Ambient Air Quality in Gawler, South Australia

Monitoring campaign: 2002–2004

South Australia

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Monitoring campaign: 2002–2004

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SUMMARY

In the years 2002 to 2004, the South Australian Environment Protection Authority conducted a monitoring campaign to assess the ambient air quality in the town of Gawler and to determine if there was a continuing need for air quality monitoring in the township. The substances monitored during this campaign were ozone, nitrogen dioxide, and particulate matter with an equivalent aerodynamic diameter of 10 Pm or less (PM_{10}). The results of the ambient air quality monitoring campaign were compared to the standards and goals set by the *National Environment Protection (Ambient Air Quality) Measure* (Air NEPM) and to the acceptance limits specified for monitoring campaigns in Technical Paper 4 'Screening Procedures', prepared by the Peer Review Committee of the National Environment Protection Council.

There were fewer than five days a year on which the standard set for PM_{10} by the Air NEPM was exceeded, so the site did not exceed the goal set by the Air NEPM. However, in the 859-day monitoring period there were 45 days on which the daily average PM_{10} concentration exceeded the acceptance limit specified in the screening procedures.

For ozone, the one-hour average and the four-hour average concentrations complied with the standards and goals of the Air NEPM. However, the acceptance limit specified for the one-hour average ozone concentration at campaign monitoring sites was exceeded twice in 2003 and once in 2004. The acceptance limit specified for the four-hour average ozone concentration at campaign monitoring sites was exceeded seven times in 2003 and twice in 2004.

For nitrogen dioxide, the annual average and the one-hour average concentrations complied with the standards and goals of the Air NEPM and met the acceptance limits specified for campaign monitoring sites.

The 2002-2004 data was compared to data collected during an earlier campaign in 1986-1987. For both ozone and nitrogen dioxide, the average concentrations obtained in the 2002-2004 monitoring period were slightly higher than the average obtained in the 1986-1987 monitoring period. This difference, although slight, has been shown to be statistically significant.

The ambient air quality data obtained during the monitoring campaign at Gawler complied with the standards and goals of the Air NEPM. However, for both ozone and PM_{10} the acceptance limits specified for monitoring campaigns were exceeded. The screening procedures indicate that there is a need to continue to monitor for ozone and particulate matter in the township of Gawler. The screening procedures also recommend that nitrogen oxides should be monitored wherever ozone is monitored.

INTRODUCTION

The town of Gawler is located on the Adelaide plains at the junction of the North Para and South Para rivers, approximately 44 kilometres to the north of Adelaide, South Australia (Figure 1). Two major routes to Adelaide converge at Gawler: the Sturt Highway from the Barossa Valley and Murray River, and the Barrier Highway from the mid-north. Gawler is a commercial service centre for the surrounding agricultural areas. It was first settled in 1839 and was incorporated as a township in 1857.

Gawler currently has a population of about 19,000. Although this population is below the guideline population of 25,000 specified by the *National Environment Protection (Ambient Air Quality) Measure* (the Air NEPM) (National Environment Protection Council 1998), Gawler is monitored as a satellite town in the greater Adelaide region.

Meteorological monitoring on the site showed that the prevailing winds in Gawler are predominantly light to moderate. In spring, summer and autumn, the winds are generally from a south-easterly direction, with a sea breeze from the south-west. In winter and early spring, the prevailing winds are westerly to north-westerly. Wind roses summarising the wind data are provided in Appendix 1. At the monitoring site in 2003, mean daily maximum temperatures ranged from 30°C in January to 14°C in August.

In June 2001, the Environment Protection Authority (EPA 2001) published the *Ambient Air Quality Monitoring Plan for South Australia* to ensure that ambient air quality monitoring in South Australia would be consistent with other states. This plan includes information on requirements for monitoring in populous regions, placement of air monitoring sites, instrumentation, data collection, management and reporting. A review of the monitoring plan, *South Australian Ambient Air Quality Monitoring Program—A review,* was published in May 2005 (EPA 2005).

The purpose of the monitoring campaign in Gawler, as outlined in the monitoring plan, was to assess ambient air quality in the town and determine if there was a continuing need for monitoring. The EPA monitoring site at Popham Avenue (Figure 2), in the south-east of the Gawler township, was chosen for this monitoring campaign because it was considered to be representative of the residential areas of the town. The substances monitored during this campaign were ozone, nitrogen dioxide and particulate matter with an equivalent aerodynamic diameter of 10 micrometres (Pm) or less (PM_{10}) (Table 1). The Air NEPM also sets air quality standards for sulfur dioxide and lead, but it was not necessary to monitor for these air pollutants as there are no local sources at Gawler.

The meteorological parameters monitored at the site during the air quality monitoring campaign (Table 1) were temperature, barometric pressure, total solar radiation, wind speed, wind direction and sigma theta (a parameter used to indicate the variability of wind direction during the averaging period).

Appendix 2 provides the technical details for the site and the monitoring equipment used at the site during the monitoring campaign.

The results of a previous monitoring campaign in Gawler, for ozone and nitrogen dioxide from 1 February 1986 to 22 May 1987, are also discussed in this report.

Table 1: Key dates for monitoring campaign in Popham Avenue, Gawler East, 2002-2004

Substance monitored	Monitoring start	Monitoring end	Monitoring period (days)
Nitrogen dioxide	18 January 2002	19 October 2004	1006
Ozone	8 January 2002	19 October 2004	1016
Particulate matter, as PM_{10}	17 June 2002	22 October 2004	859
Meteorology*	1 January 2002	19 October 2004	1023

x Meteorological parameters recorded: temperature, barometric pressure, total solar radiation, wind speed, wind direction and sigma theta

