelling studies by the CSIRO and Victorian EPA. The stations are detailed in chapter three, but an overview is presented here of existing facilities. Apart from a significant and continuing presence in Port Pirie, needs for monitoring in several regional centres are still being evaluated and are therefore not included here. Configurations of existing metropolitan monitoring stations are presented in table 4.1, and of regional monitoring in table 4.2. Methods currently used in South Australia are shown in table 4.3. Table 4-7 gives details of the sites in relation to AS2922-1987. The non-compliance with the distance criteria for proximity to trees at Elizabeth, Gawler and Northfield is non-critical in terms of site exposure as the trees are at least 15 m away and do not unduly affect micro-meteorology. Similarly, the Kensington Gardens site is not unduly compromised by the presence of the trees.

**Table 4–1: Current and proposed ambient air quality monitoring sites—metropolitan Adelaide**

| Station | $O_3$ | $NO_2$ | $PM_{10}$ | CO | $SO_2$ | Lead | $PM_{2.5}$ | Met |
|---|---|---|---|---|---|---|---|---|
| Elizabeth[3] | AT[6] | AT[6] | TEOM | IR | UVF | | | MET |
| Gawler[1] | AT[6] | AT[6] | TEOM | | | | NEPH | MET |
| Southern Metro[1] | AT[6] | AT[6] | TEOM | | LP | | NEPH | MET |
| Hope Valley | LP | LP | TEOM | | LP | | NEPH | MET |
| Netley | AT[6] | AT[6] | TEOM | | LP | | NEPH<br>TEOM(12) | MET |
| Northfield[3] | AT[6] | AT[6] | TEOM | | UVF (12) | HVS | | MET |
| Kensington[2] | AT[6] | AT[6] | TEOM | | UVF (12) | | TEOM(12) | MET |
| Kensington Gardens[2] | | | | | | HVS | | |
| St John's Christies Beach | | | | | UVF | | | |
| Hindley St | | | | IR | | | | |
| Parkside | | | | | | HVS | | |
| Gilles Plains | | | | | | HVS | | |
| Gilles Plains | | | SSI | | | SSI | | |
| Penrice, Port Adelaide | | | SSI | | | | | MET |
| Thebarton | | | SSI | | | HVS<br>SSI | | |
| Christies Beach | | | | | | | | MET |

**Notes**:

1. Shaded areas represent proposed performance monitoring stations for the parameters indicated.
2. The marker '(12)' indicates that an initial 12-month evaluation of the pollutant or instrument is to be undertaken at that site.

3. The station at Gawler has been established on a 12-month evaluation trial. If results show the need for further monitoring, the station may be retained at this site. If not, the equipment may be relocated to the new Southern Metro site to monitor exposure in that area.

4. The Kensington and Kensington Gardens stations are in a similar locality but, for logistical reasons, are about 100 m apart. They are, however, a similar distance from busy roadways.

5. The TEOM instruments earmarked for these sites will be used for the $PM_{2.5}$ monitoring trials at Netley and Kensington, so $PM_{10}$ monitoring will be delayed for 12 months.

6. Note that Airtrak instruments will be replaced by December 2001 with UVP for Ozone and CH for nitrogen dioxide.

**Key:**

Pollutant methods:

| | |
|---|---|
| AT | Airtrak parameters—ozone, nitrogen dioxide and reactive organic compounds (ROC). |
| CH | chemiluminescence |
| HVS | total suspended particulate lead sampled by high volume sampler, analysis by atomic absorption spectroscopy |
| LP | long-path UV/visible absorption (DOAS)—can be configured to measure $O_3$, $NO_2$, $SO_2$, in addition to a range of organic species |
| NEPH | fine particles (~2.5 μm) by nephelometry (light scatter) |
| SSI | $PM_{10}$ size selective inlet used with high volume sampler |
| TEOM | tapered element oscillating microbalance |
| UVF | ultraviolet fluorescence |
| UVP | ultraviolet photometry |

Meteorology:

MET standard suite of meteorological parameters measured at ten metres above ground:

- wind speed
- wind direction and wind direction variance (sigma-theta)
- temperature
- barometric pressure
- total solar radiation

## Specialised meteorological stations

To allow the development of airshed modelling, the SA EPA will require access to upper level meteorological data such as that as obtained using Doppler acoustic systems and ground-based radar systems. The SA EPA is investigating options to source this information. It has been suggested that a site along the coast and another along the hills face would be suitable locations. An upper level meteorological station at Buxton Park near the coast, currently run by the University of Adelaide, is a facility that has the potential to suit SA EPA needs.

**Table 4–2: Ambient air quality monitoring—regional population centres**

| Station | $O_3$ | $NO_2$ | $PM_{10}$ | CO | $SO_2$ | Lead | $PM_{2.5}$ | Met |
|---|---|---|---|---|---|---|---|---|
| Pt Pirie 1 West Primary School | | | | | | HVS | | |
| Pt Pirie 2 Oliver St | | | SSI | | | HVS | | |
| Pt Pirie 3 Frank Green Park | | | | | | HVS | | |
| Millicent | | | | | | | | MET |
| Mt Gambier | UVP | CH | TEOM | | UVF | | | MET |
| Pt Augusta | | | HVS | | | | | |
| Pt Pirie Meteorology site | | | | | | | | MET |
| Whyalla Hospital | | | HVS | | | | | MET |
| Mobile 1 | UVP | CH | SSI | | UVF | | | MET |
| Mobile 2 | UVP | CH | SSI | | UVF | | | MET |

**Note:** Over the next three to five years, Mobile 1 and Mobile 2 stations will be used for campaign monitoring on a rotating annual basis. This use will assist in the evaluation of air quality in five regional areas to determine the need or otherwise for continued monitoring.

**Key:**

Pollutant methods:

HVS total suspended particulate lead sampled by high volume sampler, analysis by atomic absorption spectroscopy

SSI $PM_{10}$ size selective inlet used with high volume sampler

TEOM tapered element oscillating microbalance

UVF ultraviolet fluorescence

UVP ultraviolet photometry

Meteorology:

MET standard suite of meteorological parameters measured at ten metres above ground:

- wind speed
- wind direction and wind direction variance (sigma-theta)
- temperature
- barometric pressure
- total solar radiation

**Table 4–3: Air NEPM—Current methods of measurement used in South Australia showing compliance with schedule 3 of the Air NEPM**

| Pollutant | Method(s) | Complying Method? | Australian Standard |
|---|---|---|---|
| Oxidants | Airtrak | No | |
| (ozone) | Ultraviolet photometry | Yes | AS3580.6.1-1990 |
| | Long path visible absorption | No | |
| Nitrogen dioxide | Airtrak | No | |
| | Chemiluminescence | Yes | AS3580.5.1-1993 |
| | Long path visible absorption | No | |
| Carbon monoxide | Gas filter correlation infrared | Yes | AS3580.7.1-1992 |
| | | | |
| Sulfur dioxide | Ultraviolet fluorescence | Yes | AS3580.4.1-1990 |
| | Long path visible absorption | No | |
| $PM_{10}$ | Size selective inlet | No as 6 day cycle | AS3580.9.6-1990 |
| | TEOM | No | AS3580.9.8-2001 |
| TSP lead | High volume sampler | Yes | AS2800.9.6-1990<br>AS2724.3-1984 |

**Table 4–4: Other—Current methods of measurement to be used in South Australia for NEPM monitoring**

| Pollutant | Method(s) | Complying Method? | Australian Standard |
|---|---|---|---|
| $PM_{2.5}$ | TEOM | No | - |
| | Nephelometry (light scatter) | No | AS2724.4-1987 |

**Table 4–5: Locations of current monitoring stations in metropolitan Adelaide (performance monitoring stations highlighted in yellow)**

| Station Name | Location |
|---|---|
| Elizabeth | Elizabeth Downs Primary School, Heard Street |
| Gawler | SA Water premises, cnr Popham and Barossa Avenues |
| Hope Valley | Modbury High School, Pompoota Rd, Hope Valley |
| Netley | Rear DEH offices, 310 Richmond Road |
| Northfield | Hampstead Centre, Royal Adelaide Hospital, cnr Folland Avenue and Hampstead Road |
| Kensington | Norwood Parade, adjacent East Terrace |
| Kensington Gardens | Centrally within Kensington Gardens 100 m from Kensington site |
| Mobile stations 1 and 2 | Evaluations in regional centres |
| Christies Beach | St John the Apostle Primary School, Winnerah Road |
| Gilles Plains | Gilles Plains Primary School, cnr Northeast Road and Beatty Avenue, Hillcrest |
| Hindley Street | McDonald's premises, Hindley Street, Adelaide |
| Parkside | Parkside Primary School, cnr Glen Osmond Road and Young Street |
| Penrice | Penrice premises, Mersey Road, Osborne |
| Thebarton | NE cnr South Road and Henley Beach Road |
| Port Adelaide 1 | Dulux plant, Commercial Road |
| Port Adelaide 2 | Fletcher Road, Peterhead |

**Table 4–6: Locations of current and proposed monitoring stations in regional centres of South Australia (performance monitoring stations highlighted in yellow)**

| Station Name | Location |
|---|---|
| Pt Augusta | Port Augusta Hospital |
| Pt Pirie 1 | Pirie West Primary School |
| Pt Pirie 2 | Oliver Street |
| Pt Pirie 3 | Frank Green Park |
| Whyalla | Hummock Hill |

**Table 4–7: Site compliance PMS**

| Station | Height above ground | Min. distance to support structure | Clear sky angle of $120^0$ | Unrestricted airflow 270/360 | 20 m from trees | Boiler or incinerators nearby | Min dist from road or traffic | Comment |
|---|---|---|---|---|---|---|---|---|
| Elizabeth | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | Residential area |
| Gawler[1] | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | Temporary |
| Southern Metro | | | | | | | | Residential site yet to be chosen |
| Hope Valley | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | Residential area |
| Netley | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | Light industrial, heavy traffic |
| Northfield | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | Residential area |
| Kensington | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | Residential area |
| Kensington Gardens | ✓ | ✓ | ✗ | ✗ | ✗ | ✓ | ✓ | 30 m-high gums @ 10 m, but clear aspect—thin, high canopy |
| St John's Christies Beach | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | Industrial site in residential area |
| Hindley St | ✓ | ✗ | ✓ | ✗ | ✓ | ✓ | ✗ | Peak roadside carbon monoxide station |
| Parkside | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | Peak traffic area |
| Pt Pirie 3 Frank Green Park | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | Type 2, residential |
| Pt Pirie 2 Oliver Street | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | Type 2, residential |

**Table 4–8: Other relevant monitoring carried out by SA EPA**

| Station | Location | Parameters Measured |
|---|---|---|
| Mobile stations 1and 2 | Evaluations in regional centres | $NO_2$, $SO_2$, $O_3$, $PM_{10}$, TSP |
| Gilles Plains | Gilles Plains Primary School, cnr North East Road and Beatty Avenue, Hillcrest | TSP and $PM_{10}$ |
| Penrice | Penrice premises, Mersey Road, Osborne | TSP and $PM_{10}$ |
| Thebarton | NE cnr South Road and Henley Beach Road | TSP and $PM_{10}$ with lead |
| Port Adelaide 1 | Dulux plant, Commercial Road | TSP and $PM_{10}$ with lead to be discontinued in June 2001 |
| Port Adelaide 2 | Fletcher Road, Peterhead | TSP to be relocated |
| Pt Augusta | Port Augusta Hospital | $PM_{10}$ |
| Whyalla | Hummock Hill | TSP and $PM_{10}$ next to heavy industry |

# 5 ACCREDITATION AND QUALITY CONTROL

The PRC guideline paper no. 7, *Accreditation* (PRC, 2000g) has been adopted by the SA EPA, which has developed a detailed plan to achieve NATA accreditation by July of 2003. Until accreditation is formally achieved, the SA EPA will undertake systematic and traceable validation of data.

This plan contains only a précis of system requirements. The SA EPA intends to obtain NATA accreditation for all parameters measured.

The SA EPA will maintain an open record of all activities and operations relating to the monitoring program, including:

- data validation and correction
- servicing schedules and results
- asset maintenance, repair and replacement.

This approach means that standards of monitoring required in schedule three of the NEPM will be met.

The SA EPA will carry out regular calibrations and internal audits of all monitoring equipment. Calibrations will be scheduled and performed in accordance with NATA and Australian Standards requirements, accepted good laboratory practice, or as required by the NEPM. Calibration will be performed on any instrument that has undergone servicing, repairs, or a major breakdown. Calibration will be traceable to Australian and/or International Standards.

Data validation procedures will also include electronic logging of all automated calibration values. The performance of the loggers and transmission systems themselves, including accuracy of recording and transmission, calculation errors and malfunctions, will be included in the procedures. Data may also be recorded onto charts at each station as a backup to the electronic recording system. Backup charts, calibration and service documentation will be stored for a specified period at a secure location.

For continuous automatic equipment, monitoring and calibration data will be available to the SA EPA via telephone links with each station. Service schedules will meet the requirements of Australian Standards and the manufacturers' operating instructions.

Internal audits will be carried out and, once the process has been established, the SA EPA will be involved in inter-laboratory checks.

# 6 REPORTING, COLLECTION AND HANDLING OF DATA

## 6.1 Reporting and communications

Reporting will be as stipulated in PRC guideline paper no. 8, *Annual reports* (PRC, 2000h). A report will be provided annually.

The first report containing a full year's data will be for the year ending December 2002. The report for year ending 2001 will not contain a full year's compliant data for each of the performance monitoring stations.

The SA EPA does not currently have a facility for regular communication of air monitoring results to the public, although such a facility is being developed as part of a system to make all public reports available through its web site on the Internet. Given that there could be breaches of some of the standards, this system will be a valuable asset to educate people about air pollution and their role in its creation and abatement. The SA EPA does make all reports available through the Environment Shop (either on-site or by order), operated by the South Australian Department for Environment and Heritage (DEH), which administers the SA EPA.

### 6.1.1 Reporting from regional centres

The initial monitoring in regional centres is not intended for reporting. It may be that PMS sites will be set up on which there will be reports on an ongoing basis, or reporting may utilise emission inventory data and modelling depending on findings.

### 6.1.2 Background information

Region maps with locations of performance monitoring stations as nominated in this report will be supplied. Any changes to monitoring stations will also be noted. These changes may arise from results of campaign monitoring if it is decided that further performance sites are needed.

In addition to the tabular format detailed in the guideline, it is the SA EPA's intent to present the reported data in a graphic format, similar to that of Appendix D, where data is reported against the NEPM standards and goals. Data will be reported from the nominated PMS and a summary of results from regional centres as they are investigated. Site metadata will be included in the report, as well as a data return for each site and pollutant. Historical data that will not be NATA compliant will be included as useful long-term trend indicators; it will be specified as non-compliant data.

### 6.1.3 Annual compliance summary

Compliance with standards and goals as well as annual statistics will be reported as outlined in the guideline (PRC, 2000h).

### 6.1.4 Data analysis

As mentioned in section 3.1.2, actual population exposure to a given pollutant is difficult to determine due to mobility of the population, meteorology, topography, and local emissions. In the longer term, as the monitoring network is developed, it should be possible to report on the representativeness of the site or to develop pollution concentration contours using modelling. This information will not be available in early reports.

## 6.2 Integration of estimation and monitoring tools

The NEPM recognises that direct air monitoring is but one of a suite of tools for evaluating and managing air quality. Clause 11 of the Air NEPM states:

> For the purposes of evaluating performance against the standards the concentration of pollutants in the air:
>
> (a) is to be measured at performance monitoring stations; or
>
> (b) is to be measured by other means that provide information equivalent to measurements that would otherwise occur at a performance monitoring station. (National Environment Protection Council 1998)

These added tools include modelling studies and emissions inventories, each of which can be refined on the basis of results from the others. As stated, the initial design of the expanded Adelaide network has arisen from a modelling study based on data from only two sites. It can be expected that future modelling from the broader base of data will allow refinement of the network. It will also allow interpolation of results between stations and inference of air quality beyond the boundaries of the network.

Inventories provide information on source strengths in both localised areas and across broad regions of the airshed. They provide data that are complementary to monitoring and so aid in assessing air quality and monitoring needs both in metropolitan and regional centres.

The SA EPA is compiling an updated inventory as part of the National Pollutant Inventory (NPI) program, including the collection of some data beyond the requirements of the NPI itself. This compilation must again be seen as a first cut that will be refined with experience over the next few years. Results are summarised in Appendix E. They will be used as an adjunct to monitoring data for input to models, for refinement of the monitoring system, and as a means of targeting air quality management programs to areas where they will be most effective.

Aircraft studies have also provided some broad inventories of emissions calculated from crosswind concentration profiles through the urban plume along the Adelaide foreshore. These studies are discussed in more depth in chapter three.

The SA EPA sees monitoring and the inventory program as the main prongs of its evaluation program initially simply because they are both relatively new and will need time to ‘bed down’. Over the ten-year compliance period, numerical modelling will play an increasing role in unifying programs for air quality management and broadening understanding of air quality in Adelaide.

## 6.3 Collection and handling of data

Air NEPM data will be collected and archived in accordance with draft *Procedures for the Collection and Handling of Monitoring Data for Reporting under the NEPM* (PRC, 2000e) albeit with the following conditions:

- All meteorological parameters will be electronically logged such that incoming data will be scanned at least 180 times every ten minutes as recommended in the Australian Standard AS2923-1987. Currently, the scan rate is every three seconds or 200 times in a ten-minute period. These scans will be used to calculate ten-minute averages, which are then permanently stored. Other continuous data will be scanned every ten seconds.
- The SA EPA has no plans to store shorter-term averages for continuous air pollutant measurements.

- For non-continuous data, such as high-volume samplers or instruments that only record periodically, individual readings along with appropriate information will be stored and used to calculate required averages for reporting for NEPM purposes.
- Ten-minute-average data will be stored to the number of figures indicated in the current procedure of 30 April 2000.
- A database of sites along with metadata is currently being compiled. This database will include Australian map grid references, site description, instrument type, and methodology.

## 6.4 Data security

All recorded data will be archived to the Department's network, which is backed up on a daily basis. Once data is validated, both raw and validated data will also be backed up to CD-ROM or similar appropriate medium. The SA EPA will keep an off-site copy of all raw and validated monitoring data.

# APPENDIX A: SCHEDULES OF THE AIR NEPM MONITORING PROTOCOL[1]

The Air NEPM defines National Environment Protection Standards for the six pollutants specified in schedule 1. The standards are as shown in schedule 2 of the protocol, as an averaging period (column 3) and a maximum (average) concentration (column 4). These values reflect upon exposure as a function not only of concentration of a particular pollutant, but also of the time for which people are exposed to that concentration. This may represent a period over which specific damage to human health has been demonstrated or inferred (e.g. ozone), or a period over which biological indicators such as blood concentrations reach significant equilibrium levels (eg lead, carbon monoxide). The third element is a frequency of allowable exceedences of the standard, shown in column 5, which reflect a potential for cumulative effects of multiple short-term exposures to many pollutants.