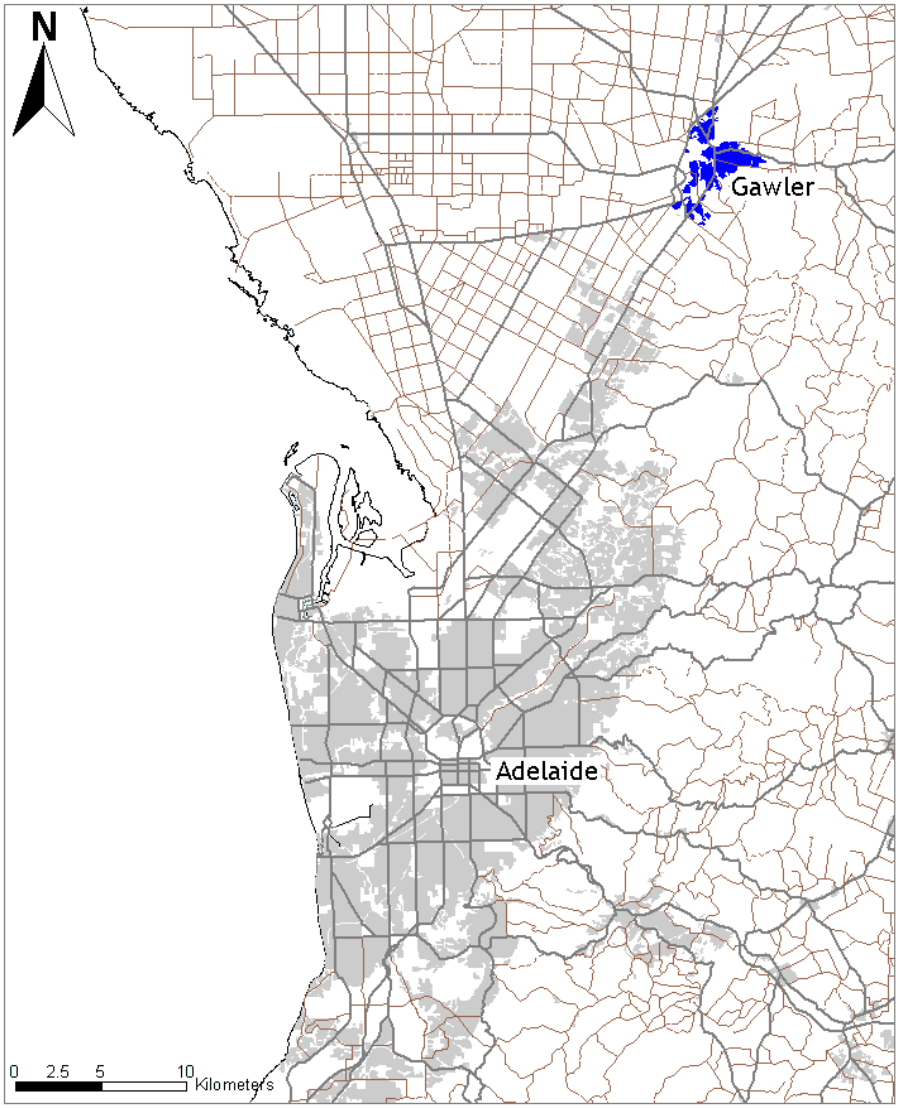

Figure 1: The greater Adelaide region, showing the town of Gawler to the north

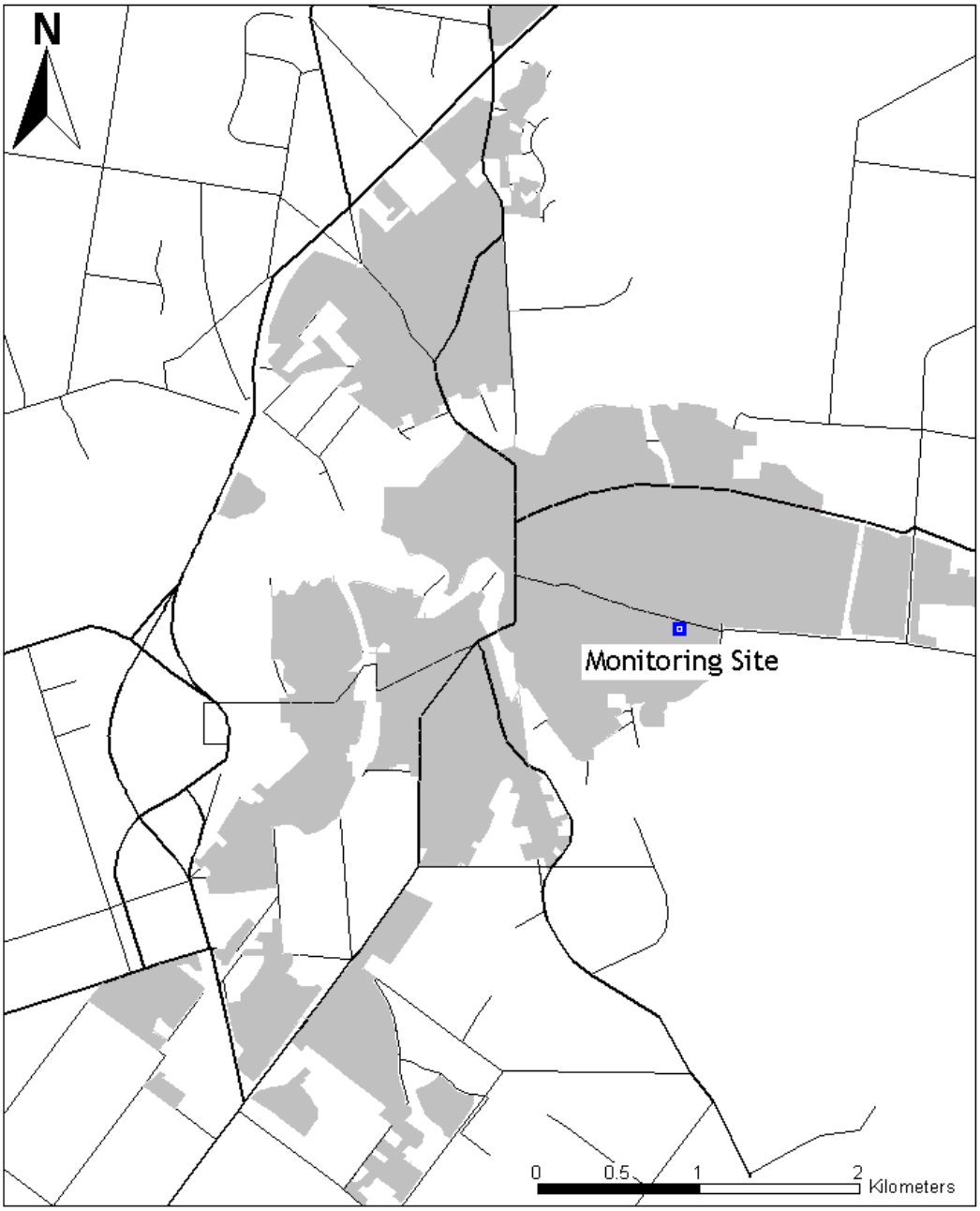

Figure 2: The town of Gawler, showing the Popham Avenue monitoring site

AIR QUALITY STANDARDS, GOALS AND SCREENING PROCEDURES

South Australia has enacted the *National Environment Protection (Ambient Air Quality) Measure* (Air NEPM) as the required standard for six common pollutants: carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide, lead, and particulate matter as PM_{10}. The Air NEPM sets standards and goals at levels that protect human health and wellbeing, aesthetic enjoyment and local amenity.

The standards are defined as concentrations either in parts per million (ppm) or, for particulate matter, micrograms per cubic metre (Pg/m^3). The goals in the Air NEPM specify a maximum permissible number of days per year when the standards may be exceeded and a timeframe of 10 years (1998–2008) within which these goals must be met.

Since the monitoring program in Gawler was implemented to determine if there was a need for continued monitoring in the township, data from the air monitoring program was also compared to the acceptance limits set in the screening procedures published by the Peer Review Committee (2001a) of the National Environment Protection Council (PRC). The acceptance limits set by the screening procedures are transparent criteria that can be used to demonstrate that pollutant levels can reasonably be expected to be consistently lower than the Air NEPM standards, and that continuing air quality monitoring need not take place in the area under consideration.

The screening procedures note that, to maintain a conservative approach, except for PM_{10}, the maximum predicted or measured concentration should be used for comparison with the acceptance limit, even though the Air NEPM goal may specify a maximum permissible number of days per year when the standard can be exceeded. For pollutants that have standards for more than one averaging period, the acceptance limit to be used is that of the standard which is most difficult to meet in any given region. In most cases, this is expected to be the shortest averaging period.

For PM_{10}, the screening procedures note that screening is not simple in centres subject to wood fires or smoke from prescribed burning. High concentrations of smoke from wood fires occur locally under near calm conditions. Large smoke plumes from prescribed burns affect small and large centres alike over hundreds of kilometres. The acceptance limit specified in the screening procedures is intended to apply to the fifth highest daily reading when the higher readings can be shown to be due to bushfires or controlled burning.