Schedule 2 also incorporates a range of definitions stipulating how the averaging periods must be calculated and how other time periods are to be used and specifying how lead must be sampled and measured. These are not detailed here.

Schedule 3 specifies the Australian Standards that define the performance requirements for methods for pollutant monitoring under the Air NEPM. Jurisdictions must demonstrate equivalency of any alternative methods to those included in schedule 3, and also show that the equipment provides equivalent information for assessment purposes.

**Schedule 1: Pollutants**

Pollutants include:

- carbon monoxide
- nitrogen dioxide
- photochemical oxidants (as ozone)
- sulfur dioxide
- lead
- $PM_{10}$.

[1] Appendix A has been downloaded from the NEPC web site.

**Schedule 2: Standards and goals**

| Column 1<br><br>**Item** | Column 2<br><br>**Pollutant** | Column 3<br><br>**Averaging period** | Column 4<br><br>**Maximum concentration** | Column 5<br><br>**Goal within 10 years maximum allowable exceedences** |
|---|---|---|---|---|
| **1** | **Carbon monoxide** | 8 hours | 9.0 ppm | 1 day a year |
| **2** | **Nitrogen dioxide** | 1hour<br>1 year | 0.12 ppm<br>0.03 ppm | 1 day a year<br>none |
| **3** | **Photochemical oxidants (as ozone)** | 1hour<br>4 hours | 0.10 ppm<br>0.08 ppm | 1 day a year<br>1 day a year |
| **4** | **Sulfur dioxide** | 1hour<br>1 day<br>1 year | 0.20 ppm<br>0.08 ppm<br>0.02 ppm | 1 day a year<br>1 day a year<br>none |
| **5** | **Lead (as TSP)** | 1 year | 0.50 µg/m3 | None |
| **6** | **Particles as $PM_{10}$** | 1 day | 50 µ g/m3 | 5 days a year |

**Schedule 3: Australian Standards methods for pollutant monitoring**

| Pollutant | Method Title | Method Number |
|---|---|---|
| **Carbon monoxide** | Determination of carbon monoxide – direct reading instrumental method | AS3580.7.1-1992 |
| **Nitrogen dioxide** | Determination of oxides of nitrogen—chemiluminescence method | AS3580.5.1-1993 |
| **Photochemical oxidants (as ozone)** | Determination of ozone—direct reading instrumental method | AS3580.6.1-1990 |
| **Sulfur dioxide** | Determination of sulfur dioxide—direct reading instrumental method | AS3580.4.1-1990 |
| **Lead** | Determination of particulate lead—high volume sampler gravimetric collection—flame atomic absorption spectrometric method | AS2800-1985 |
| | Determination of total suspended particulate matter—high volume sampler gravimetric method | AS2724.3-1990 |
| **Particles as $PM_{10}$** | Determination of Suspended particulate matter—$PM_{10}$ high volume sampler with size selective inlet—gravimetric method | AS3580.9.6-1990 |
| | Determination of suspended particulate matter—$PM_{10}$ dichotomous sampler—gravimetric method | AS3580.9.7-1990 |

# APPENDIX B: SCREENING PROCEDURES[2]

## B.1 Introduction

According to Clause 14 (3) of the Air NEPM:

> Fewer performance monitoring 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. (National Environment Protection Council 1998)

In order to provide transparent and reasonable criteria by which jurisdictions may evaluate whether 'pollutant levels are reasonably expected to be consistently lower than the standards mentioned in this Measure', the Peer Review Committee (PRC) has considered and documented a range of analyses that could be used. These analyses are called 'screening procedures'.

Screening procedures may be used to:

- reduce the number of performance monitoring sites for a given pollutant below that proposed by the NEPM formula of clause 14(1)
- justify not monitoring a pollutant in regions with a population over 25,000.

It is important to note that the use of screening procedures is limited to the purpose described in clause 14(3) of the Air NEPM. Clause 11(b) is very different in context to clause 14(3). Clause 11(b) provides for the possible use of alternatives to performance monitoring stations in situations where performance monitoring would otherwise occur. In any situation where a jurisdiction employs clause 11(b), it is obliged to report and employ the data generated by the clause 11(b) assessment method in exactly the same way as if a performance monitoring station had been used (see clause 17(2)). For instance, if the clause 11(b) method is modelling, then results of the model (for example, one-hour time series predictions) must be used under clauses 17 and 18 (evaluation and reporting) in the same way that monitoring data would.

As noted above, screening may result in monitoring not taking place in areas where it can be demonstrated that pollutant levels can be reasonably expected to be consistently lower than the NEPM standards. Depending on the methodology employed to evaluate population exposures in unmonitored areas, there is potential for computational bias to be introduced in exposure assessments. To counter or minimise such potential bias, it will be necessary for jurisdictions to identify the area and populations to which the screening applies and the screening level concentration below which concentrations are expected to lie. This information should be documented in monitoring plans and when reporting.

## B.2 Generic types of screening procedures

When consideration of any particular region occurs, it may not be possible to make a determination under clause 14(3) based on a single screening procedure applied to all pollutants. For example, a region with a population of, say, 30,000 might clearly have low levels of $O_3$, $NO_2$, $SO_2$ and Pb, but might experience events which exceed the NEPM standard for $PM_{10}$ due to domestic solid fuel heating or fuel reduction burns.

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[2] Appendix B reproduces National Environment Protection Council Peer Review Committee's guidelines paper no. 4, *Screening procedures*, published on the NEPC web site in November 2000. The format has been slightly changed, however, to reflect its position in Appendix B of this report.

Nevertheless, it is possible to describe generic types of screening procedures and to rank these in terms of the confidence that can be attached to the respective screening determinations. It is then reasonable to formalise the use of screening procedures by setting acceptance limits, generally expressed as percentages of the NEPM standards. These acceptance limits would take account of the confidence attached to the associated screening procedures. Screening would be considered acceptable only if the procedure yielded a prediction of maximum pollutant concentration, which was below the acceptance limit for that procedure. If a procedure with low confidence (large uncertainty) did not predict a maximum concentration below the acceptance limit, a different procedure with higher confidence and higher acceptance limit could be used. This is best explained by examining the generic procedures in tables B.1 to B.3 for the various pollutants.

The screening procedure should allow for trends in projected emissions over five to ten years. This is consistent with the possible schedule for reviewing NEPM plans.

The hierarchy of procedures in tables B.1 to B.3 can be applied to each pollutant in each region within a jurisdiction. Consider, for example, CO in a particular region that, according to clause 14(1), requires three monitoring stations. Full performance monitoring at 3 stations is the default. However, the jurisdiction is permitted to apply any screening procedure in table B.1 as long as the concentration of CO predicted by that procedure is less than the concentration set by the acceptance limit.

In the use of the screening procedures presented in tables B.1 to B.3, the following notes apply.

- The maximum acceptance limit for any screening procedure, no matter how reliable, has been set at 75%. In other words, the PRC considers that if concentrations in excess of 75% of the standard for a pollutant are probable within a region, performance monitoring (or an approved alternative under clause 11(b)) should occur. This is in accord with the intent of clause 14(3).
- To maintain a conservative approach, the maximum predicted or measured concentration should be used for comparison with acceptance limits, even though the NEPM goal may specify a number of exceedences.
- For pollutants which have standards for more than one averaging period, the acceptance limit criteria to be used is that of the standard which is most difficult to meet in any given region. In the majority of cases, this is expected to involve the shortest averaging period.

### B.3 Periodic review of screening determinations

The NEPM does not specify the need for periodical review of determinations under clause 14(3). The PRC recommends that a jurisdiction that has employed a screening procedure to demonstrate that performance monitoring is not required in part or the whole of a region should formally review the validity of the determination at five-yearly intervals thereafter, or sooner if there are indications of a significant upward trend in emissions or concentrations.

**Table B–1: Acceptance limits by screening procedure for carbon monoxide, nitrogen dioxide, sulfur dioxide and lead**

| Screening procedure | Acceptance limit (% of NEPM standard) |
|---|---|
| A. Campaign monitoring at a generally representative upper bound (GRUB) monitoring location (with no significant deterioration expected over 5-10 years) | 55% for 1 year of data<br>60% for 2 or more years of data |
| B. Use of historical data within a region which will contain one or more GRUB monitoring stations to demonstrate that the full number of stations (according to 14(1)) is not required either to detect exceedences or gain a more representative depiction of pollutant distribution | 65% for 2 or more years of data<br>75% for 5 or more years of data |
| C. Use of modelling within a region which will contain one or more GRUB monitoring stations to demonstrate that the full number of stations (according to 14(1)) is not required, either to detect exceedences or gain a more representative depiction of pollutant distribution. | 55% |
| D. In a region with no performance monitoring, use of validated[3] modelling with detailed and reliable estimates of emissions and meteorological data<br>As above in combination with F | 45%<br>50% |
| E. In a region with no performance monitoring, and in the absence of emissions and detailed meteorological data, use of generic model results based on gross emissions estimates, 'worst case' meteorology estimates and other conservative assumptions<br>As above in combination with F | 35%<br>45% |
| F. In a region with no performance monitoring, comparison with a NEPM compliant region with greater population, emissions and pollution potential[4] | 40% |
| G. Use of non-standard monitoring methods, including passive samplers, which have been 'calibrated' against data from performance monitoring stations | This procedure should only be used in support of C, D, E or F, adding say 5% to the respective acceptance limits |

3 Validation means demonstrated satisfactory correlations between observations and predictions in the same or similar airshed.

4 Pollution potential must take into account meteorology and topography.

**Table B–2: Acceptance limits by screening procedure for photochemical oxidants (as ozone)**

| Screening Procedure | Acceptance limit<br>(% of NEPM standard) |
|---|---|
| A. Campaign monitoring at a generally representative upper bound (GRUB) monitoring location (with no significant deterioration expected over 5-10 years) | 70% for 2 or more years<br>75% for 5 or more years |
| B. Use of historical data within a region which will contain one or more GRUB monitoring stations to demonstrate that the full number of stations (according to 14(1)) is not required either to detect exceedences or gain a more representative depiction of pollutant distribution | 78% for 2 or more years<br>82% for 5 or more years |
| C. Use of modelling within a region which will contain one or more GRUB monitoring stations to demonstrate that the full number of stations (according to 14(1)) is not required either to detect exceedences or gain a more representative depiction of pollutant distribution | 70% |
| D. In a region with no performance monitoring, use of validated[5] modelling with detailed and reliable estimates of emissions and meteorological data<br>As above in combination with F | 65%<br>68% |
| E. In a region with no performance monitoring, and in the absence of emissions and detailed meteorological data, use of generic model results based on gross emissions estimates, 'worst case' meteorology estimates and other conservative assumptions<br>As above in combination with F | 58%<br>66% |
| F. In a region with no performance monitoring, comparison with a NEPM compliant region with greater population, emissions and pollution potential[6] | 60% |
| G. Use of non-standard monitoring methods, which have been 'calibrated' against data from performance monitoring stations. | This procedure should only be used in support of C, D, E or F, adding say 5% to the respective acceptance limits |

[5] Validation means demonstrated satisfactory correlations between observations and predictions in the same or similar airshed.

[6] Pollution potential must take into account meteorology and topography.

**Table B–3: Acceptance levels by screening procedure for $PM_{10}$**

| Screening procedure | Acceptance limit (% of NEPM standard) |
|---|---|
| A. Campaign monitoring at a generally representative upper bound (GRUB) monitoring location (with no significant deterioration expected over 5–10 years) | 55% for 1 year of data<br>60% for 2 or more years of data |
| B. Use of historical data within a region which will contain one or more GRUB monitoring stations to demonstrate that the full number of stations (according to 14(1)) is not required either to detect exceedences or gain a more representative depiction of pollutant distribution | 65% for 2 or more years of data<br>75% for 5 or more years of data |
| C. As in B above but using TSP and a conservative assumption about $PM_{10}$:TSP ratios | 70% for 5 or more years of data<br>60% for 2 or more years of data |
| D. In a region with no performance monitoring, comparison with a NEPM compliant region with greater population, emissions and pollution potential[7] | 40% |
| E. Use of non-standard monitoring methods, which have been 'calibrated' against data from performance monitoring stations. | This procedure should only be used in support of C, D, E or F, adding say 5% to the respective acceptance limits |

7 Pollution potential must take into account meteorology and topography.

### B.4 Screening notes for particular pollutants

The PRC has determined screening criteria based on the best professional judgement with information available at the time. It is recognised that these criteria may need to be updated to reflect experience with their application.

#### B.4.1 Carbon monoxide

Jurisdictions may wish to continue to measure CO at a peak CBD site, representing a maximum for traffic-generated CO.

High CO may be associated with wood fires. CO monitors may be required in centres that have wood smoke problems.

Since jurisdictions are likely to have performance monitoring station data from a number of centres, most of which will show CO levels well below the standard, conclusions based on the lower emissions of smaller centres should be quite reliable, without the need to model. Modelling would be complicated by the difficulty in quantifying wood fire emissions. A check should nevertheless be made on the relative frequencies of stable meteorological conditions.

#### B.4.2 Nitrogen dioxide

Wherever ozone is monitored, it is recommended that $NO_x$ also be monitored irrespective of the likely $NO_2$ concentrations. Ozone distributions cannot be interpreted without $NO_x$ data.

Emissions of $NO_x$ within a region can be fairly readily estimated. The time-dependent conversion of $NO_x$ to $NO_2$ and loss of $NO_2$ via surface deposition and chemical reaction are factors which complicate modelling.

A full 3D meteorology/dispersion/chemistry modelling exercise is possible but it is a major undertaking.

A conservative screening modelling approach would be to assume all (or say 50% of) NOx is $NO_2$, ignoring reactions and losses, and simply modelling $NO_2$ dispersion (as a conserved tracer) for a few selected days with adverse meteorological conditions. The model would handle area and point sources (surface and elevated releases). It may be possible to avoid running a model in some cases where a worst case desktop calculation yields an $NO_2$ maxima well under than the NEPM standard.

Passive samplers can be used to measure 24-hour averages of $NO_2$. For general urban emissions there may be a reasonably consistent relationship between 24-hour average and one-hour maximum across populations centres of varying sizes. A combination of passive sampler measurement coincident with continuous monitor measurements in the capital city and a few smaller centres may provide a reliable method of screening via passive sampler alone in yet smaller centres. At the very least, passive sampling would be a useful component of ongoing assessment of a population centre that has been screened out (i.e. by providing long-term trend information).

#### B.4.3 Photochemical oxidants (as ozone)

Determining appropriate screening levels for photochemical oxidants (as ozone) has been made more difficult because the PRC recognises that, in Australia, there is often a substantial background level of ozone. This is formed from the interaction of naturally emitted substances: reactive organic compounds from trees, plants and grasses and oxides of nitrogen from soil and the sea. The PRC agreed that the available Australian evidence points to the background being nowhere lower than about 0.03 ppm. On this basis, it was decided to generate screening percentages for photochemical oxidant by the following procedure.

Use the percentages of table B.1 for the gaseous pollutants with negligible backgrounds and apply these to the *anthropogenic* component of the standard. Thus the percentages of table B.1 were applied to the 0.07 ppm of the one-hour standard assumed to come from human activities and then this was added to the natural background. This result was then reconverted to a percentage of the standard. The same calculations were applied to the four-hour standard resulting in values that were about 3–4 per cent higher. The results were then rounded to the nearest 0, 2, 5 or 8 with preference given to 0 and 5 reflecting the inherent accuracy of the method (see below).

For example, in row F of table B.1, the percentage is 40 %. For row F in table B.2, the value has been determined as the following.

Using the one-hour standard:

40/100 x 0.07 + 0.03 ppm expressed as a percentage of 0.10 ppm. The result is 58%.

Using the four-hour standard:

40/100 x 0.05 + 0.03 ppm expressed as a percentage of 0.08 ppm. The result is 62%.

Thus the value found in table B.2 is 60% —the average in this case.

It should be noted that even though the results are expressed to two significant figures, this does not imply that the screening process has this level of accuracy. The PRC recognises that screening is an imprecise tool that should be used as a guide, not a prescription. Where measured or inferred levels are close to the screening levels presented in the tables, jurisdictions need to be careful in the application so as not to screen out situations which, with a less literal application of the guidelines, should either require monitoring or a stronger justification for its exclusion. This is particularly the case for one-hour ozone levels and table B.2 where more lenient screening criteria have been established to recognise the impact of background levels on four-hour average results.

### B.4.4 Sulfur dioxide

$SO_2$ is relatively easy to assess, since it is almost entirely an industrial emission and reacts only slowly.

Kwinana in the Perth region is a useful example of where procedure C from table B.1 might be applied. Kwinana and surrounds might be considered a sub-region containing all of the region's $SO_2$ emissions and the upper bound site(s). There will be a performance monitoring station downwind of Kwinana which will demonstrate NEPM compliance. The fact that concentrations reduce further downwind will be readily demonstrated by reference to the concentration gradients measured by the existing network of six 'source management' stations and by previously validated Gaussian plume modelling. Lack of $SO_2$ emissions elsewhere in Perth will preclude the need for more than the single Kwinana station. $SO_2$ has been previously monitored at another site in the metropolitan area to confirm that concentrations are very low. This data could be used to support a clause 14(3) assessment.

Passive $SO_2$ samplers provide a useful means of confirming the reduction in $SO_2$ concentration with distance from sources. Data from these samplers are directly applicable to the 24-hour standard but can also be used to confirm the results of a model which produces estimates of both one-hour and 24-hour concentrations.

### B.4.5 Lead

Jurisdictions are likely to want their CBD lead monitoring station to be a performance monitoring station and trend station for the purpose of the NEPM. This is possible under the wording of clause 13(2), given that lead concentrations at the site are well below the NEPM and reducing. Lead levels in suburban areas are likely to be insignificant, a fact which could be confirmed by a brief campaign of monitoring.

Modelling of near-roadside lead could be verified in a few instances by campaign monitoring and thereafter be used as a screening tool. Furthermore, it should be possible to develop simple conservative screening rules based on vehicle kilometres travelled (VKT) per square kilometre and petrol lead content.

### B.4.6 Particles (as $PM_{10}$)

Screening in centres subject to wood fire or prescribed burning smoke is not easy. High wood fire smoke concentrations occur locally under near calm conditions, so total population is not a key determinant. Large prescribed burn plumes impact small and large centres alike over hundreds of kilometres. The values in table B.3 will apply to the fifth highest daily reading, where the higher readings can be shown to be due to bushfires or controlled burning.

High volume samplers are relatively easy to install and operate on a six-day cycle for a year to provide data to support a screening assessment.

If TSP data exists for an area, it can be used to assess the likelihood of $PM_{10}$ exceedences by applying a conservative TSP:$PM_{10}$ ratio.

There are doubts about the use of particle counters for general NEPM measurements, but they may have a place in providing measurements of relative smoke concentration for use in screening. Their use in this role (or for other particle types) would need to be verified against $PM_{10}$ (say TEOM) measurements. Nephelometers might similarly be used as they provide a good surrogate measurement of smoke.