The Peer Review Committee (2001b) has published requirements for data collection and handling. To demonstrate annual compliance, in addition to a 75% annual data availability requirement, at least 75% data per calendar quarter is required to cover the possible seasonal effects in pollutant behaviour. Years with less than 75% data availability can still demonstrate non-compliance if the number of days when the standard is exceeded is greater than the goal specified by the Air NEPM.

Nitrogen dioxide and ozone were monitored for full calendar years in 2002 and 2003 and the quarterly data recovery rates exceeded the 75% requirement specified by the PRC, meeting the PRC requirements for compliance reporting. In 2004, the monitoring did not cover a complete calendar year, so did not fulfil the PRC reporting requirements.

Particulate matter as PM_{10} was monitored for the full calendar year in 2003 and the quarterly data recovery rate exceeded the 75% requirements of the PRC, meeting the PRC requirements for compliance reporting. In 2002 and 2004, the monitoring did not cover a complete calendar year, so did not fulfil the PRC reporting requirements.

NITROGEN DIOXIDE

Nitrogen dioxide is a gas generated by combustion processes. Exposure to nitrogen dioxide has been associated with increases in daily mortality, hospital admissions and emergency room attendances for cardiovascular and respiratory disease, increases in respiratory illness and symptoms, and decreases in lung function. The elderly, asthmatics, children and people with existing disease are particularly susceptible to the effects of nitrogen dioxide (National Environment Protection Council 2000).

The levels of nitrogen dioxide in the ambient air were monitored from 18 January 2002 to 19 October 2004. During this time, the annual average and the one-hour average nitrogen dioxide concentrations complied with the standards and goals of the Air NEPM (Table 2) and met the acceptance limits specified for campaign monitoring sites (Table 3).

Table 2: Air NEPM standards and goals for nitrogen dioxide

Pollutant	Averaging period	Maximum concentration	Goal within 10 years: maximum allowable exceedences
Nitrogen dioxide	1 hour	0.12 ppm	1 day a year
	1 year	0.03 ppm	None

Table 3: Acceptance limits for nitrogen dioxide

Pollutant	Acceptance limit: % of Air NEPM standard	Averaging period	Acceptance limit
Nitrogen dioxide	60% for two or more years of data	1 hour	0.072 ppm
		1 year	0.018 ppm

Annual average

In the complete calendar years 2002 and 2003, the annual average nitrogen dioxide concentration was within the standard set by the Air NEPM.

In 2004, when the monitoring did not cover a complete calendar year, the average nitrogen dioxide concentration recorded for the monitoring period was lower than the standard set by the Air NEPM.

During the period of monitoring, the annual average nitrogen dioxide concentration was lower than the acceptance limit specified for campaign monitoring sites.

Table 4 reports the annual average nitrogen dioxide concentrations and compares them to the Air NEPM Standard and the acceptance limit set by the screening procedures.

Table 4: Nitrogen dioxide, annual averages, compliance with standard and acceptance limit

Year	Data recovery (% hours)	Annual average (ppm)	Did site meet NEPM standard and goal?	Did site meet acceptance limit?
2002	91	0.003	Yes	Yes
2003	97	0.003	Yes	Yes
2004*	76	0.004	Incomplete	Yes

* Incomplete data for 2004 year: monitoring campaign ceased 19 October 2004 and data recovery rate for the last quarter was 19%

One-hour average

In the complete calendar years 2002 and 2003, the one-hour average nitrogen dioxide concentrations were within the standard set by the Air NEPM.

In 2004, when the monitoring did not cover a complete calendar year, the one-hour average nitrogen dioxide concentrations recorded for the monitoring period were lower than the standard set by the Air NEPM.

During the monitoring period, the maximum one-hour average nitrogen dioxide concentration did not exceed the acceptance limit specified for campaign monitoring sites.

Table 5 shows how the one-hour average nitrogen dioxide concentrations compared to the requirements of the Air NEPM standard and the acceptance limit of the screening procedures.

Table 5: Nitrogen dioxide, one-hour averages, compliance with standard and acceptance limit

Year	Number of days NEPM standard exceeded	Did site meet NEPM standard and goal?	Number days acceptance limit exceeded	Did site meet acceptance limit?
2002	0	Yes	0	Yes
2003	0	Yes	0	Yes
2004*	0	Incomplete	0	Yes

* Incomplete data for 2004 year: monitoring campaign ceased 19 October 2004 and data recovery rate for the last quarter was 19%

Table 6 reports the annual average, maxima and percentiles for the one-hour average nitrogen dioxide concentrations.

Table 6: Nitrogen dioxide, one-hour averages, statistics

Year	Data recovery (% hours)	Annual average (ppm)	Annual maximum (ppm)	Percentiles (ppm)*		
				99th	95th	90th
2002	91	0.003	0.035	0.019	0.011	0.008
2003	97	0.003	0.036	0.018	0.010	0.007
2004**	76	0.004	0.028	0.018	0.011	0.008

* Percentiles have been calculated from all one-hour averages, not from peak daily one-hour averages

** Incomplete data for 2004 year: monitoring campaign ceased 19 October 2004 and data recovery rate for the last quarter was 19%

Figure 3 compares the daily maximum one-hour average nitrogen dioxide concentration to the standard set by the Air NEPM and to the acceptance limits set by the screening procedures.

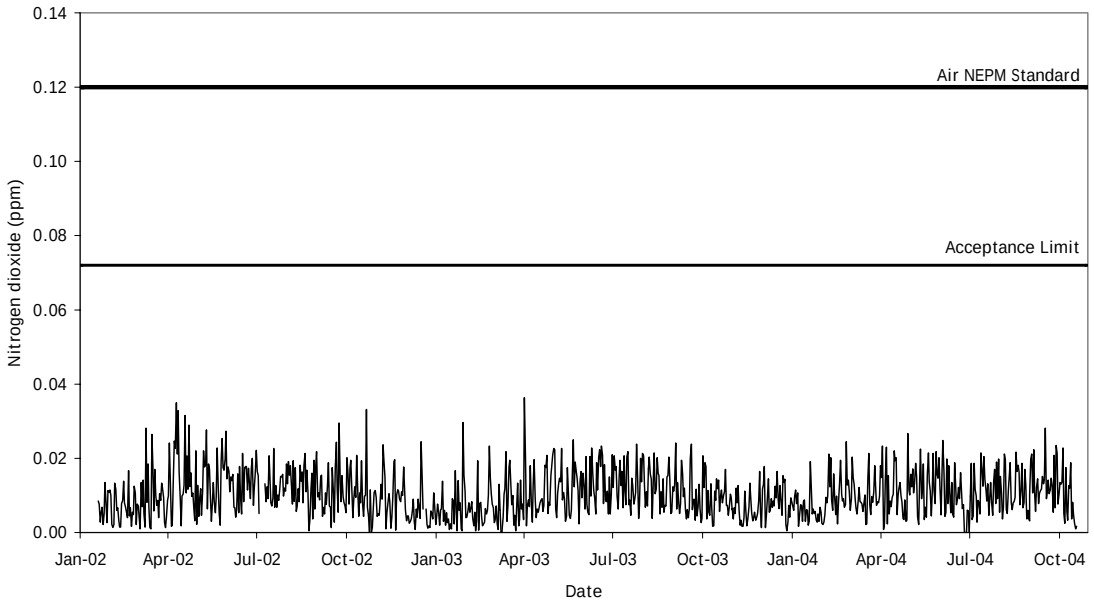

Figure 3: Nitrogen dioxide, daily maximum one-hour averages versus standard and acceptance limit

OZONE (PHOTOCHEMICAL OXIDANTS)

Ozone is an oxidising gas created by the interaction of sunlight, nitrogen oxide and volatile organic compounds in the atmosphere. Exposure to ozone has been associated with increases in daily mortality, increases in hospital admissions and emergency room visits for respiratory and cardiovascular disease, decreases in lung function, increases in symptoms of respiratory illness such as cough, phlegm and wheeze, and increases in bronchodilator usage. These effects are observed in sensitive subpopulations, although effects on lung function have been observed in the healthy normal population (National Environment Protection Council 2000).