# APPENDIX C: HISTORICAL BACKGROUND, CURRENT MONITORING AND AIR QUALITY

## C.1 Brief History of monitoring in South Australia

Ambient air monitoring was commenced in a very modest way by the Department of Public Health (DPH) in the early seventies. PDH used some traditional passive methods for dust, sulfur dioxide and oxidants; high-volume samplers for total suspended particulate material; and chemical methods and some instruments for carbon monoxide, smoke, sulfur dioxide, non-methane hydrocarbons, oxidants, ozone and nitrogen oxides. Over the next few years, as the department acquired more and better instrumentation, long-term data became available at a range of locations, so that trends could start to be evaluated.

TSP dust and lead monitoring became quite widespread in the Adelaide metropolitan area and at Port Pirie, which had special needs. In urban areas, many of the samplers were located in school grounds along busy roads, with the specific purpose of evaluating the exposure of school children to lead from motor vehicles. In the mid-eighties, a program commenced to upgrade the suite of high-volume samplers and to install size selective inlets for $PM_{10}$, so there are extensive long-term records at several sites for $PM_{10}$, including some with concurrent measurements of both TSP and $PM_{10}$.

Reliable long-term continuous oxidant monitoring has been undertaken at only two suburban sites, but these have been producing data of good quality for the best part of two decades, sufficient for the recent CSIRO/Victorian EPA modelling studies to provide a credible basis for siting monitoring stations in an expanded network.

Sulfur dioxide was monitored for many years in the CBD and metropolitan areas using acid gas bubblers, but it is clear that, because of some of the materials and methods used with those samplers, the data have little credibility. With one exception, no general long-term monitoring of sulfur dioxide was undertaken in the metropolitan area using automated instrumentation, as it was not considered to be a problem. In the mid-eighties, a station was set up in the Christies Beach area, south of Adelaide, to monitor the impact of sulfur dioxide emitted by the PRA Refinery at Port Stanvac. Incidentally, this station also housed a hydrogen sulphide monitor for a period. After several changes of location along the Christies Creek Valley, the station was established at its current position within the grounds of St John's School at Christies Beach.

By contrast, the Air Quality Branch of the DPH (later transferred to the Department for Environment and Planning (DEP)) conducted extensive sulfur dioxide monitoring in the regional centres of Port Pirie and Port Augusta over two decades to monitor the impacts of major industrial sources within those towns. Early work used an auto-analyser method, but this was largely superseded in the late seventies and early eighties by ultraviolet fluorescence instruments.

The DPH undertook some early monitoring of carbon monoxide from a mobile caravan in busy city streets over a period of several years, and some of this data contributed to the establishment of a pedestrian mall along a large section of Rundle Street, a major shopping precinct within the CBD. Since the early eighties, carbon monoxide monitoring has been carried out in Hindley Street, as an indicator of the impact of traffic in a busy city street. This station is still in use, although it required shifting by some fifty metres in 1986 because of the sale of the building in which it was located.

## C.2 Air quality summary

Summary data is presented here for lead, ozone and nitrogen dioxide, Airtrak parameters, sulfur dioxide and carbon monoxide in the Adelaide metropolitan area.

### C.2.1 Oxidants

Section 4.1 of this report includes an acknowledgement that the Airtrak cannot at this time be regarded as a conforming method under schedule three of the protocol, as the instrumentation is still under development as a commercial product. The SA EPA has operated six Airtraks over the last two years at the sites listed in table 4.1. To evaluate their performance, Airtraks were co-located with 'conventional' ultraviolet photometers for ozone and chemiluminescent monitors for nitrogen oxides at some sites. Conventional ozone and nitrogen dioxide data appear in figures C.1 and C.2 for Northfield and Netley. Airtrak data are included in figures C.1 and C.2 also and are presented in figures D.3 to D.5 to provide an expanded context for the SA EPA's air monitoring plan.

The graph shows that exceedences of the National Environment Protection Standard for Ozone (0.08 ppm averaged over four hours) occurred only rarely at Netley and Northfield over a decade or more. Airtrak data are, however, suggestive of more frequent exceedences at other locations (see below).

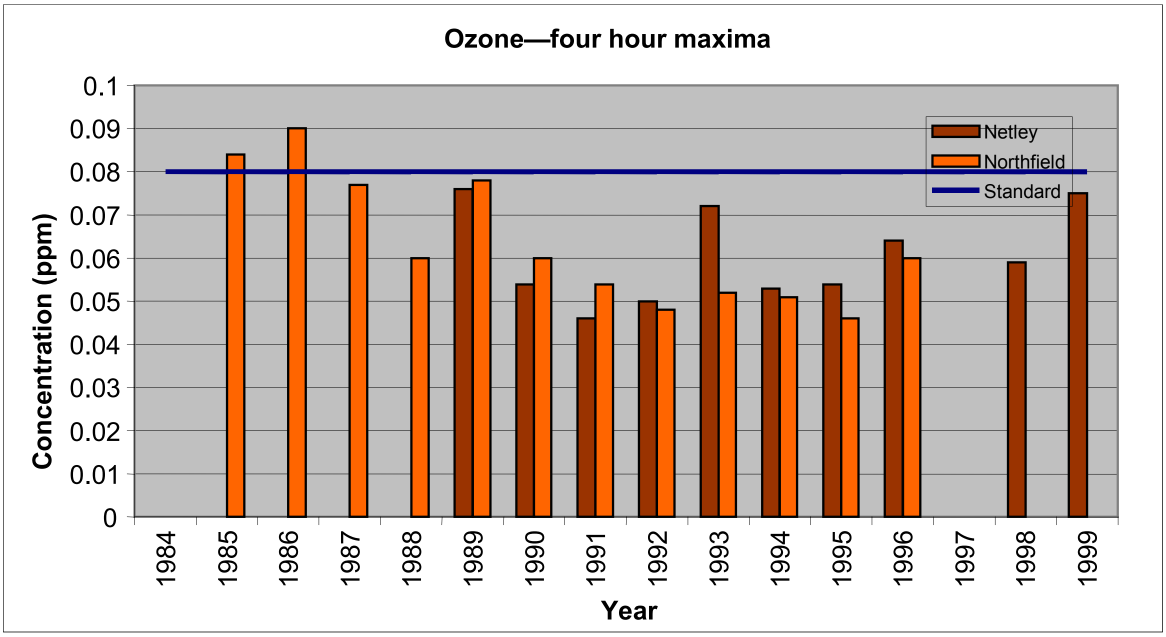


**Figure C–1: Four-hour ozone maxima in metropolitan Adelaide (using ultravioletphotometry to 1996 and Airtrak afterwards)**

### C.2.2 Nitrogen dioxide

Nitrogen dioxide concentrations have generally stayed below the National Environment Protection Standard (0.12 ppm averaged over one hour) at Netley and Northfield. The high levels shown in figure C–2 were attributed to a combination of emissions from an auxiliary gas-fired power station (located at Dry Creek north of the CBD) and particular meteorological conditions. This power station is no longer in continuous use.

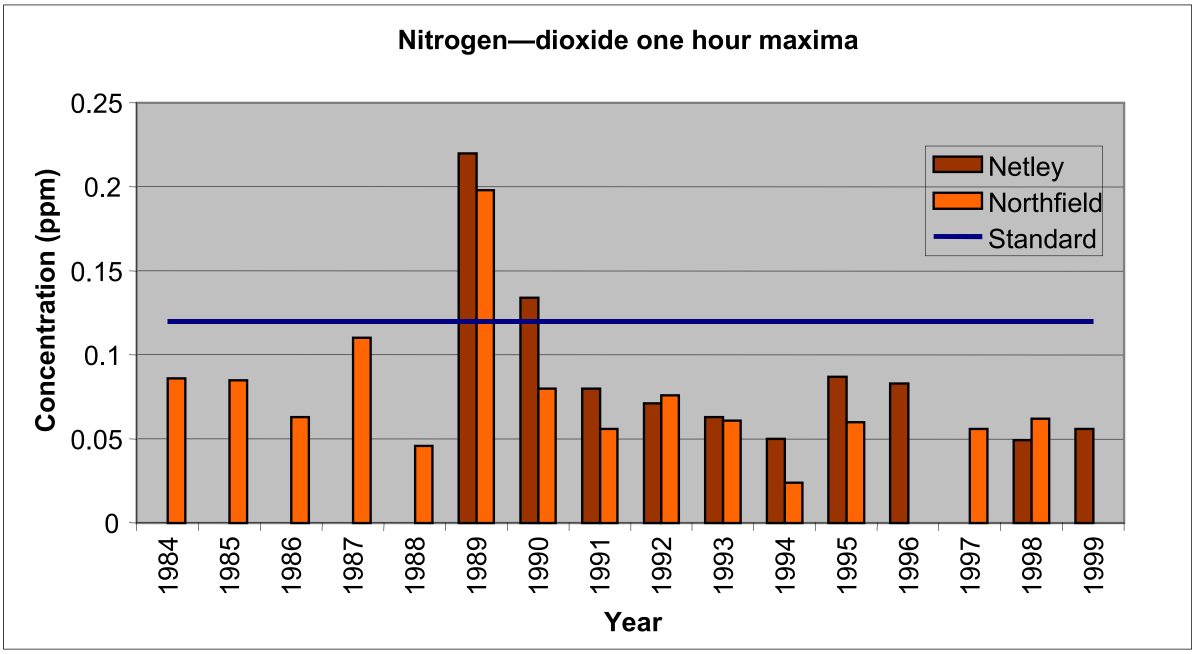


**Figure C–2: One-hour maximum nitrogen dioxide concentrations in metropolitan Adelaide (using the ozone chemiluminescence method until 1996 and Airtrak afterwards)**

### C.2.3 Airtrak parameters

The Airtrak method has been in use in the Adelaide airshed for several years. As noted elsewhere, it is still under development and has undergone testing. It will be replaced with conventional monitors for NEPM monitoring. Ozone and nitrogen dioxide data are presented in figures C.1 to C.5 for Netley and Gawler. These show the potential for significant oxidant formation in the Adelaide airshed during summer months.

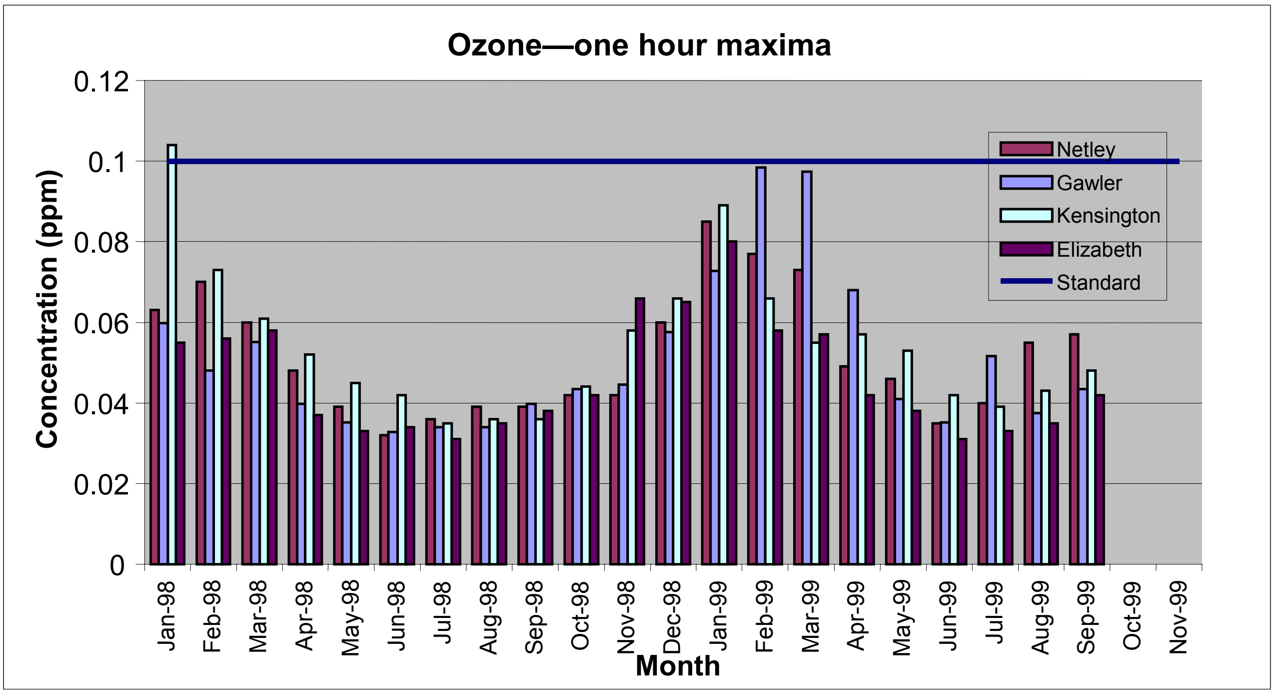


**Figure C–3: One-hour maximum ozone concentrations 1998–9 (Airtrak data)**

**Note**: Data has been corrected. No ozone data were retained from Northfield.

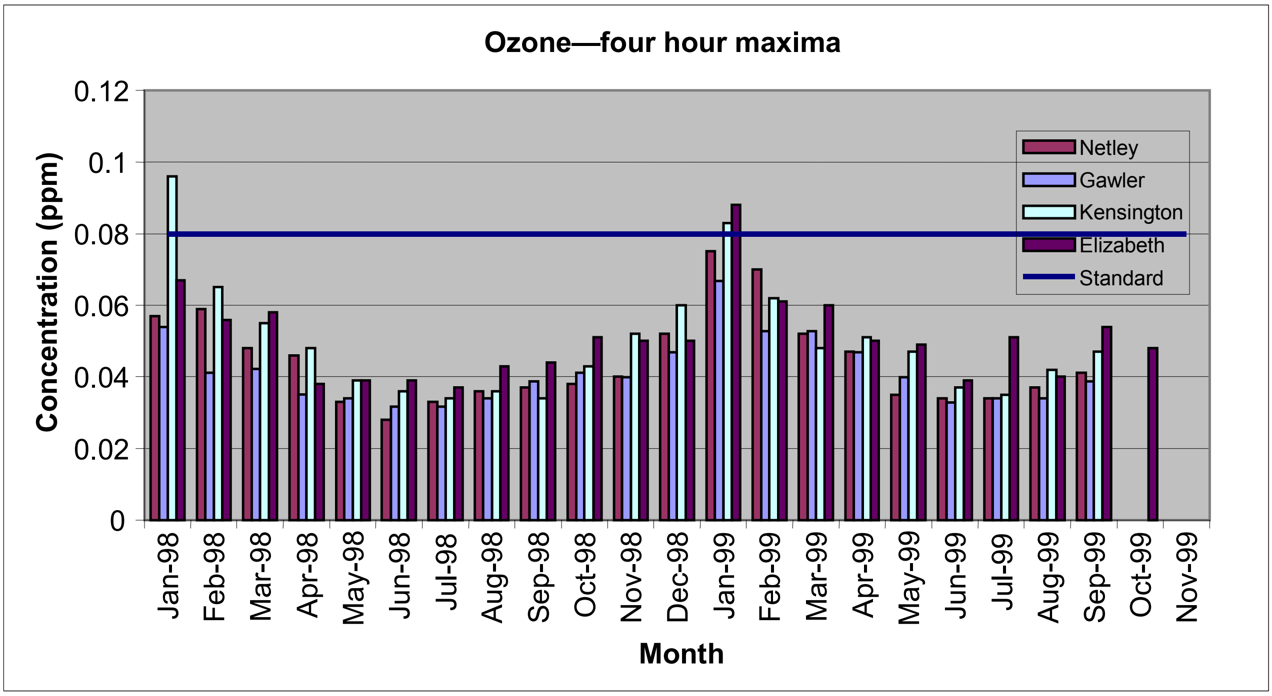


**Figure C–4: Four-hour maximum ozone concentrations 1998–9 (Airtrak data)**

**Note:** Data has been corrected. No ozone data were retained from Northfield.

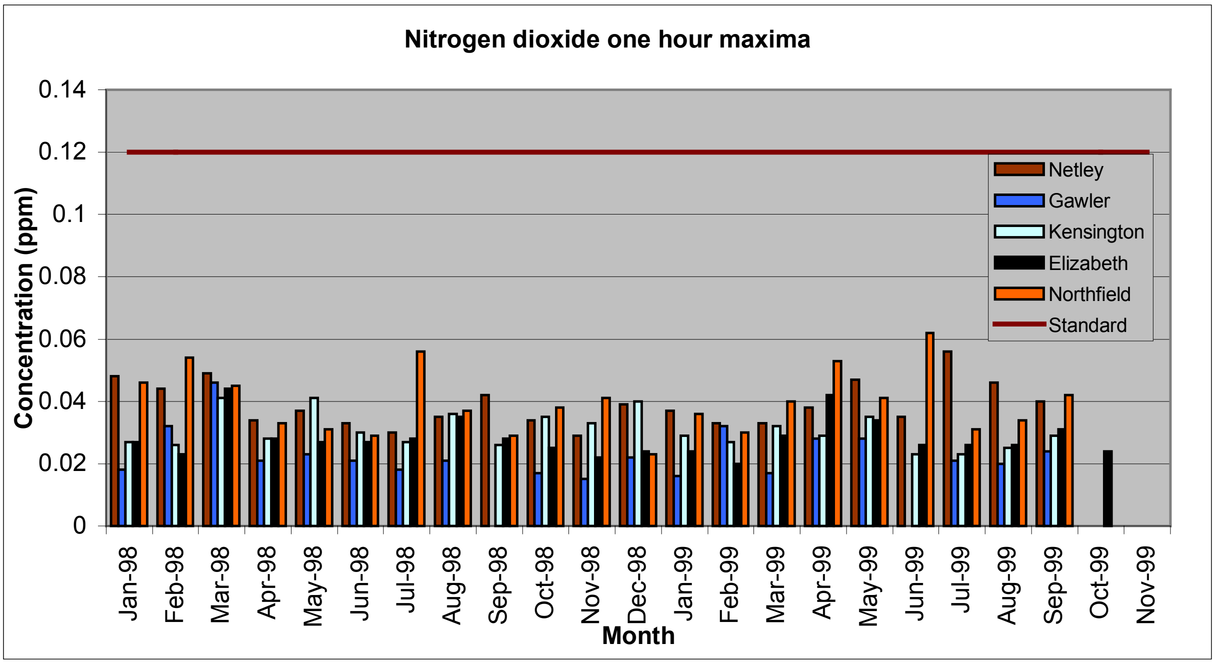


**Figure C–5: Nitrogen dioxide one-hour maxima using Airtrak**

### C.2.4 Carbon monoxide

As noted previously, the SA EPA has long-term monitoring data for only one site, in Hindley Street within the CBD. This site is an area of high traffic density and low traffic flow, so there is a tendency for vehicles to sit under idling conditions for extended periods—particularly on weekends, when there is an influx of patrons to cinemas and clubs in the area. It is also an area that is closed in by tall buildings, which create the familiar canyon effect. Hence, the station has a historical pattern of carbon monoxide concentrations exceeding the National Environment Protection Standard of 9 ppm averaged over eight hours. As might be expected, the pattern is highly seasonal.

The significance of this for human exposure to carbon monoxide is not clear, as it would be difficult to assess the likely time that people might spend in the vicinity. It might well be seen, however, as an index for exposure to other emissions from motor vehicles in the area, such as $PM_{10}$ and $PM_{2.5}$ particles, volatile organics and nitrogen oxides.

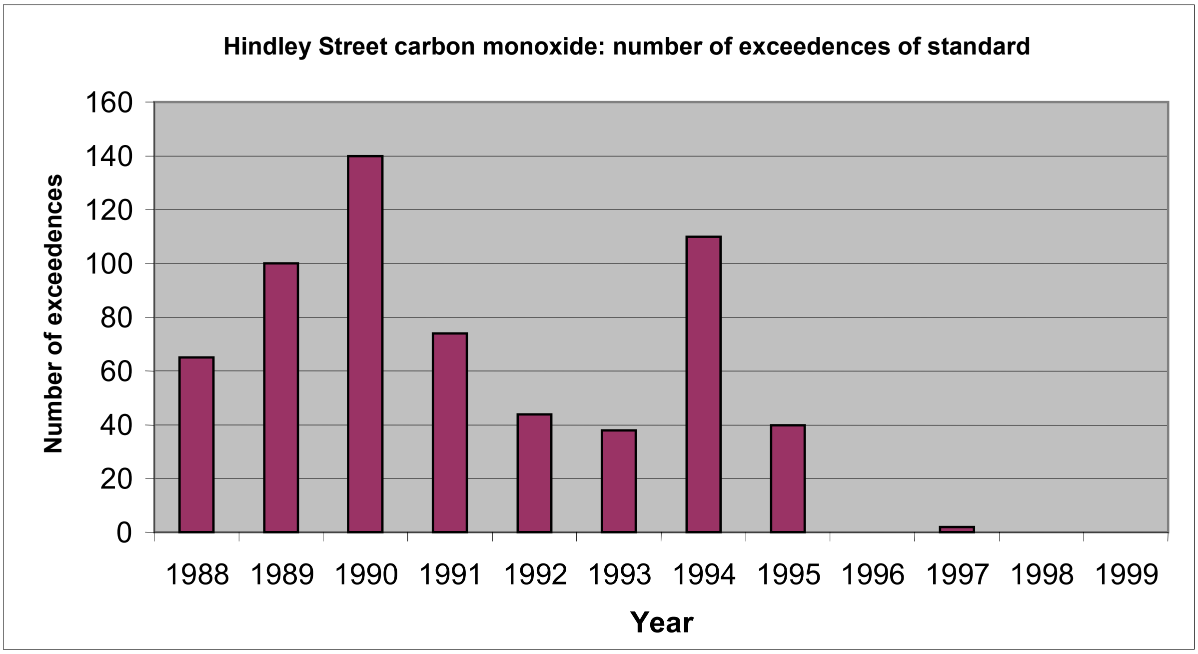


**Figure C–6: Carbon monoxide monitoring—Adelaide CBD**

### C.2.5 Sulfur dioxide

Sulfur dioxide was monitored in Adelaide using the equivalent of *Methods for sampling and analysis of air: determination of acid gases – titrimetric method* (AS3580-1-1990) for a number of years at multiple sites. With the introduction of natural gas, levels declined and, since only low levels were being measured in Adelaide, the monitoring was discontinued in 1986. Campaign monitoring has been conducted in regional centres. Currently, the SA EPA is monitoring adjacent to the Port Stanvac oil refinery and has been since 1992. Exceedences of the NEPM standard can be associated with plant difficulties. The results of this monitoring are shown in figures D.7a–d. Further campaign monitoring will be conducted both in regional centres and in the Adelaide airshed to determine the ongoing need for monitoring this pollutant.

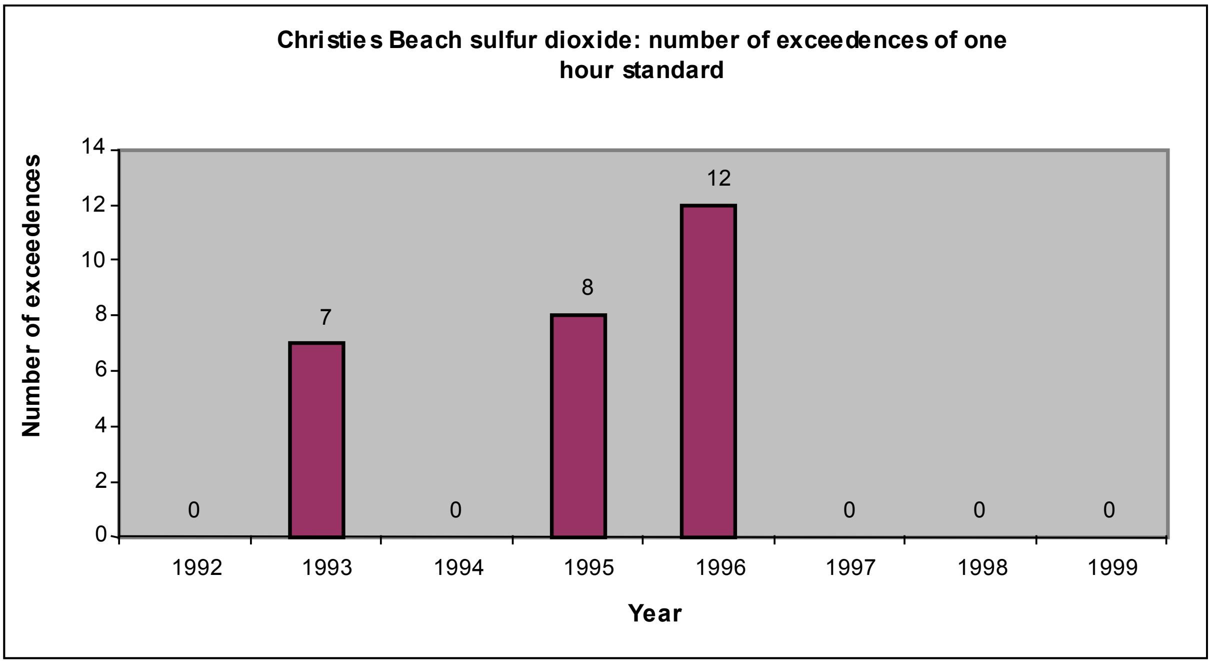


**Figure C–7a: Sulfur dioxide monitoring at Christies Beach—number of exceedences on one-hour standard**

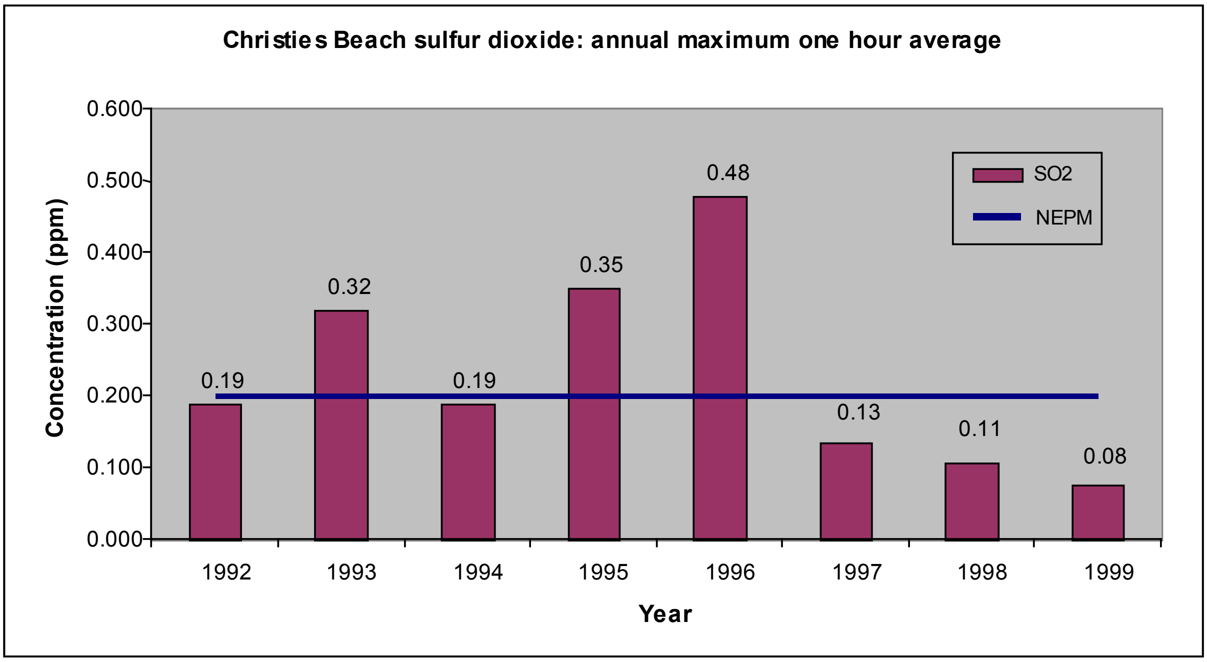


**Figure C–7b: Sulfur dioxide monitoring at Christies Beach—annual maximum one-hour average**

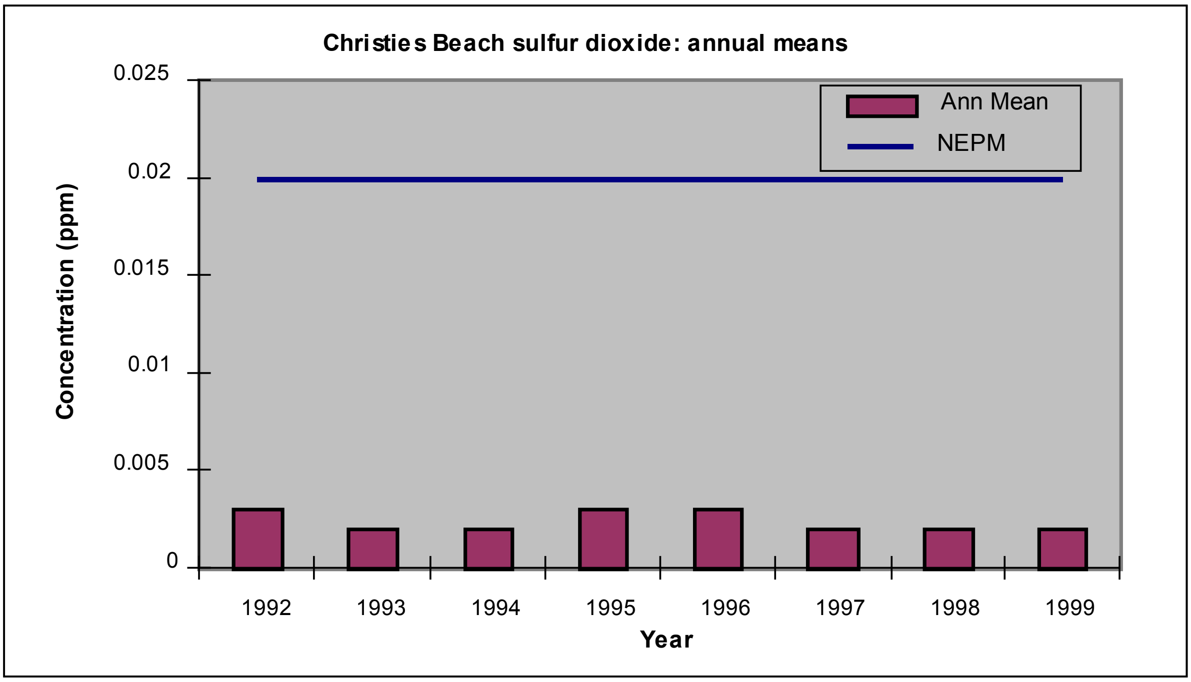


**Figure C-7c: Sulfur dioxide monitoring at Christies Beach—annual means**

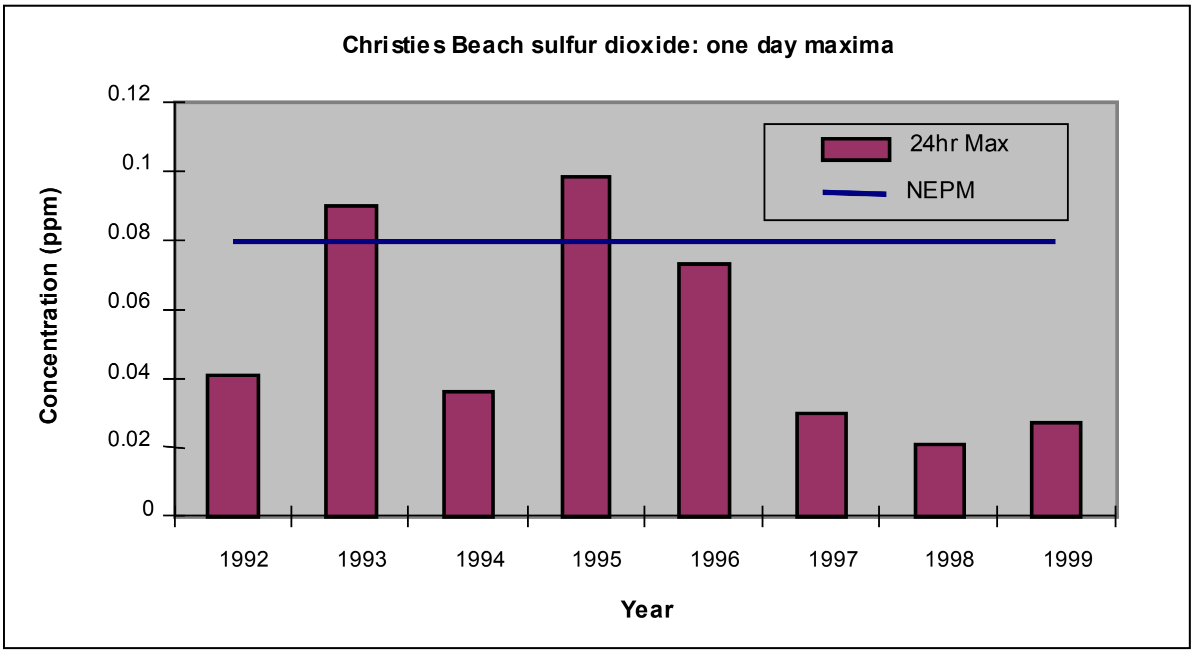


**Figure C–7d: Sulfur dioxide monitoring at Christies Beach—one-day maxima**

### C.2.6 Particles

Historically, $PM_{10}$ particle concentrations have not generally exceeded the NEPM standard (50 µg/m$^3$) for more than the specified five days per year in suburban Adelaide, as shown in figures C–8a–d. There have been exceptions, however, particularly in industrial areas such as Osborne (figure C–8c). Weather conditions would obviously have a significant effect on dust levels around the Adelaide airshed, particularly in dry years, although it is rare for the standard to be exceeded for more than six days at any site in a given year. Figures C–8a–d show $PM_{10}$ monitoring in metropolitan Adelaide at Port Adelaide, Thebarton, Osborne and Gilles Plains sites. Figures C–8e–g show $PM_{10}$ monitoring in the Spencer Region.