The levels of ozone in the ambient air were monitored from 8 January 2002 to 19 October 2004. During this time, the one-hour average and the four-hour average ozone concentrations complied with the standards and goals of the Air NEPM (Table 7).

The acceptance limits specified for campaign monitoring sites (Table 8) were exceeded for the one-hour average ozone concentration twice in 2003 and once in 2004, and for the four-hour average ozone concentration seven times in 2003 and twice in 2004.

Table 7: Air NEPM standards and goals for photochemical oxidants (as ozone)

Pollutant	Averaging period	Maximum concentration	Goal within 10 years: maximum allowable exceedences
Photochemical oxidants	1 hour	0.10 ppm	1 day a year
(as ozone)	4 hours	0.08 ppm	1 day a year

Table 8: Acceptance limits for photochemical oxidants (as ozone)

Pollutant	Acceptance limit: percentage of Air NEPM standard	Averaging period	Acceptance limit
Photochemical oxidants	70% for two to four years of data	1 hour	0.070 ppm
(as ozone)		4 hours	0.056 ppm

One-hour average

In the complete calendar years 2002 and 2003, the one-hour average ozone concentrations were within the standard set by the Air NEPM.

In 2004, when the monitoring did not cover a complete calendar year, the one-hour average ozone concentrations recorded for the monitoring period were lower than the standard set by the Air NEPM.

The one-hour average ozone concentrations exceeded the acceptance limit specified for campaign monitoring sites on two days in 2003 and on one day in 2004.

Table 9 compares the one-hour average ozone concentrations to the Air NEPM standard and the acceptance limit of the screening procedures. Table 10 reports the annual average, maxima and percentiles for the one-hour ozone concentrations.

Table 9: Ozone, one-hour averages, compliance with standard and acceptance limit

Year	Number of days NEPM standard exceeded	Did site meet NEPM standard and goal?	Number days acceptance limit exceeded	Did site meet acceptance limit?
2002	0	Yes	0	Yes
2003	0	Yes	2	No
2004*	0	Incomplete	1	No

* Incomplete data for 2004 year: monitoring campaign ceased 19 October 2004 and data recovery rate for the last quarter was 19%

Table 10: Ozone, one-hour averages, statistics

Year	Data recovery (% hours)	Annual average (ppm)	Annual maximum (ppm)	Percentiles (ppm)*		
				99th	95th	90th
2002	95	0.021	0.056	0.040	0.033	0.030
2003	98	0.022	0.078	0.046	0.035	0.031
2004**	78	0.020	0.077	0.040	0.031	0.028

* Percentiles have been calculated from all one-hour averages, not from the peak daily one-hour averages

** Incomplete data for 2004 year: monitoring campaign ceased 19 October 2004 and data recovery rate for the last quarter was 19%

Figure 4 compares the daily maximum one-hour average ozone concentration to the standard set by the Air NEPM and to the acceptance limit set by the screening procedures. This figure demonstrates the seasonal cycle of ozone concentration. In the lower atmosphere, ozone is created by the reaction of nitrogen oxides and volatile organic compounds under the influence of sunlight. There are higher concentrations of ozone in summertime because there is more sunlight and because higher air temperatures promote the chemical reactions that create ozone.

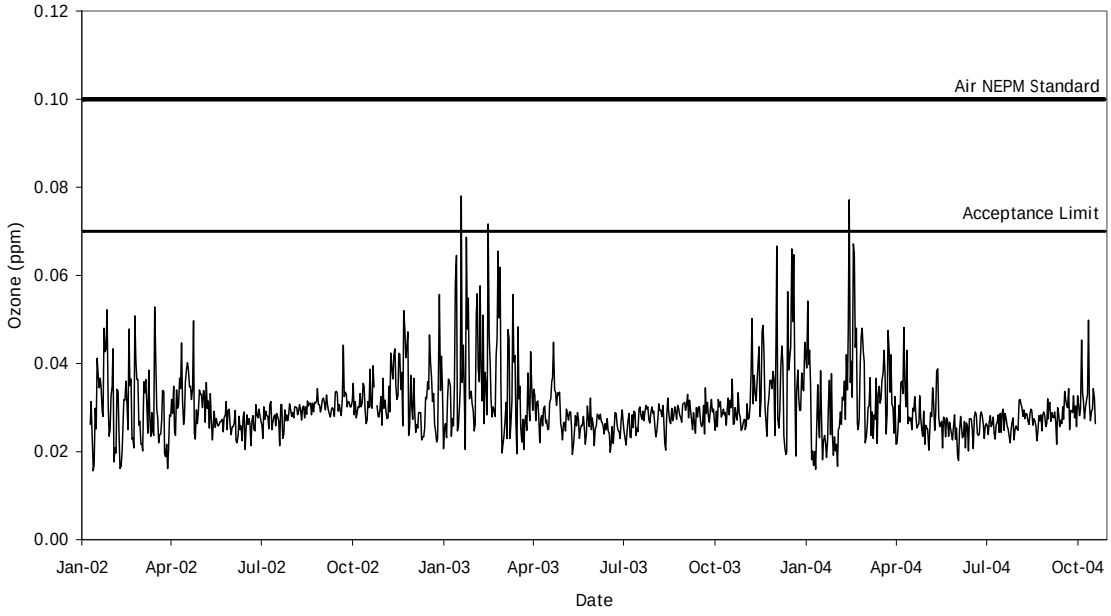

Figure 4: Ozone, daily maximum one-hour averages versus standard and acceptance limit

Four-hour average

In the complete calendar years 2002 and 2003, the four-hour average ozone concentrations were within the standard set by the Air NEPM.

In 2004, when the monitoring did not cover a complete calendar year, the four-hour average ozone concentrations were lower than the standard set by the Air NEPM.

The four-hour average ozone concentrations exceeded the acceptance limit specified for campaign monitoring sites on seven days in 2003 and on two days in 2004.

Table 11 compares the four-hour average ozone concentrations to the requirements of the Air NEPM standard and the acceptance limit of the screening procedures.

Table 11: Ozone, four-hour averages, compliance with standard and acceptance limit

Year	Number of days NEPM standard exceeded	Did site meet NEPM standard and goal?	Number days acceptance limit exceeded	Did site meet acceptance limit?
2002	0	Yes	0	Yes
2003	0	Yes	7	No
2004*	0	Incomplete	2	No

* Incomplete data for 2004 year: monitoring campaign ceased 19 October 2004 and data recovery rate for the last quarter was 19%

Table 12 reports the annual average, maxima and percentiles for the four-hour ozone concentrations.

Figure 5 compares the daily maximum four-hour average ozone concentration to the standard set by the Air NEPM and to the acceptance limit set by the screening procedures.

Table 12: Ozone, four-hour averages, statistics

Year	Data recovery (% hours)	Annual average (ppm)	Annual maximum (ppm)	Percentiles (ppm)* 99th	95th	90th
2002	95	0.021	0.050	0.038	0.032	0.030
2003	100	0.022	0.069	0.045	0.034	0.030
2004**	79	0.020	0.065	0.039	0.030	0.028

* Percentiles have been calculated from all one-hour averages, not from the peak daily one-hour averages

** Incomplete data for 2004 year: monitoring campaign ceased 19 October 2004 and data recovery rate for the last quarter was 19%

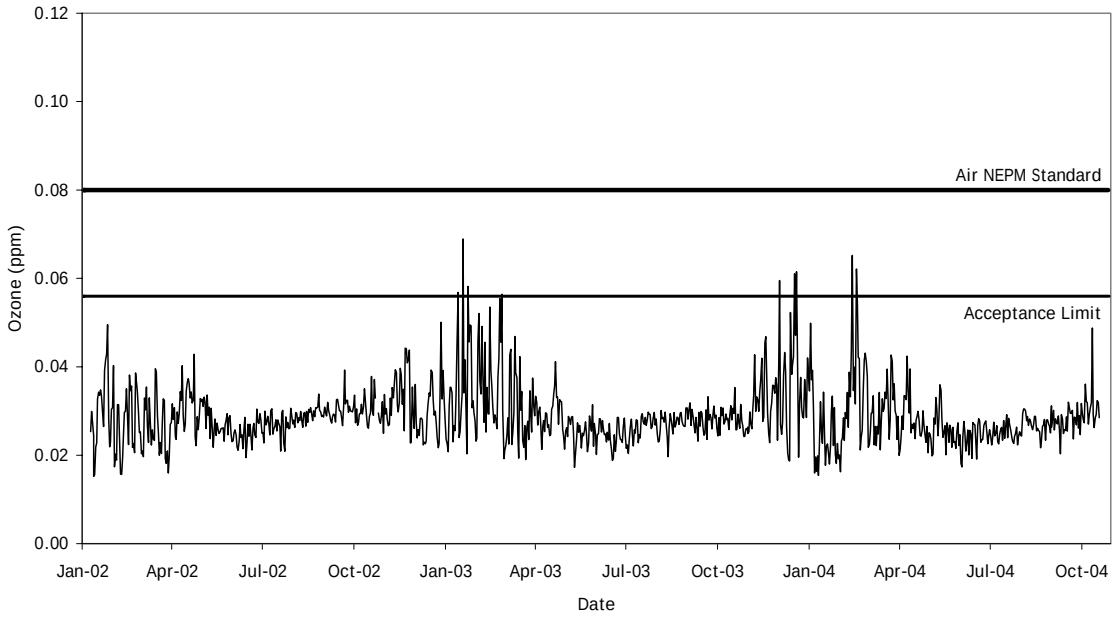

Figure 5: Ozone, daily maximum four-hour averages versus standard and acceptance limit

PARTICULATE MATTER AS PM_{10}

Unlike the other common air pollutants, particles are a broad class of chemically and physically diverse substances. They are emitted from a wide range of sources and include natural substances such as dusts and pollens. The biological effects of particles are determined by their physical and chemical nature, the physics of deposition and distribution in the respiratory tract, and physiological events in response to the presence of the particle. Particles can prompt increases in daily mortality, hospital admissions and emergency room attendances, and exacerbation of respiratory symptoms and asthma.

Particulate matter is measured as total suspended particles (TSP), as PM_{10} particles and as particles with an equivalent aerodynamic diameter smaller than 2.5 Pm ($PM_{2.5}$). There is no conclusive evidence on the role of particle size in the health response, but different sizes may be important for different health outcomes—for example, $PM_{2.5}$ for mortality and PM_{10} for asthma (National Environment Protection Council 2000).

The monitoring campaign in Gawler monitored the PM_{10} component of particulate matter, as the Air NEPM has set a standard and goal for this component (Table 13). The acceptance limit specified for campaign monitoring sites is shown in Table 14.

The levels of PM_{10} in ambient air were monitored from 17 June 2002 to 22 October 2004.

In 2003, when the monitoring covered a complete calendar year, the daily average PM_{10} concentration exceeded the Air NEPM standard on three occasions. Since the goal of the Air NEPM is that there should be not more than five days a year on which the standard is exceeded, the site complied with the goal set by the Air NEPM in 2003.

During the 859-day period of monitoring there were eight days, averaging 3.4 days per year, on which the daily average PM_{10} concentration exceeded the standard set by the Air NEPM. This was less than the Air NEPM goal of not more than five days per year.

During the monitoring period there were 45 days, or 19 days per year on average, on which the daily average PM_{10} concentration exceeded the acceptance limit (Table 14).

Table 13: Air NEPM standard and goal for PM_{10}

Pollutant	Averaging period	Maximum concentration	Goal within 10 years: maximum allowable exceedences
Particulate matter, as PM_{10}	1 day	50 Pg/m^3	5 days a year

Table 14: Acceptance limit for PM_{10}

Pollutant	Acceptance limit: percentage of Air NEPM standard	Averaging period	Acceptance limit
Particulate matter, as PM_{10}	60% for two or more years of data	1 day	30 Pg/m^3

Table 15 compares the daily average PM_{10} concentrations to the requirements of the Air NEPM and the acceptance limit of the screening procedures.

Table 15: PM_{10} compliance with standard and acceptance limit

Year	Number of days NEPM standard exceeded	Did site meet NEPM standard and goal?	Number days acceptance limit exceeded	Did site meet acceptance limit?
2002*	1	Incomplete	10	No
2003	3	Yes	17	No
2004**	4	Incomplete	18	No

* Incomplete data for 2002 year: monitoring campaign started 17 June 2002

** Incomplete data for 2004 year: monitoring campaign ended 22 October 2004

Table 16 reports the annual average, maxima and percentiles for the one-day average PM_{10} concentrations.

Table 16: PM_{10} one-day averages by TEOM, statistics

Year	No. of valid days	Average	Maximum	2nd highest	6th highest	90th percentile	Median value
		($\mu g/m^3$)					
2002*	171	17.3	50.7	48.0	39.1	26.5	15.3
2003	358	15.5	51.9	51.7	44.7	24.4	13.5
2004**	279	16.6	90.3	69.7	40.6	27.2	14.3

* Incomplete data for 2002 year: monitoring campaign started 17 June 2002

** Incomplete data for 2004 year: monitoring campaign ended 22 October 2004

Figure 6 compares the daily maximum one-day average PM_{10} concentration to the standard set by the Air NEPM and to the acceptance limit set by the screening procedures.