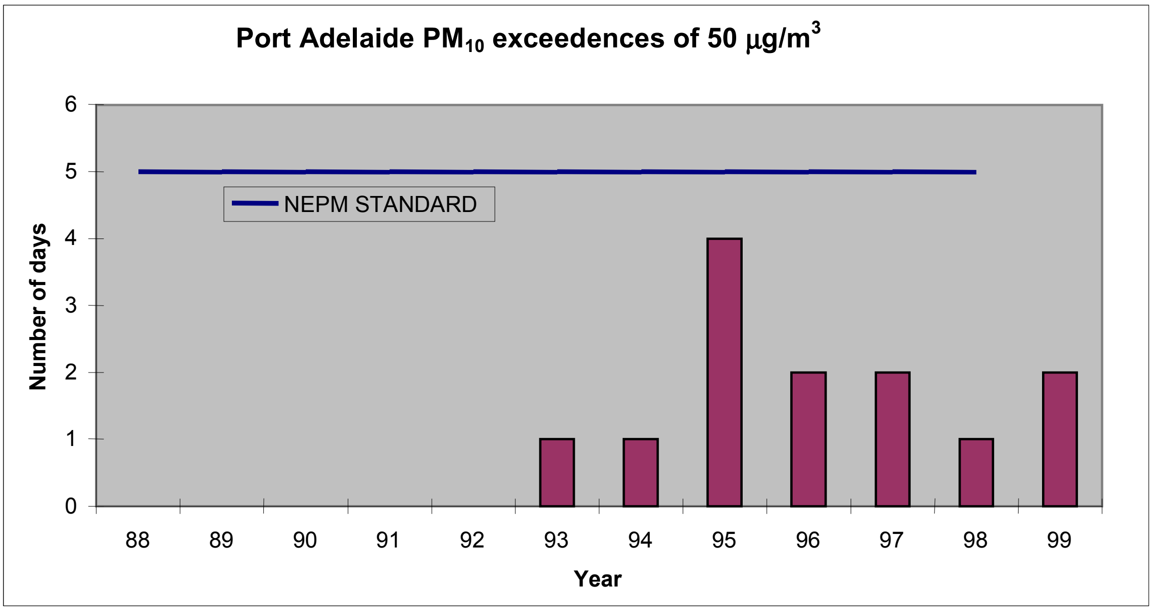


**Figure C–8a: Port Adelaide $PM_{10}$ exceedences of 50 µg/m$^3$ (monitoring commenced 1992)**

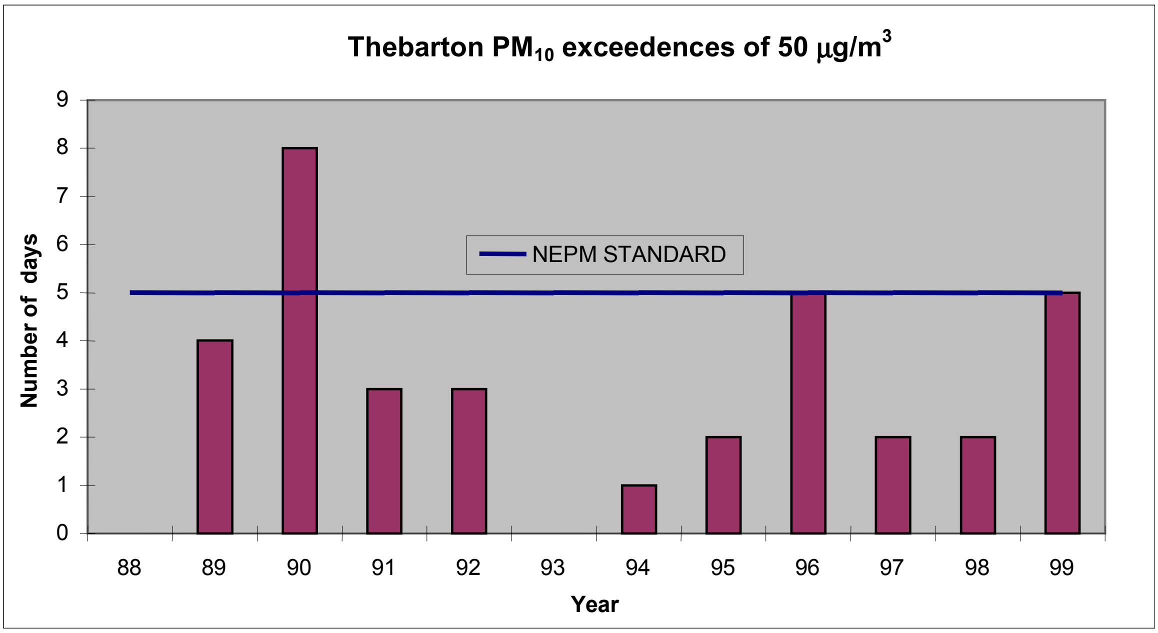


**Figure C–8b: Thebarton $PM_{10}$ exceedences of 50 µg/m$^3$**

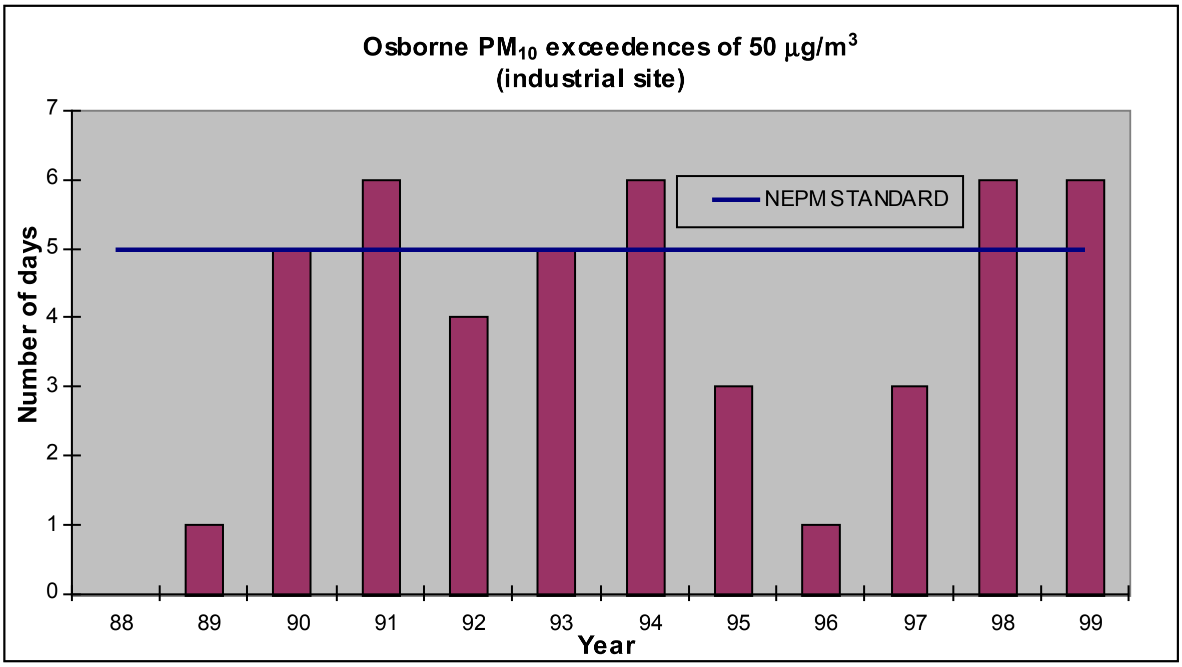


**Figure C–8c:** **Osborne $PM_{10}$ exceedences of 50 $\mu g/m^3$ (industrial site)**

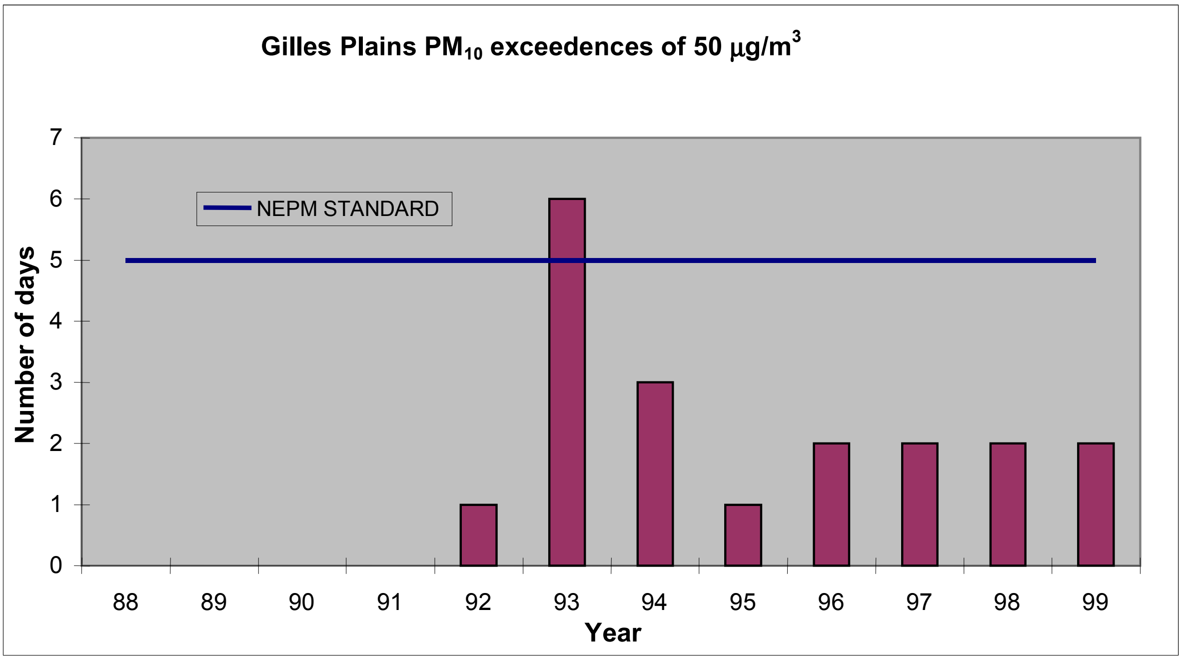


**Figure C–8d:** **Gilles Plains $PM_{10}$ exceedences of 50 $\mu g/m^3$ (monitoring commenced 1992)**

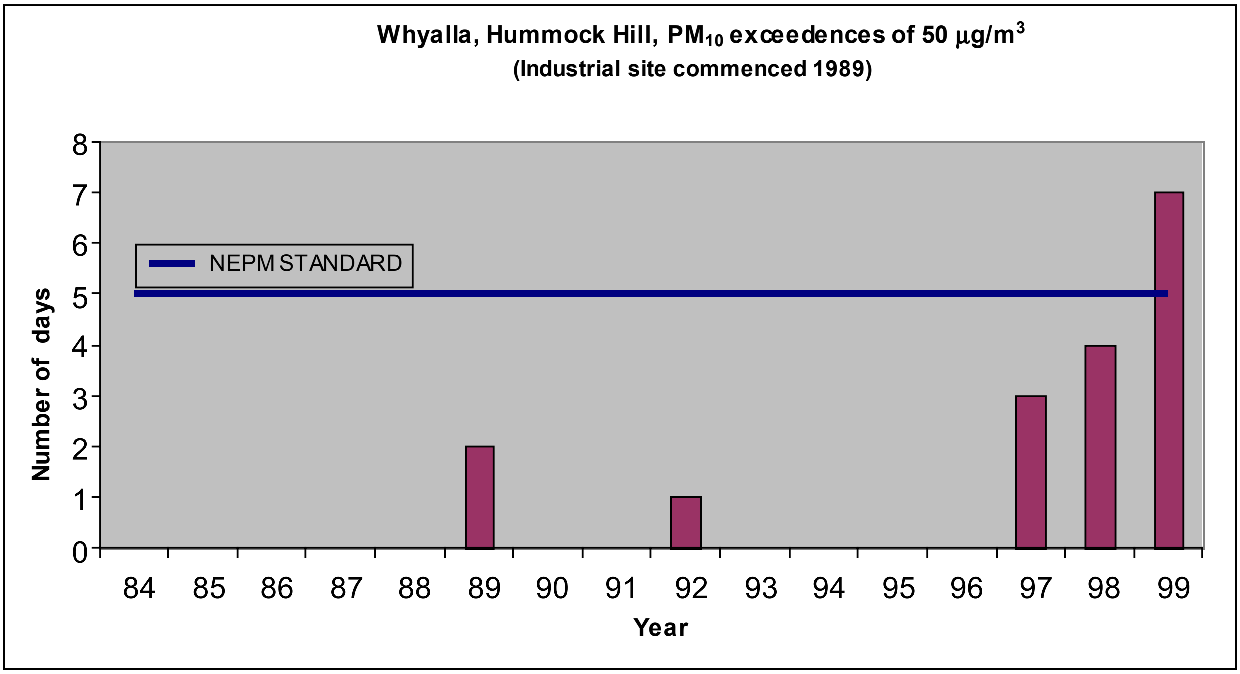


**Figure C–8e: Whyalla $PM_{10}$ monitoring**

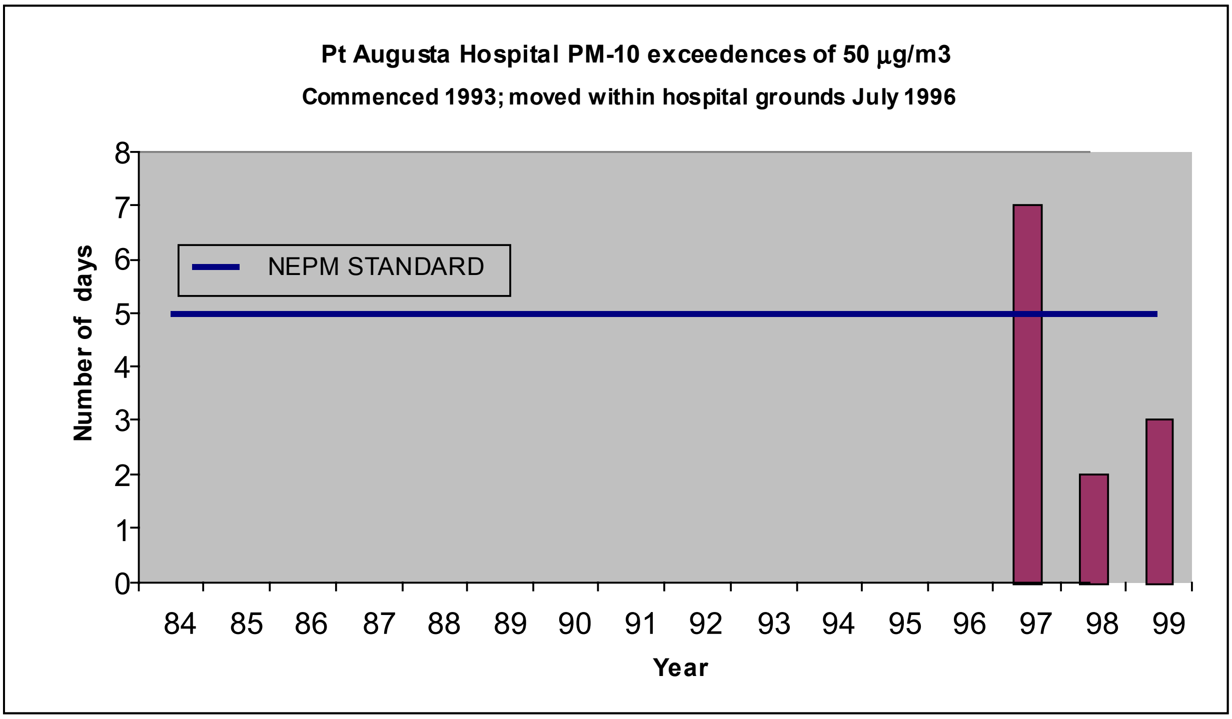


**Figure C–8f: Port Augusta $PM_{10}$ monitoring**

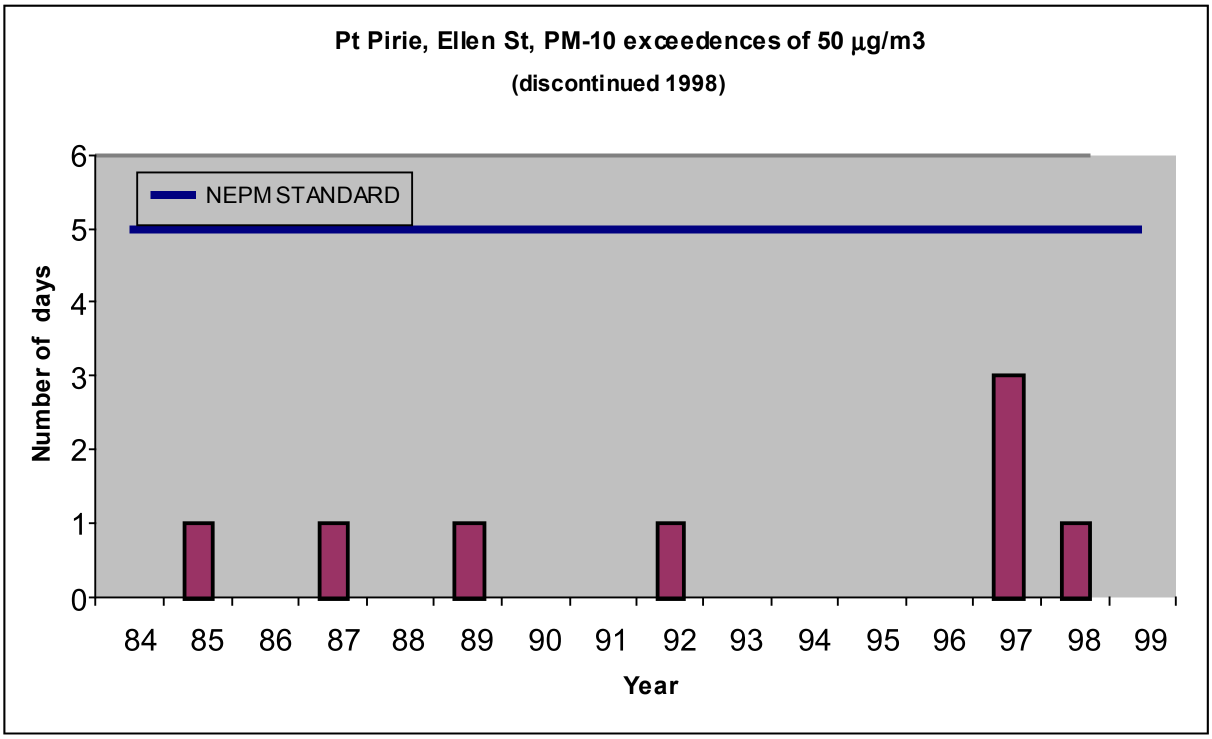


**Figure C–8g: Port Pirie $PM_{10}$ monitoring**

### C.2.7 Lead

Lead concentrations have exceeded the National Environment Protection Standard (0.5 µg/m³ annual average) by quite large margins in several locations around metropolitan Adelaide. As applies elsewhere in Australia, however, measured concentrations have reduced markedly, in line with reductions in the lead content of petrol and the phase-out of leaded petrol from the market, and are now generally below 0.5 µg/m³. The South Australian vehicle fleet still includes a proportion of pre-1986 petrol-fuelled cars, so that leaded petrol still amounts to a significant part of the market, as shown in figure C–9. Results of lead monitoring in the Adelaide metropolitan area are summarised graphically in figure C–10.

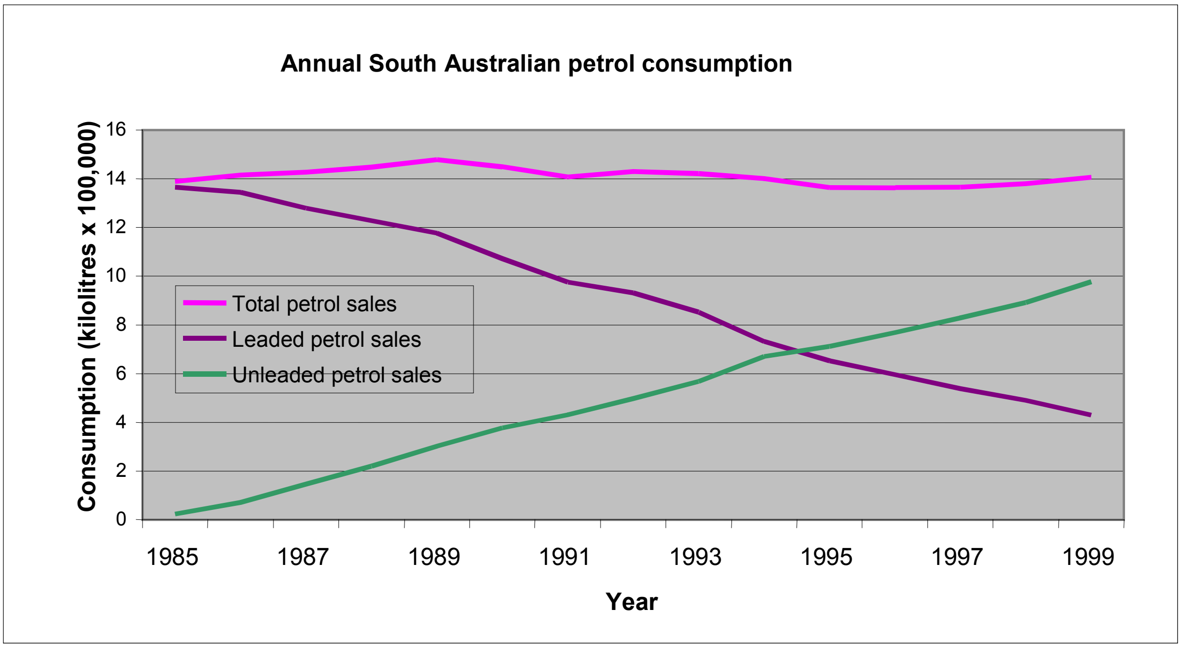


**Figure C–9: Trends in annual petrol consumption and associated lead emissions in South Australia**

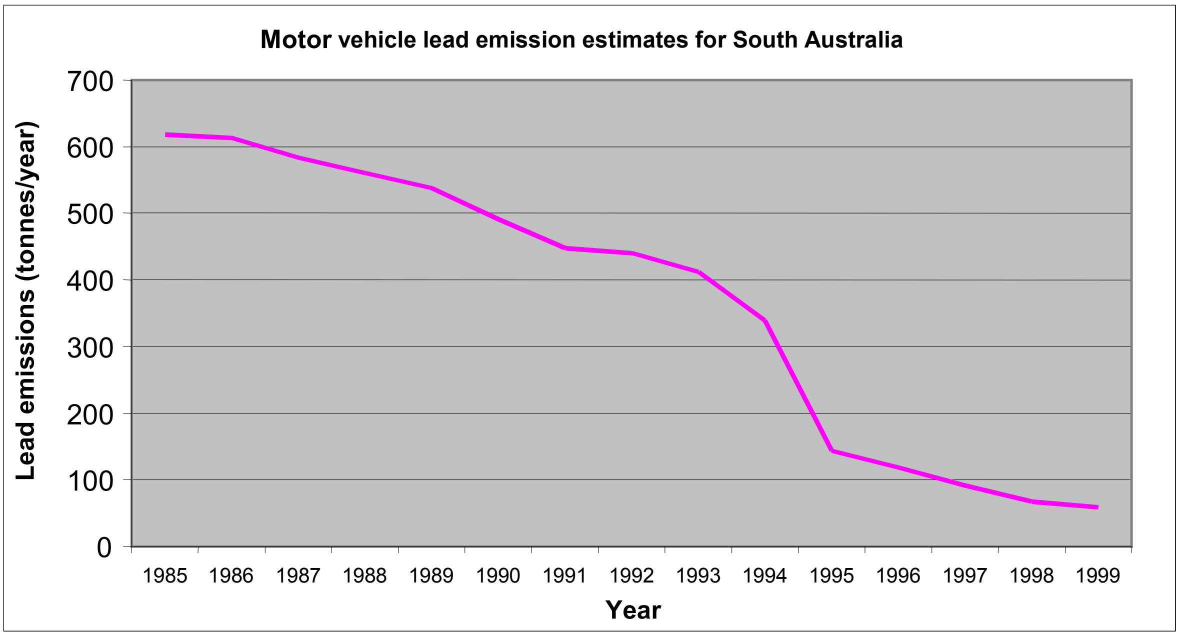


**Figure C–10a: TSP vehicle lead emission estimates for South Australia**

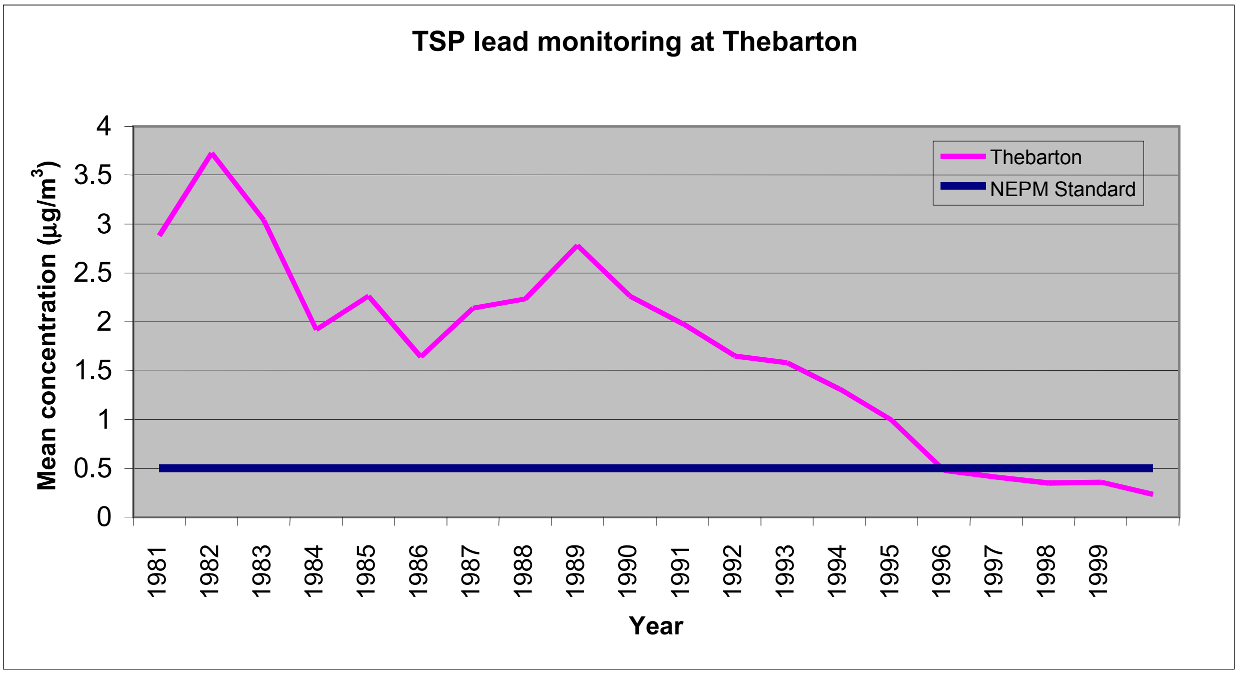


**Figure C–10b: TSP lead monitoring at Thebarton**

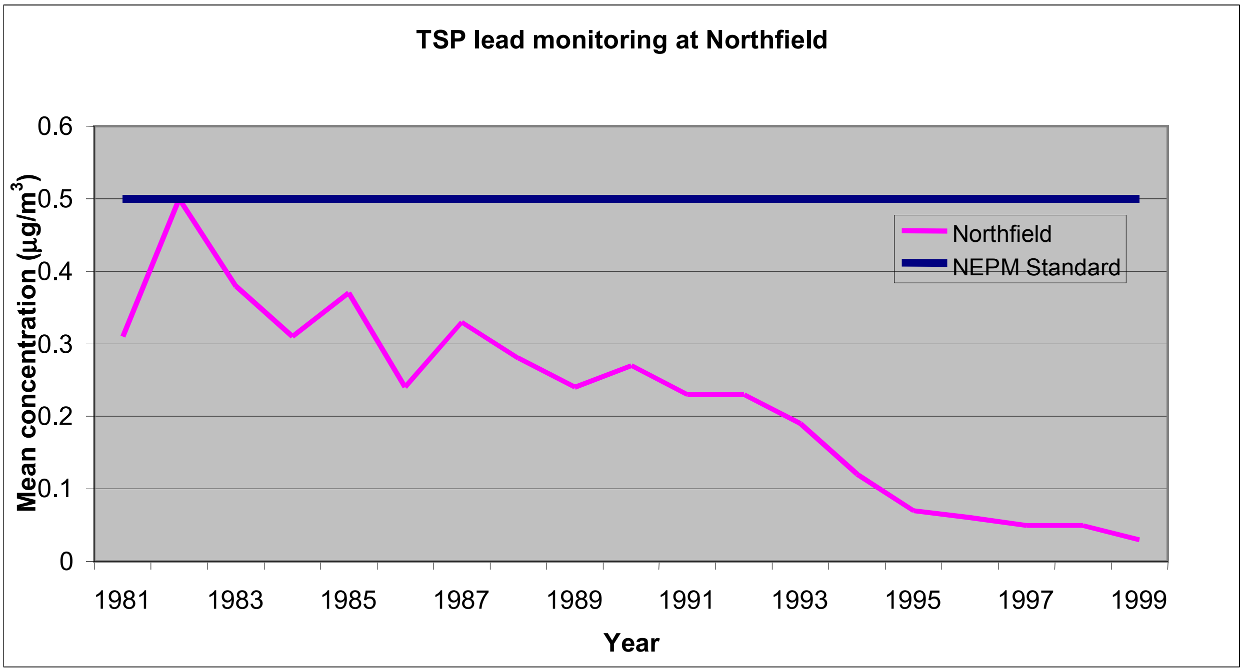


**Figure C–10c: TSP lead monitoring at Northfield**

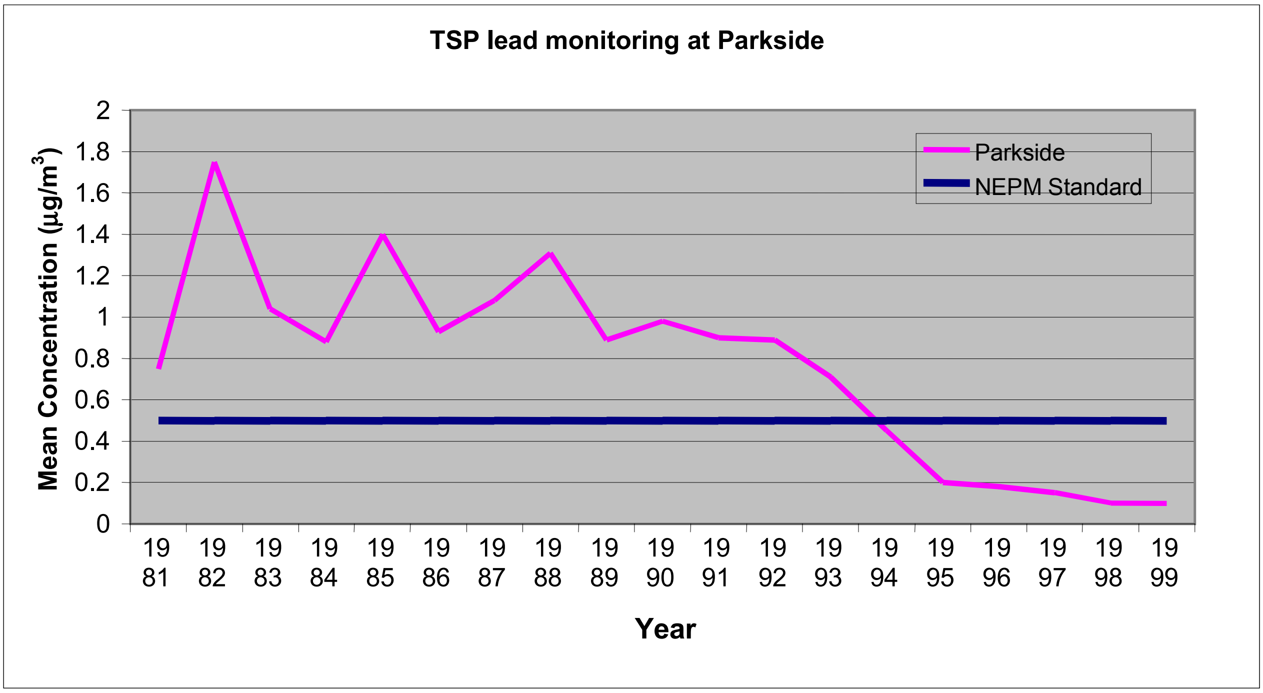


**Figure C–10d: TSP lead monitoring at Parkside**

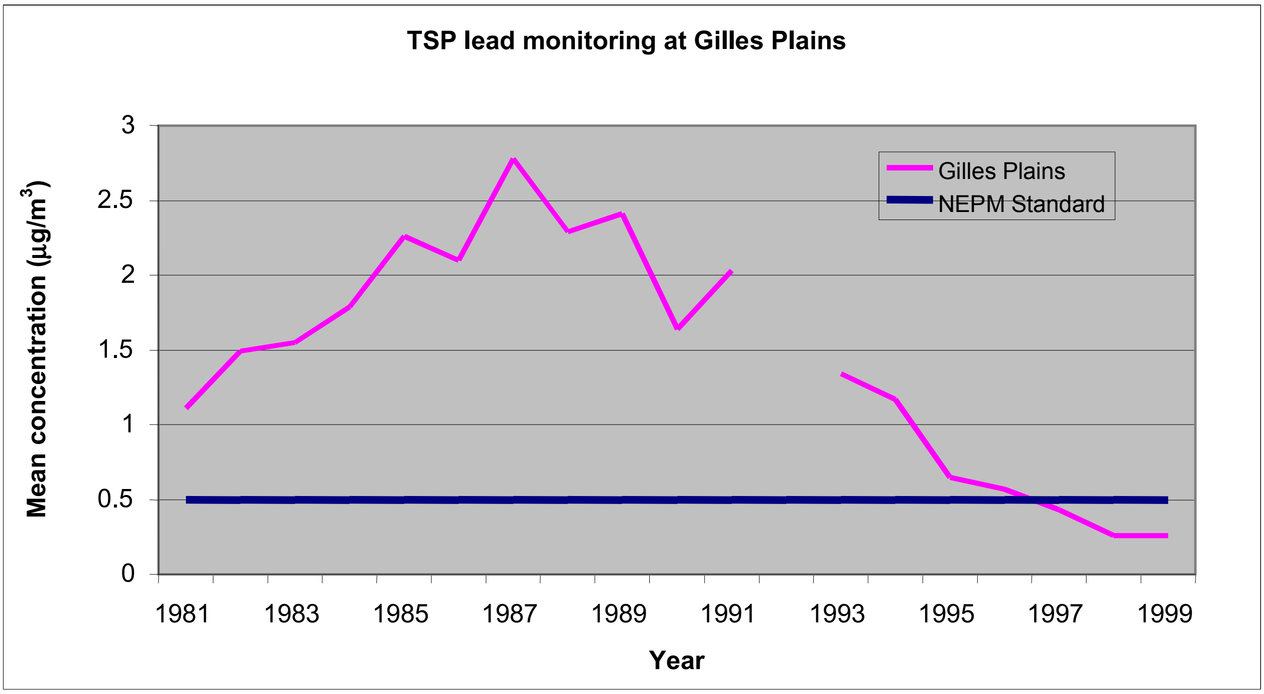


**Figure C–10e: TSP lead monitoring at Gilles Plains**

# APPENDIX D: EMISSIONS INVENTORY

## D.1 Emissions in regional centres

There is little inventory information at this stage for regional centres in South Australia. The NPI program is in the process of capturing and collating information on the 36 chemicals and classes included in the NPI Reporting List in the regional centres cited in this report. Much of this information will become available over the next year.

## D.2 Emissions in the Adelaide Region

The relevant available data from aircraft and NPI studies have been summarised below.

**Table D–1: Annual inventory estimates from the NPI for the metropolitan Adelaide region†**

| Source | Carbon monoxide | | Nitrogen oxides | | Sulfur dioxide | | Total VOC | | Lead and compounds | | $PM_{10}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $kgx10^6$ | % | $kgx10^6$ | % | $kgx10^6$ | % | $kgx10^6$ | % | $kgx10^6$ | % | $kgx10^6$ | % |
| **TOTAL ($kgx10^6$/yr)** | 170 | | 30 | | 3.9 | | 40 | | 0.063 | | 11 | |
| Motor vehicles | 140 | 84.5 | 20 | 68.1 | 1.2 | 30.8 | 18 | 44.4 | 0.034 | 53.0 | 0.98 | 8.7 |
| Other mobile sources‡ | 1.3 | 0.7 | 1.2 | 4.0 | 0.39 | 10.0 | 0.16 | 0.4 | 0.00093 | 1.5 | 0.21 | 1.9 |
| Facilities | 4.7 | 2.7 | 7.8 | 26.2 | 2.2 | 57.5 | 3.1 | 7.7 | 0.00048 | 0.8 | 2.9 | 25.9 |
| Domestic solid fuel combustion | 15 | 8.7 | 0.18 | 0.6 | 0.060 | 1.5 | 6.0 | 15.0 | 0.000058 | <0.1 | 1.5 | 13.3 |
| Domestic gaseous fuel combustion | 0.13 | <0.1 | 0.30 | 1.0 | 0.0016 | <0.1 | 0.017 | <0.1 | 0.0000017 | <0.1 | 0.024 | 0.2 |
| Domestic & commercial solvents* | | | | | | | 9.5 | 23.7 | | | | |
| Lawn mowing | 5.6 | 3.3 | 0.023 | <0.1 | 0.0046 | 0.1 | 1.9 | 4.7 | 0.00035 | 0.6 | 0.046 | 0.4 |
| Road related** | | | | | | | 0.059 | 0.1 | 0.028 | 44.1 | 5.6 | 49.6 |
| Service stations | | | | | | | 1.6 | 4.0 | 0.00000041 | <0.1 | | |
| **Calculated total emission rate (kg/s)** | | 5.4 | | 0.94 | | 0.12 | | 1.3 | | 0.0020 | | 0.36 |

† Emissions represented to two significant figures ($kgx10^6$/yr)

‡ Includes aircraft, railways, recreational boating and commercial shipping

* Includes dry cleaners, domestic and commercial solvents, architectural surface coatings, printers and motor vehicle refinishers

** Includes paved roads and road resurfacing (cutback bitumen)

**Table D–2: Emission inventory estimates for metropolitan Adelaide from aircraft measurements compared with NPI values**

| Pollutant | Nitrogen oxides | Carbon dioxide | Methane | Carbon monoxide | Non-methane hydrocarbons |
|---|---|---|---|---|---|
| Emission rate (kg/s)<br>Clark, et al, 1999 | 0.1–0.4 | 155–180 | 0.5–0.9 | 3.5–4.2 | 0.4–0.5 |
| Calculated NPI rate (kg/s) | 0.8 | | | 7.3 | 1.0 |

**Table D–3: Annual inventory estimates from the NPI for the Mount Gambier Region†**

| Source | Carbon monoxide | | Nitrogen oxides | | Sulfur dioxide | | Total VOC | | Lead and compounds | | $PM_{10}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kgx10⁶ | % | kgx10⁶ | % | kgx10⁶ | % | kgx10⁶ | % | kgx10⁶ | % | kgx10⁶ | % |
| **TOTAL (kgx10⁶/yr)** | 13 | | 1.4 | | 0.26 | | 2.1 | | 0.0033 | | 1.0 | |
| Motor vehicles | 6.1 | 48.5 | 0.98 | 69.3 | 0.033 | 13.0 | 0.79 | 36.9 | 0.0016 | 48.4 | 0.029 | 2.8 |
| Other mobile sources‡ | 0.12 | 1.0 | 0.0018 | 0.1 | 0.00017 | <0.1 | 0.019 | 0.9 | 0.000028 | 0.8 | 0.0043 | 0.4 |
| Facilities | 3.7 | 29.7 | 0.39 | 27.6 | 0.22 | 84.8 | 0.12 | 5.6 | 0.000048 | 1.5 | 0.45 | 44.2 |
| Domestic solid fuel combustion | 2.2 | 17.5 | 0.028 | 2.0 | 0.0053 | 2.1 | 0.69 | 32.2 | 0.0000039 | 0.1 | 0.21 | 20.7 |
| Domestic gaseous fuel combustion | 0.0033 | <0.1 | 0.012 | 0.8 | 0.000032 | <0.1 | 0.00047 | <0.1 | 0.00000012 | <0.1 | 0.00064 | <0.1 |
| Domestic & commercial solvents* | | | | | | | 0.33 | 15.5 | | | | |
| Lawn mowing | 0.42 | 3.3 | 0.0021 | 0.1 | 0.00034 | 0.1 | 0.12 | 5.6 | 0.000025 | 0.8 | 0.0029 | 0.3 |
| Road related** | | | | | | | 0.0094 | 0.4 | 0.0016 | 48.3 | 0.32 | 31.5 |
| Service stations | | | | | | | 0.060 | 2.8 | 0.000000015 | <0.1 | | |
| **Calculated total emission rate (kg/s)** | 0.40 | | 0.045 | | 0.0082 | | 0.068 | | 0.00010 | | 0.032 | |