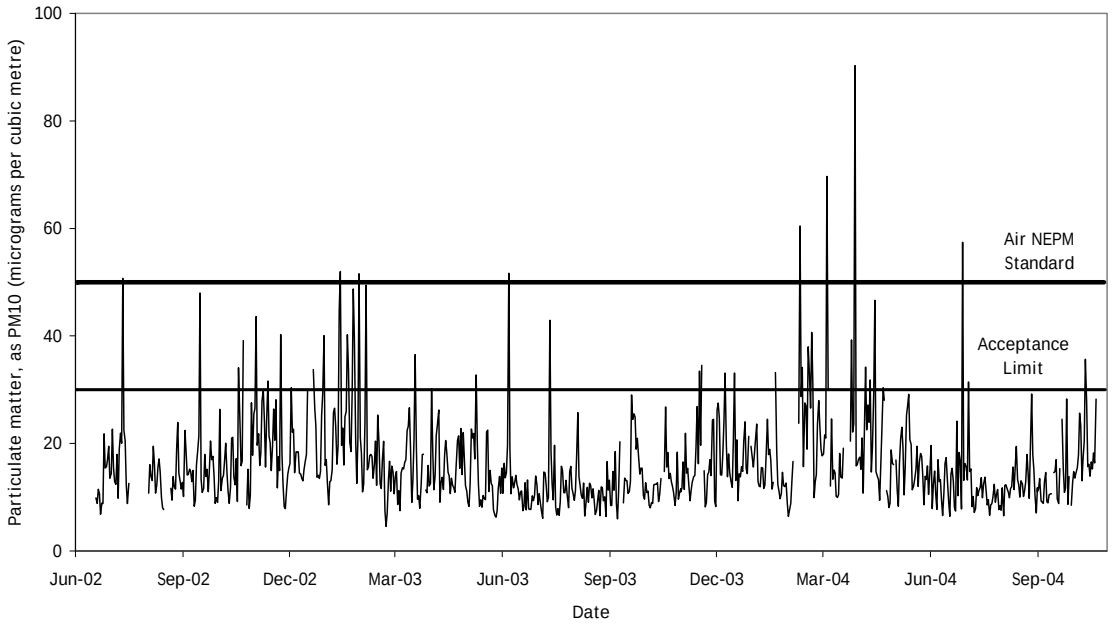

Figure 6: PM_{10} one-day averages versus standard and acceptance limit

DISCUSSION

Nitrogen dioxide and ozone were previously monitored in Gawler from 1 February 1986 to 22 May 1987 and data from that monitoring campaign is compared to the data from the current campaign below. This earlier campaign predates the Air NEPM standards, promulgated in 1998, and the selection criteria, promulgated in 2001.

Nitrogen dioxide monitoring in Gawler, 1986-1987

Long-term averages

For the 476-day period of monitoring, the average nitrogen dioxide concentration was 0.002 ppm. For the one-year period from 1 April 1986 to 31 March 1987 (not a calendar year), the average nitrogen dioxide concentration was also 0.002 ppm. These averages are less than the standard of 0.03 ppm set for the annual average by the Air NEPM.

During the period of monitoring, the annual average nitrogen dioxide concentration did not exceed the acceptance limit of 0.018 ppm specified for campaign monitoring sites.

One-hour average

The maximum one-hour average nitrogen dioxide concentration in the 1986-1987 monitoring period was 0.035 ppm. This is less than the standard of 0.12 ppm set by the Air NEPM and less than the acceptance limit of 0.072 ppm specified for campaign monitoring sites.

Table 17 compares the statistics for the one-hour average nitrogen dioxide concentrations during the two monitoring periods: 1986-1987 and 2002-2004.

Table 17: Nitrogen dioxide, one-hour averages, statistics for monitoring periods

Period	Data recovery (% hours)*	Average (ppm)	Maximum (ppm)	Percentiles (ppm)**		
				99th	95th	90th
1986-1987	87	0.002	0.067	0.018	0.010	0.007
2002-2004	96	0.003	0.036	0.018	0.011	0.008

* Data recovery calculated for actual periods of monitoring, not calendar years

** Percentiles calculated from all one-hour averages, not from the peak daily one-hour averages

The average obtained in the 2002-2004 monitoring period is slightly higher (1 part per billion (ppb)) than the average obtained in the 1986-1987 monitoring period. This difference has been shown to be statistically significant[1].

[1] The means have been shown to be not equal at a probability of 99.999% by testing both untransformed data and log-transformed data using the student's 'T' test.

Figure 7 compares the daily maximum one-hour average nitrogen dioxide concentration in 1986-1987 to the standard set by the Air NEPM and to the acceptance limits set by the screening procedures.

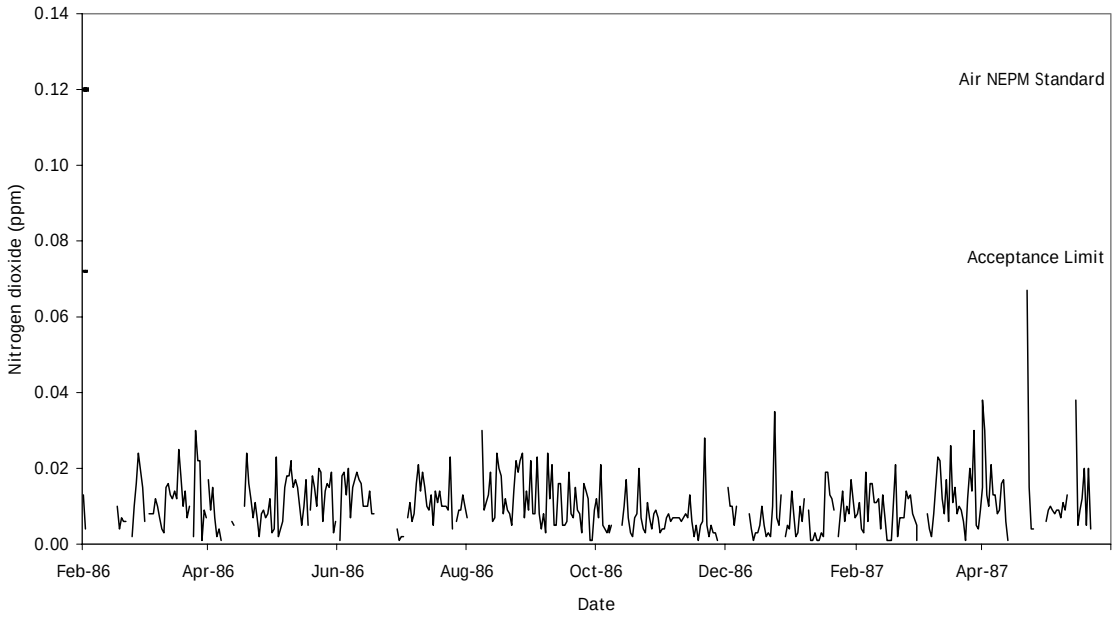

Figure 7: Nitrogen dioxide, daily maximum one-hour averages in 1986-1987

Ozone monitoring in Gawler, 1986-1987

One-hour average

For the 476-day period of monitoring in 1986-1987, the maximum one-hour average ozone concentration was 0.079 ppm. This is less than the Air NEPM Standard of 0.10 ppm.

One-hour average ozone concentrations exceeded the acceptance limit of 0.070 ppm specified for campaign monitoring sites on two days during the monitoring period.

Table 18 compares the statistics for the one-hour ozone concentrations during the two monitoring periods: 1986-1987 and 2002-2004.

The average obtained in the 2002-2004 monitoring period is slightly higher (2 ppb) than the average obtained in 1986-1987. This difference has been shown to be statistically significant.[2]

Figure 8 compares the daily maximum one-hour average ozone concentration in 1986-1987 to the Air NEPM Standard and to the acceptance limits set by the screening procedures.

[2] The means have been shown to be not equal at a probability of 99.999% by testing both untransformed data and log-transformed data using the student's 'T' test.

Table 18: Ozone, one-hour averages, statistics for monitoring periods

Period	Data recovery (% hours)*	Average (ppm)	Maximum (ppm)	Percentiles (ppm)** 99th	95th	90th
1986-1987	89	0.019	0.079	0.037	0.030	0.028
2002-2004	97	0.021	0.078	0.043	0.033	0.030

* Data recovery calculated for actual periods of monitoring, not calendar years

** Percentiles calculated from all one-hour averages, not from the peak daily one-hour averages

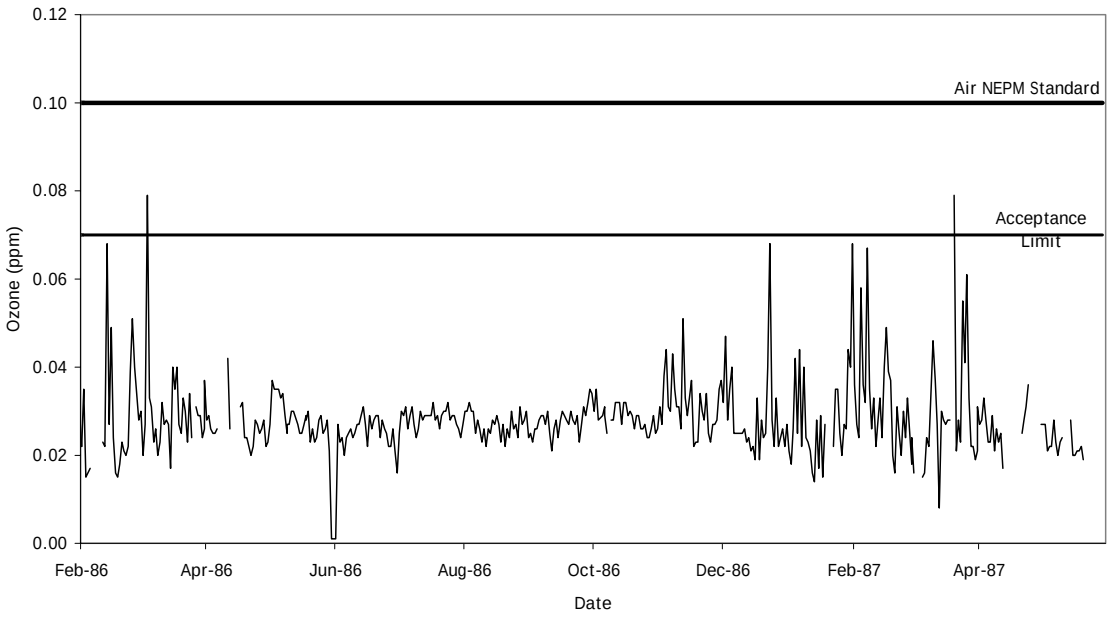

Figure 8: Ozone, daily maximum one-hour averages in 1986-1987

Four-hour average

For the 476-day period of monitoring in 1986-1987, the maximum four-hour average ozone concentration was 0.077 ppm. This is less than the standard of 0.08 ppm set by the Air NEPM.

Four-hour average ozone concentrations exceeded the acceptance limit of 0.056 ppm specified for campaign monitoring sites on two days during the monitoring period.

Table 19 compares statistics for the four-hour ozone concentrations of the two monitoring periods: 1986-1987 and 2002-2004.

The average obtained in the 2002-2004 monitoring period is slightly higher (2 ppb) than the average obtained in 1986-1987. This difference has been shown to be statistically significant[3].

[3] The means have been shown to be not equal at a probability of 99.999% by testing both untransformed data and log-transformed data using the Student's 'T' test.

Table 19: Ozone, four-hour averages, statistics for monitoring periods

Period	Data recovery (% hours)*	Average (ppm)	Maximum (ppm)	Percentiles (ppm)** 99th	95th	90th
1986-1987	89	0.019	0.077	0.037	0.030	0.027
2002-2004	99	0.021	0.069	0.042	0.032	0.029

* Data recovery calculated for actual periods of monitoring, not calendar years

** Percentiles calculated from all one-hour averages, not from the peak daily one-hour averages

Figure 9 compares the daily maximum four-hour average ozone concentration to the Air NEPM Standard and to the acceptance limit set by the screening procedures.

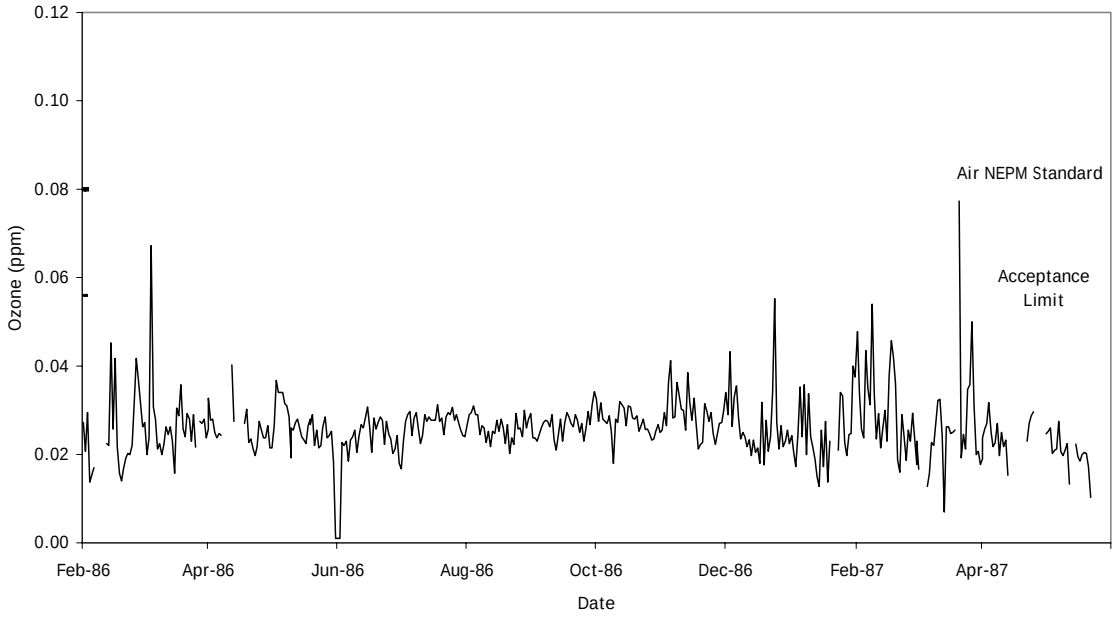

Figure 9: Ozone, daily maximum four-hour averages in 1986-1987

Particulate matter levels and airborne dust activity

Wind-blown dust carried by strong winds from the rural areas of South Australia is a significant cause of elevated particulate matter levels in South Australia. In 2004, two of the four days on which the Air NEPM Standard for particulate matter as PM_{10} was exceeded coincided with days on which DustWatch observers had reported dust storm activity in the Mid-North of South Australia; a third day coincided with reports of local blowing dust in Adelaide and Marla. (DustWatch is an Australia-wide network of volunteer observers who make observations about the timing and characteristics of dust storms; see <*www.griffith.edu.au/centre/riverlandscapes/dustwatch*>).

Figure 10 shows the 10-minute average data for particulate matter as PM_{10} obtained from the EPA monitoring site at Gawler and also from the EPA sites at Kensington

Gardens and Netley on 28 March 2004, the day on which the highest daily average particulate matter value was recorded at the Gawler site.