† Emissions represented to two significant figures (kgx10⁶/yr)

‡ Includes aircraft, recreational boating and commercial shipping

* Includes dry cleaners, domestic and commercial solvents, architectural surface coatings, printers and motor vehicle refinishers

** Includes paved roads and road resurfacing (cutback bitumen)

**Table D–4: Annual inventory estimates from the NPI for the Barossa Region†**

| Source | Carbon monoxide | | Nitrogen oxides | | Sulfur dioxide | | Total VOC | | Lead and compounds | | $PM_{10}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kgx$10^6$ | % | kgx$10^6$ | % | kgx$10^6$ | % | kgx$10^6$ | % | kgx$10^6$ | % | kgx$10^6$ | % |
| **TOTAL (kgx$10^6$/yr)** | 4.2 | | 1.6 | | 0.026 | | 0.87 | | 0.0020 | | 1.5 | |
| Motor vehicles | 2.9 | 68.7 | 0.43 | 26.7 | 0.014 | 51.9 | 0.36 | 40.8 | 0.00072 | 36.2 | 0.012 | 0.8 |
| Other mobile sources‡ | 0.0049 | 0.1 | 0.039 | 2.4 | 0.0017 | 6.4 | 0.0017 | 0.2 | 0.000000027 | <0.1 | 0.00091 | <0.1 |
| Facilities | 0.29 | 7.0 | 1.1 | 70.0 | 0.0089 | 33.7 | 0.015 | 1.8 | 0.000029 | 1.5 | 1.18 | 77.4 |
| Domestic solid fuel combustion | 0.84 | 20.2 | 0.011 | 0.7 | 0.0020 | 7.6 | 0.26 | 29.7 | 0.0000015 | <0.1 | 0.082 | 5.4 |
| Domestic gaseous fuel combustion | 0.00031 | <0.1 | 0.0023 | 0.1 | 0.000000019 | <0.1 | 0.000049 | <0.1 | 0.000000033 | <0.1 | 0.000066 | <0.1 |
| Domestic & commercial solvents* | | | | | | | 0.17 | 19.4 | | | | |
| Lawn mowing | 0.16 | 3.9 | 0.00079 | <0.1 | 0.00013 | 0.5 | 0.046 | 5.3 | 0.000010 | 0.5 | 0.0011 | <0.1 |
| Road related** | | | | | | | 0.0027 | 0.3 | 0.0012 | 61.7 | 0.25 | 16.3 |
| Service stations | | | | | | | 0.023 | 2.6 | 0.0000000060 | <0.1 | | |
| **Calculated total emission rate (kg/s)** | 0.13 | | 0.052 | | 0.00084 | | 0.028 | | 0.000063 | | 0.050 | |

† Emissions represented to two significant figures (kgx$10^6$/yr)

‡ Includes railway

* Includes dry cleaners, domestic and commercial solvents, architectural surface coatings, printers and motor vehicle refinishers

** Includes paved roads and road resurfacing (cutback bitumen)

**Table D–5: Annual inventory estimates from the NPI for the Spencer Gulf area[†]**

| Source | Carbon monoxide | | Nitrogen oxides | | Sulfur dioxide | | Total VOC | | Lead and compounds | | $PM_{10}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kgx10⁶ | % | kgx10⁶ | % | kgx10⁶ | % | kgx10⁶ | % | kgx10⁶ | % | kgx10⁶ | % |
| **TOTAL (kgx10⁶/yr)** | 112 | | 22 | | 61 | | 3.2 | | 0.032 | | 4.6 | |
| Motor vehicles | 8.2 | 7.3 | 2.1 | 9.8 | 0.053 | <0.1 | 1.2 | 36.6 | 0.0024 | 7.5 | 0.046 | 1.0 |
| Other mobile sources[‡] | 0.57 | 0.5 | 0.57 | 2.6 | 0.26 | 0.4 | 0.14 | 4.4 | 0.000063 | 0.2 | 0.049 | 1.1 |
| Facilities | 100 | 88.5 | 19 | 87.4 | 61 | 99.5 | 0.021 | 0.6 | 0.028 | 89.1 | 4.0 | 86.6 |
| Domestic solid fuel combustion | 3.3 | 2.9 | 0.042 | 0.2 | 0.0080 | <0.1 | 1.00 | 31.0 | 0.0000058 | <0.1 | 0.32 | 6.9 |
| Domestic gaseous fuel combustion | 0.0035 | <0.1 | 0.014 | <0.1 | 0.000030 | <0.1 | 0.00050 | <0.1 | 0.00000016 | <0.1 | 0.00069 | <0.1 |
| Domestic & commercial solvents* | | | | | | | 0.45 | 14.0 | | | | |
| Lawn mowing | 0.88 | 0.8 | 0.0024 | <0.1 | 0.00073 | <0.1 | 0.340 | 10.5 | 0.000056 | 0.2 | 0.0086 | 0.2 |
| Road related** | | | | | | | 0.0057 | 0.2 | 0.00096 | 3.0 | 0.19 | 4.2 |
| Service stations | | | | | | | 0.086 | 2.7 | 0.000000022 | <0.1 | | |
| **Calculated total emission rate (kg/s)** | 3.6 | | 0.69 | | 1.9 | | 0.10 | | 0.0010 | | 0.15 | |

† Emissions represented to two significant figures (kgx10⁶/yr)

‡ Includes aircraft, railways, recreational boating and commercial shipping

* Includes dry cleaners, domestic and commercial solvents, architectural surface coatings, printers and motor vehicle refinishers

** Includes paved roads and road resurfacing (cutback bitumen)

**Table D–6: Annual inventory estimates from the NPI for the Riverland region†**

| Source | Carbon monoxide | | Nitrogen oxides | | Sulfur dioxide | | Total VOC | | Lead and compounds | | $PM_{10}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kgx$10^6$ | % | kgx$10^6$ | % | kgx$10^6$ | % | kgx$10^6$ | % | kgx$10^6$ | % | kgx$10^6$ | % |
| **TOTAL (kgx$10^6$/yr)** | 5.6 | | 0.63 | | 0.045 | | 1.5 | | 0.0017 | | 0.32 | |
| Motor vehicles | 3.1 | 55.8 | 0.59 | 93.4 | 0.017 | 38.0 | 0.41 | 28.2 | 0.00083 | 48.9 | 0.015 | 4.6 |
| Other mobile sources‡ | 0.68 | 12.1 | 0.0092 | 1.5 | 0.0011 | 2.4 | 0.20 | 13.8 | 0.000050 | 2.9 | 0.00039 | 0.1 |
| Facilities | 0.019 | 0.3 | 0.0077 | 1.2 | 0.023 | 51.1 | 0.026 | 1.8 | 0.00000011 | <0.1 | 0.00026 | <0.1 |
| Domestic solid fuel combustion | 1.5 | 26.7 | 0.019 | 3.0 | 0.0036 | 8.0 | 0.47 | 32.2 | 0.0000026 | 0.2 | 0.14 | 43.9 |
| Domestic gaseous fuel combustion | 0.00057 | <0.1 | 0.0041 | 0.7 | 0.00000014 | <0.1 | 0.000090 | <0.1 | 0.000000058 | <0.1 | 0.00012 | <0.1 |
| Domestic & commercial solvents* | | | | | | | 0.22 | 15.2 | | | | |
| Lawn mowing | 0.28 | 5.0 | 0.0014 | 0.2 | 0.00023 | 0.5 | 0.082 | 5.6 | 0.000017 | 1.0 | 0.0020 | 0.6 |
| Road related** | | | | | | | 0.0047 | 0.3 | 0.00080 | 47.0 | 0.16 | 50.6 |
| Service stations | | | | | | | 0.041 | 2.8 | 0.000000010 | <0.1 | | |
| **Calculated total emission rate (kg/s)** | 0.18 | | 0.020 | | 0.0014 | | 0.046 | | 0.000054 | | 0.010 | |

† Emissions represented to two significant figures (kgx$10^6$/yr)

‡ Includes railways, recreational boating and commercial shipping

* Includes dry cleaners, domestic and commercial solvents, architectural surface coatings, printers and motor vehicle refinishers

** Includes paved roads and road resurfacing (cutback bitumen)

**Table D–7: Annual inventory estimates from the NPI for Pt Lincoln†**

| Source | Carbon monoxide | | Nitrogen oxides | | Sulfur dioxide | | Total VOC | | Lead and compounds | | $PM_{10}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kgx10^6 | % | kgx10^6 | % | kgx10^6 | % | kgx10^6 | % | kgx10^6 | % | kgx10^6 | % |
| **TOTAL (kgx10^6/yr)** | 2.2 | | 0.25 | | 0.047 | | 0.62 | | 0.00082 | | 0.19 | |
| Motor vehicles | 1.2 | 54.1 | 0.17 | 68.1 | 0.0054 | 11.6 | 0.15 | 23.7 | 0.00030 | 36.4 | 0.0048 | 2.6 |
| Other mobile sources‡ | 0.084 | 3.8 | 0.063 | 25.3 | 0.038 | 82.3 | 0.011 | 1.9 | 0.000025 | 3.1 | 0.010 | 5.4 |
| Facilities | 0.00072 | <0.1 | 0.0045 | 1.8 | 0.00088 | 1.9 | 0.029 | 4.7 | 0.0000000028 | <0.1 | 0.00018 | <0.1 |
| Domestic solid fuel combustion | 0.73 | 33.0 | 0.0093 | 3.7 | 0.0018 | 3.8 | 0.23 | 37.2 | 0.0000013 | 0.2 | 0.071 | 38.3 |
| Domestic gaseous fuel combustion | 0.00027 | <0.1 | 0.0020 | 0.8 | 0.000000000011 | <0.1 | 0.000043 | <0.1 | 0.000000029 | <0.1 | 0.000057 | <0.1 |
| Domestic & commercial solvents* | | | | | | | 0.11 | 17.2 | | | | |
| Lawn mowing | 0.2 | 9.1 | 0.00054 | 0.2 | 0.00016 | 0.3 | 0.075 | 12.1 | 0.000012 | 1.5 | 0.0019 | 1.0 |
| Road related** | | | | | | | 0.00093 | 0.2 | 0.00048 | 58.9 | 0.10 | 52.5 |
| Service stations | | | | | | | 0.019 | 3.1 | 0.0000000049 | <0.1 | | |
| **Calculated total emission rate (kg/s)** | 0.070 | | 0.0079 | | 0.0015 | | 0.020 | | 0.000026 | | 0.010 | |

† Emissions represented to two significant figures (kgx10^6/yr)

‡ Includes aircraft, railways, recreational boating and commercial shipping

* Includes dry cleaners, domestic and commercial solvents, architectural surface coatings, printers and motor vehicle refinishers

** Includes paved roads and road resurfacing (cutback bitumen)

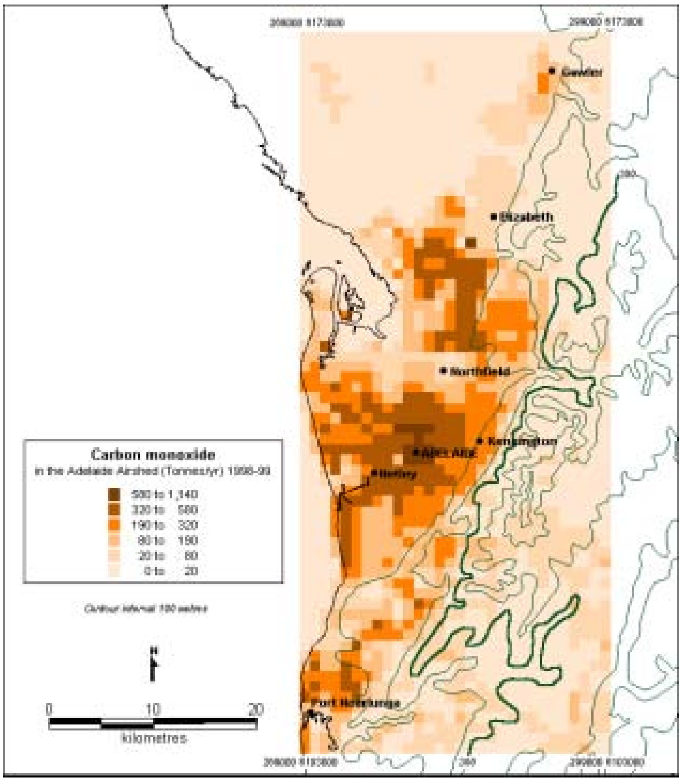


**Figure D–1: NPI inventory map of carbon monoxide emissions from all sources in metropolitan Adelaide**

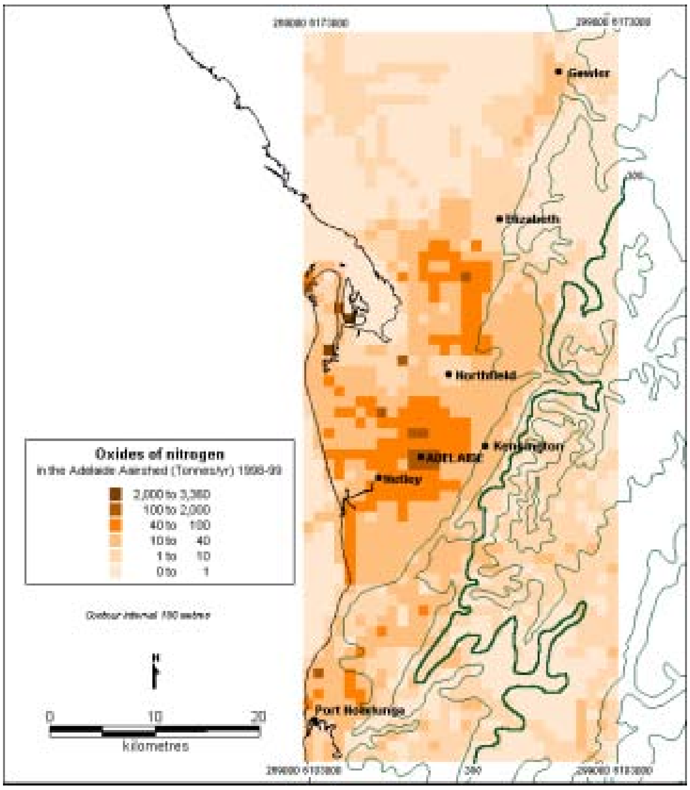


**Figure D–2: NPI inventory map of total nitrogen oxides emissions from all sources in metropolitan Adelaide (eastern airshed shown as black line)**

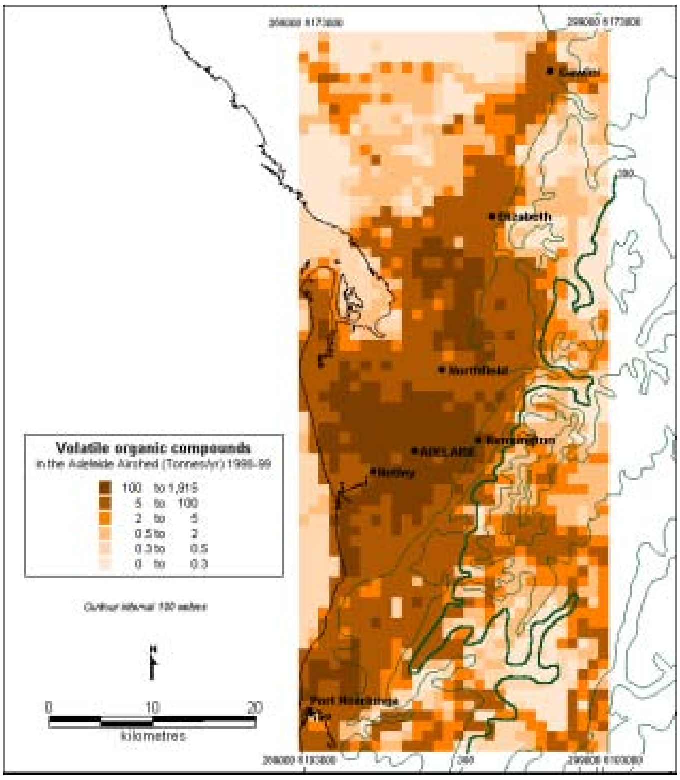


**Figure D–3:** NPI inventory map of total volatile organic compound emissions from all sources in metropolitan Adelaide

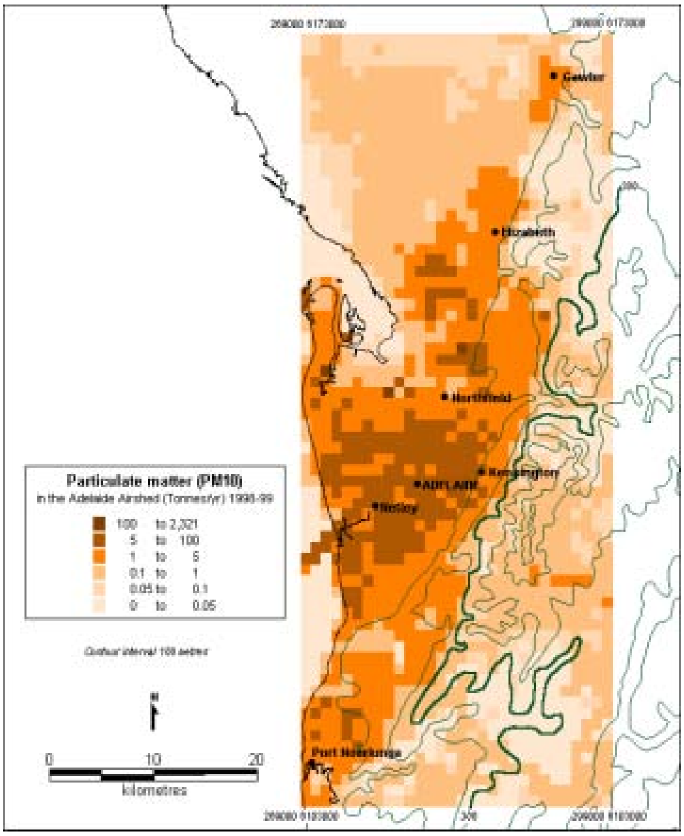


**Figure D–4:** NPI inventory map of total $PM_{10}$ particle emissions from all sources in metropolitan Adelaide (eastern airshed shown as black line)

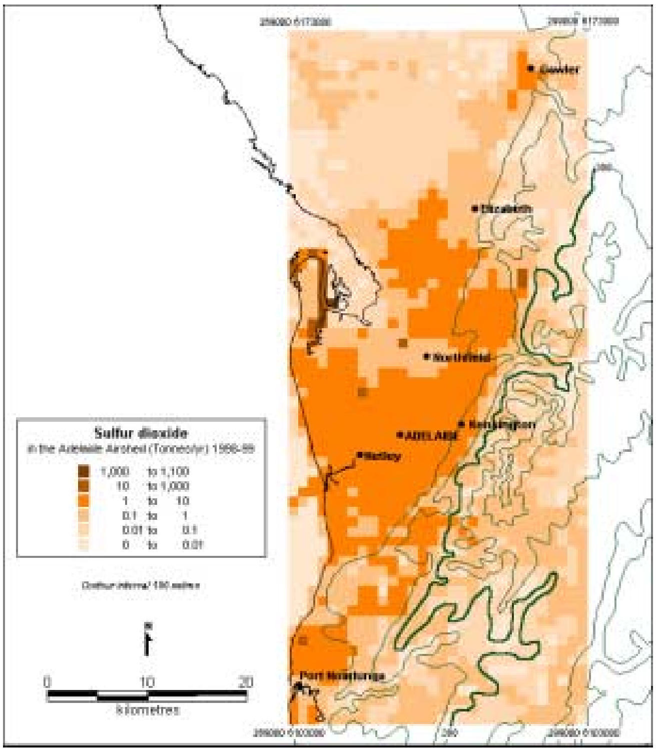


**Figure D–5: NPI inventory map of total sulfur dioxide emissions from all sources in metropolitan Adelaide (eastern airshed shown as black line)**

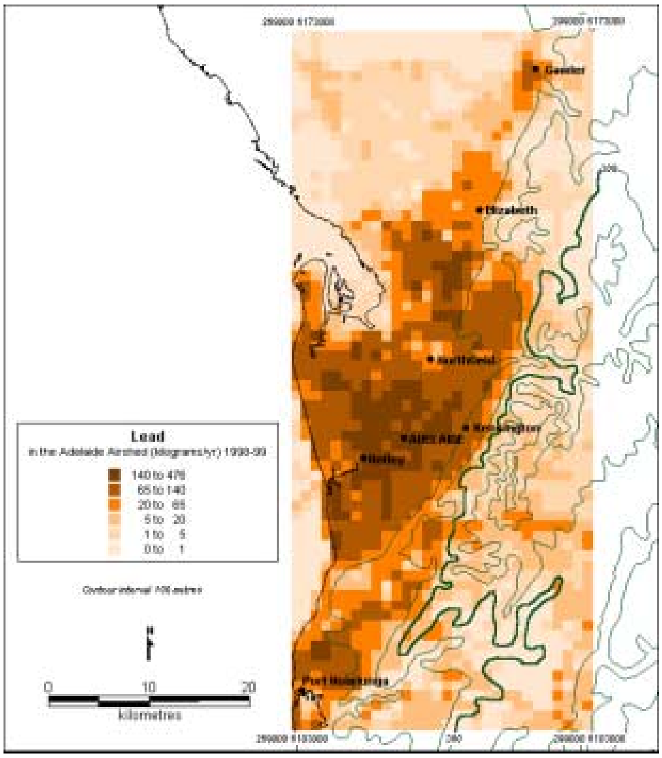


**Figure D–6: NPI inventory map of total lead emissions from all sources in metropolitan Adelaide (eastern airshed shown as black line)**

# APPENDIX E: CSIRO/VICTORIAN EPA MODELLING STUDY

As noted previously, the SA EPA commissioned a modelling study by the Environmental Consulting and Research Unit of the CSIRO (Division of Atmospheric Physics) and the Victorian EPA to provide recommendations about the size and configuration of an expanded air monitoring network in the Adelaide metropolitan area. Those recommendations are discussed in chapter four.

Long-term monitoring data for ozone and nitrogen oxides were available from Northfield, and from Netley for a somewhat shorter period. The models were run for two ozone 'events' on 24 and 25 December 1986 and on 13 and 14 March 1979, using simplified emissions inventory figures and a range of meteorological data.

The model actually predicts two plumes. The first develops offshore over Gulf St Vincent from precursor emissions between 0600 and 0900, with elevated ozone concentrations from 1300. The second plume arises from photochemical reactions of pollutants inland after incursion of the sea breeze and results from emissions during and onwards from late morning. The model predicts that, on the study days, ozone concentrations exceeding 0.06 ppm would extend from east of Adelaide Airport inland to Northfield, and high concentrations would be found at Elizabeth and Gawler.

Figure E–1 shows 'snapshots' of the model results for development of photochemical smog in the Adelaide plume, and its transport across Gulf St Vincent and the northern areas of Yorke Peninsula, for one case study—24 December 1986. White areas represent emissions from urban areas, while red denotes ozone formed by photochemical reactions of precursor compounds—e.g. nitrogen oxides and volatile organic compounds (VOC), also called reactive organic compounds (ROC).

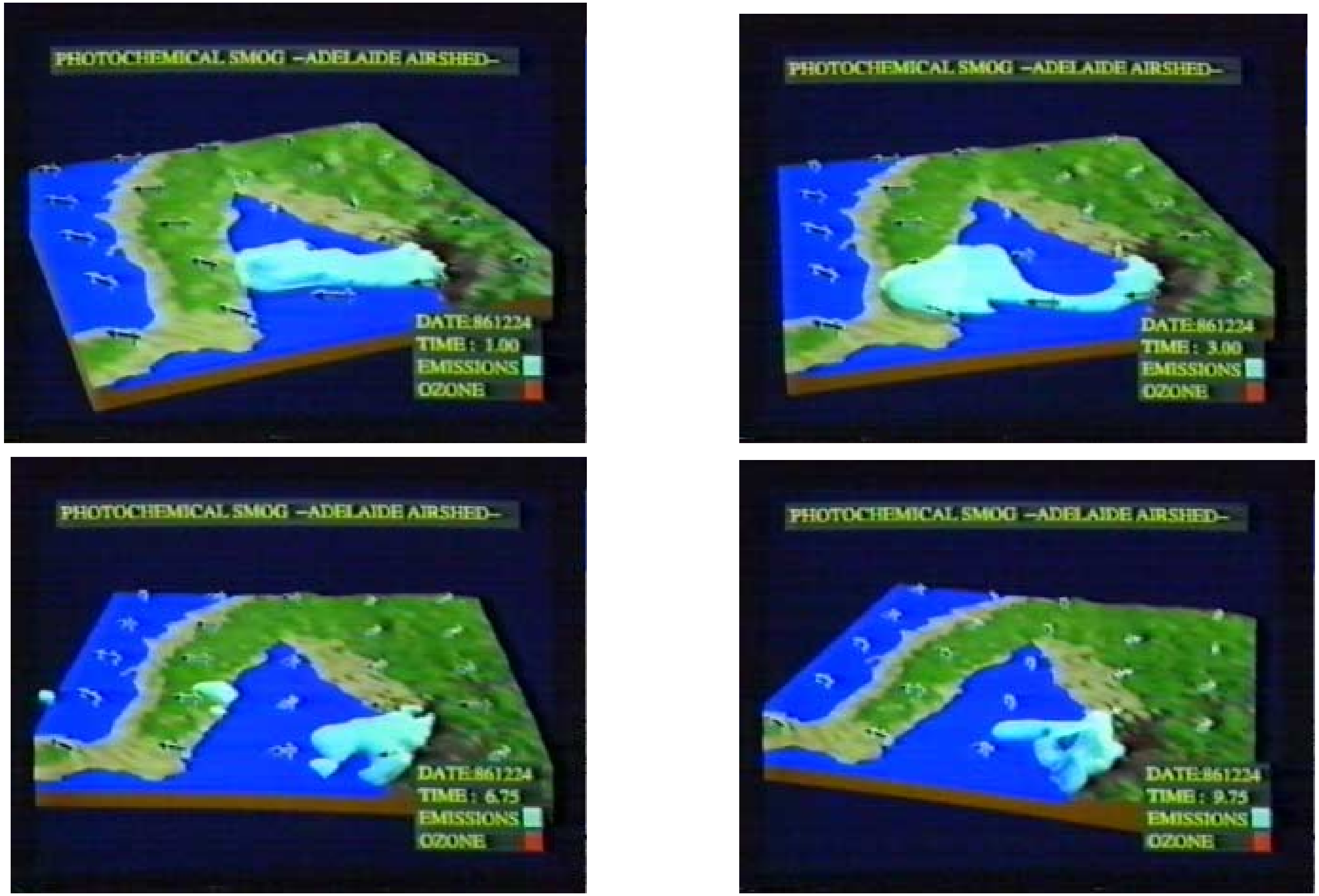


**Figure E–1: Modelled smog event 24-12-86**

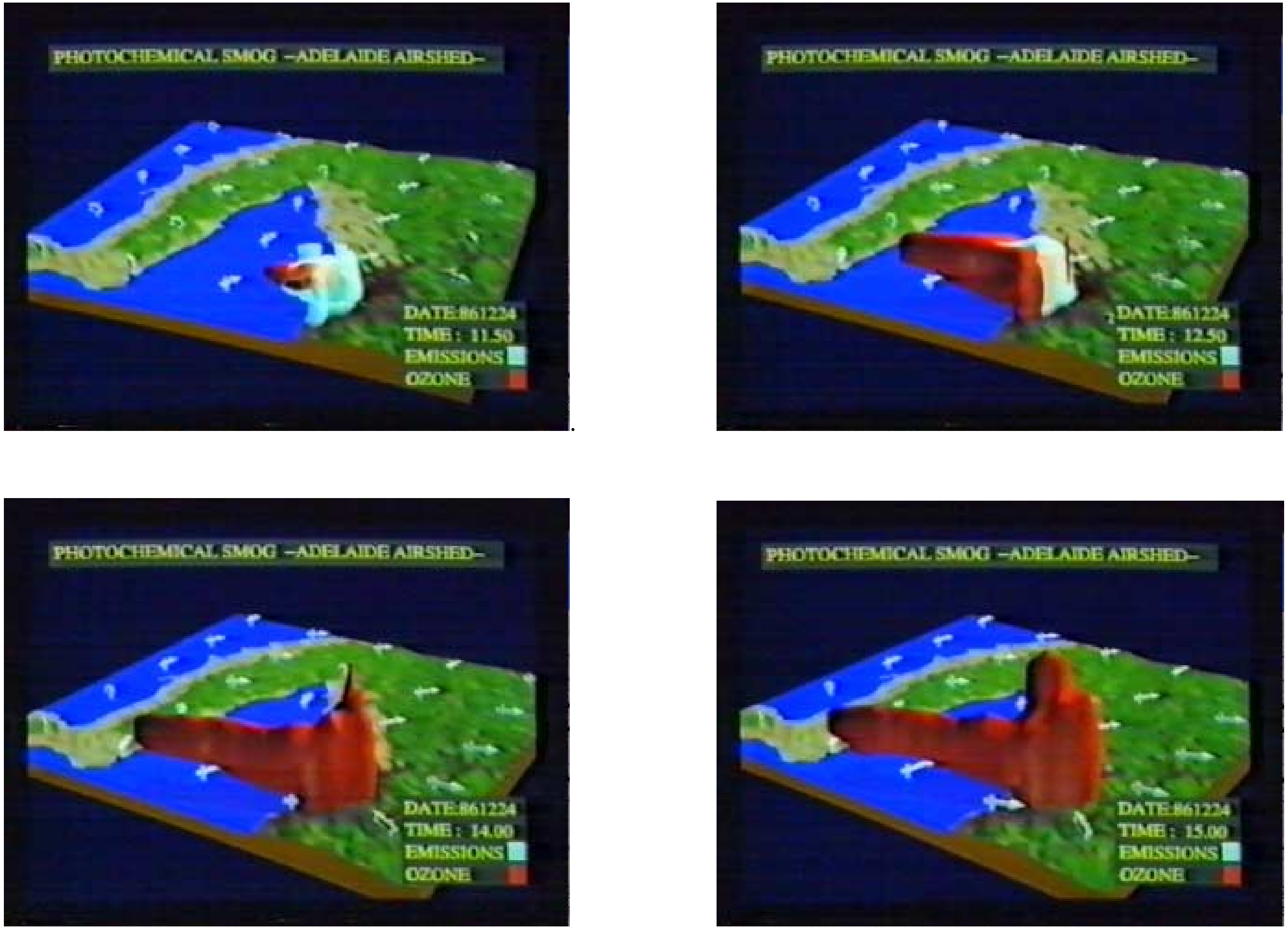


**Figure E–1: Modelled smog event 24-12-86 (continued)**

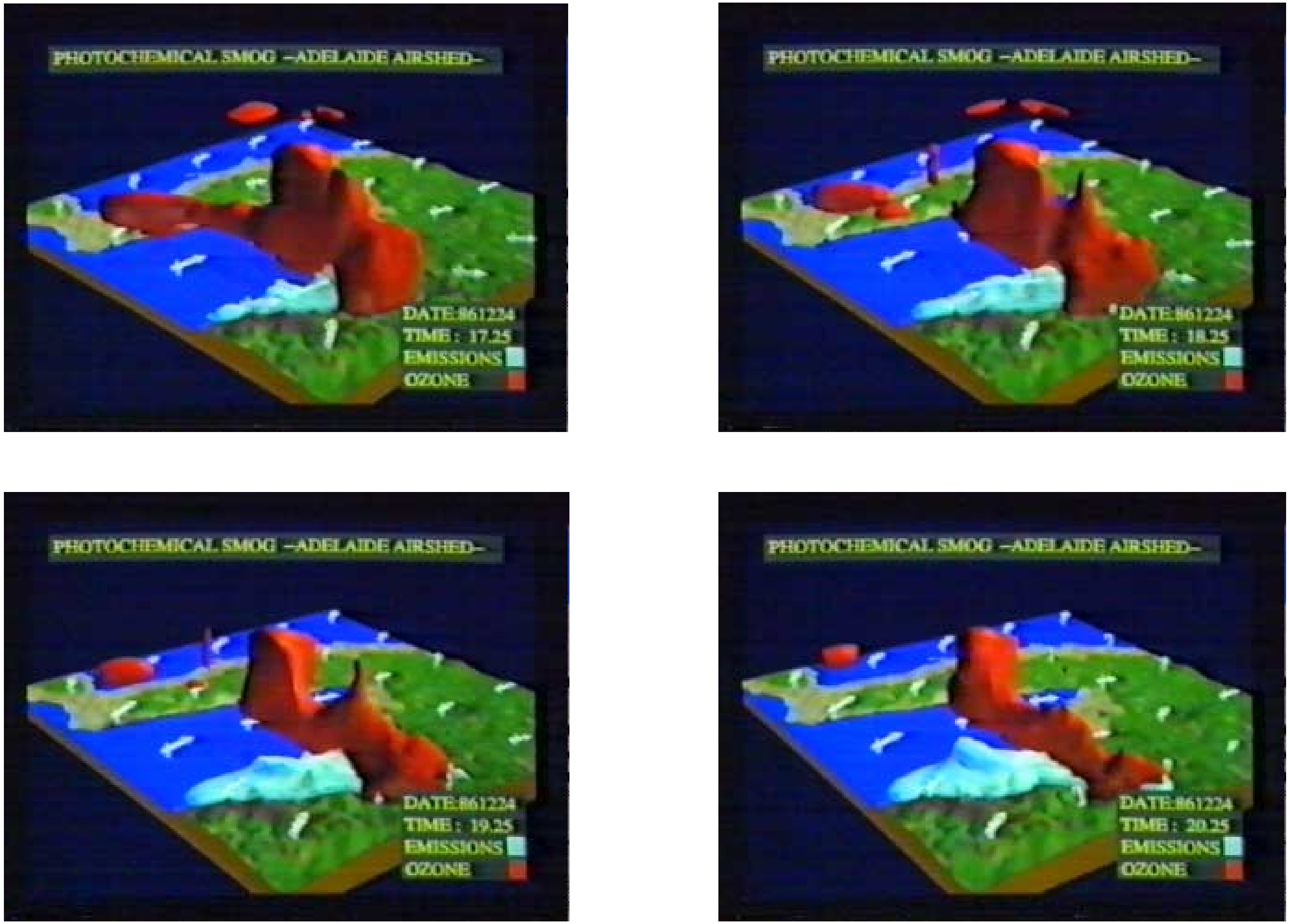


**Figure E–1: Modelled smog event 24-12-86 (continued)**

# GLOSSARY

| | |
|---|---|
| **agreement** | the agreement made on 1 May 1992 between the Commonwealth, the States, the Australian Capital Territory, the Northern Territory and the Australian Local Government Association, a copy of which is set out in the schedule to the Commonwealth Act |
| **Air NEPM** | National Environment Protection (Ambient Air Quality) Measure (26 June 1998) |
| **airshed** | an area in which air quality is subject to common influences from emissions, meteorology, and topography |
| **ambient air** | the external air environment (does not include the air environment inside buildings or structures) |
| **Airtrak** | a type of photochemical smog monitor |
| **CBD** | central business district |
| **CSIRO** | Commonwealth Scientific and Industrial Research Organisation |
| **CO** | carbon monoxide |
| **DOAS** | differential optical absorption spectrometry |
| **GRUB** | generally representative upper bound—refers to a performance monitoring station (see Peer Review Committee 2000c) |
| **katabatic** | refers to movements of cold air; katabatic flows drain down a valley, analogous to stormwater flows |
| **monitoring station** | a facility for measuring the concentration of one or more pollutants in the ambient air in a region or sub-region |
| **NATA** | National Association of Testing Authorities |
| **NEPC** | National Environment Protection Council |
| **NEPM** | National Environment Protection Measure |
| **NPI** | National Pollutant Inventory |
| **NO** | nitric oxide |
| **$NO_2$** | nitrogen dioxide |
| **$NO_X$** | oxides of nitrogen |
| **NMHC** | non-methane hydrocarbons |
| **$O_3$** | ozone |
| **Pb** | lead |
| **performance monitoring station** | a monitoring station used to measure achievement against the goal |
| **$PM_{10}$** | particles that have an aerodynamic diameter less than or equal to 10 µg/m |
| **$PM_{2.5}$** | particles that have an aerodynamic diameter less than or equal to 2.5 µg/m |
| **PMS** | performance monitoring station, as defined in the Air NEPM |
| **ppm** | parts per million by volume |
| **PRC** | Peer Review Committee—a reference committee set up by NEPC to advise on technical issues related to implementation of the NEPM |

| | |
|---|---|
| **region** | an area within a boundary surrounding population centres as determined by the relevant participating jurisdiction |
| **SA EPA** | South Australian Environment Protection Agency, administered by the Department for Environment and Heritage |
| **$SO_2$** | sulfur dioxide |
| **SSI** | size selective inlet designed to sample a particular particles size e.g. $PM_{10}$ |
| **sub-region** | a populated area within a region in which air quality differs from other areas in the region due to topography, meteorology, and sources of pollutants |
| **TEOM** | tapered element oscillating microbalance particle monitor |
| **trend station** | a performance monitoring station intended to remain in place for an extended period of at least ten years to observe long-term changes in pollutant levels |
| **TSP** | total suspended particulate matter |
| **VOC** | volatile organic compounds |
| **$\mu g/m^3$** | microgram (1 millionth of 1 gram) per cubic metre |

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