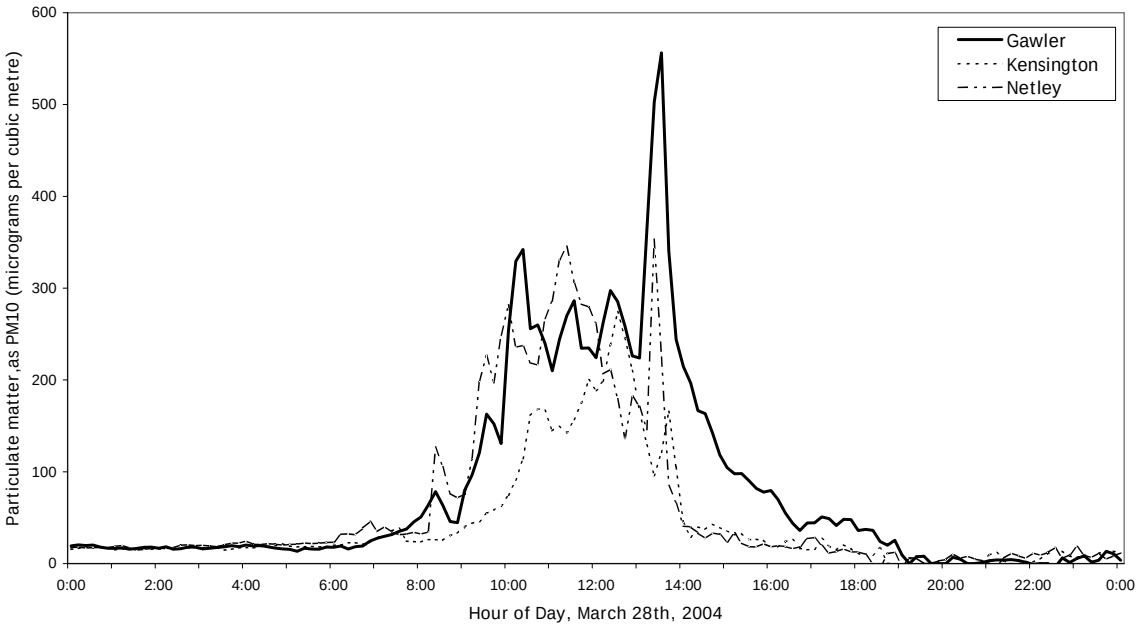

Figure 10: PM_{10} at Gawler, Kensington Gardens and Netley, 28 March 2004

This day started with light winds (4 metres/second) from the north-east overnight, trending to the north-west during the morning. There was a cool south-westerly change with moderate winds at about 1300 Australian Central Standard Time (ACST). The wind eased and changed to north-westerly at about 1600 ACST, then settled to a light westerly for the rest of the day

After a warm night with a minimum temperature of 24.2°C, the temperature warmed to a maximum of 33.3°C at 1100 ACST. The temperature fell sharply from 31°C at 1300 ACST to 24°C at 1400 ACST then declined to about 15°C in the evening.

Figure 11 demonstrates that the three EPA monitoring sites in the Adelaide airshed recorded elevated levels of particulate matter between the hours of 0900 and 1700 ACST, with peak levels between 1000 and 1400 ACST. On this day, the DustWatch observers reported dust storms in Yongala and Eudunda, local blowing dust in Warooka, Victor Harbor and Adelaide, and dust haze at Karoonda. This illustrates that climatic events can cause wind-blown dust and high particulate levels on an extensive scale throughout the State.

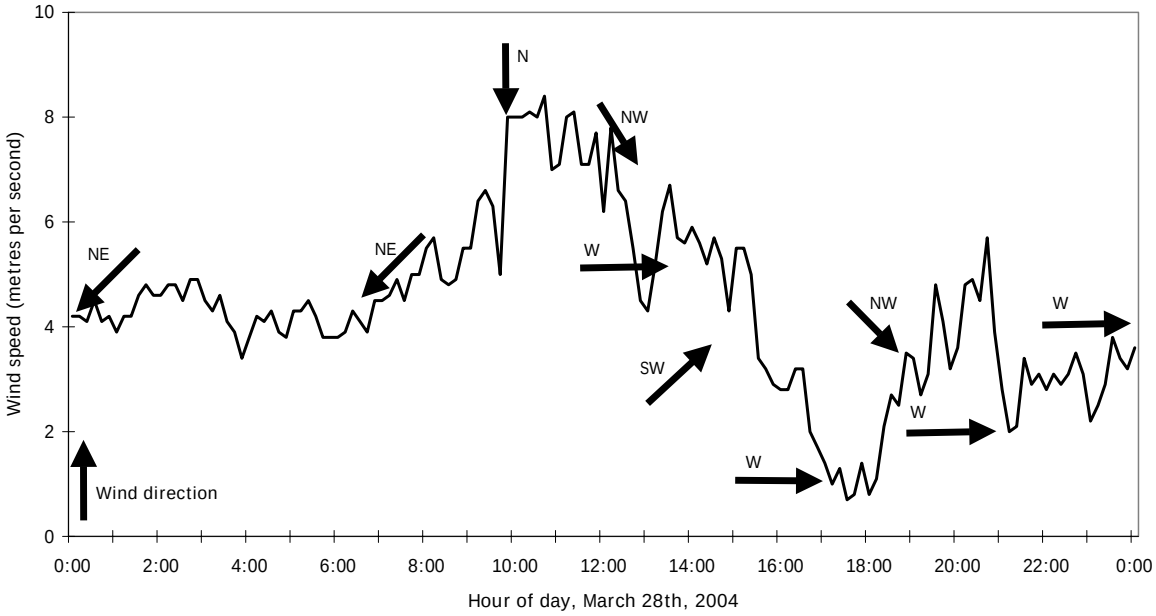

Figure 11: Wind speed and direction for 28 March 2004

CONCLUSIONS

The campaign in Gawler monitored nitrogen dioxide (for 1006 days), ozone (1016 days) and particulate matter, as PM_{10} (859 days) to determine if there was a continuing need for air quality monitoring in the township.

For ozone, the one-hour average and the four-hour average concentrations complied with the standards and goals of the Air NEPM. The acceptance limit specified for the one-hour average ozone concentration was exceeded twice in 2003 and once in 2004. The acceptance limit specified for the four-hour average ozone concentration at campaign monitoring sites was exceeded seven times in 2003 and twice in 2004.

Since the acceptance limits have been exceeded, the screening procedures state that it is desirable to continue monitoring for ozone in the township. Since the average ozone levels obtained in 2002-2004 are slightly (2 ppb) but statistically significantly higher than the averages obtained in an earlier monitoring campaign in 1986-1987. For nitrogen dioxide, the annual average and the one-hour average concentrations complied with the standards and goals of the Air NEPM and met the acceptance limits specified for campaign monitoring sites. The average hourly nitrogen dioxide level in 2002-2004 was slightly (1 ppb) but statistically significantly higher than the average level found in 1986-1987.

The screening procedures note that ozone distributions cannot be interpreted without data on nitrogen oxides, and recommend that nitrogen oxides should be monitored wherever ozone is monitored.

During the monitoring campaign, there were several days each year on which the daily average concentration of particulate matter, as PM_{10}, exceeded the standard set by the Air NEPM. As there were, on average, less than five days a year on which the standard is exceeded, the site meets the goal set by the Air NEPM. However, there were on average 19 days per year on which the daily average particulate matter concentration exceeded the acceptance limit specified in the screening procedures. It is desirable to continue monitoring for particulate matter, as PM_{10}.

The results of this monitoring campaign, and of the previous campaign, indicate that monitoring should continue for nitrogen dioxide, ozone and particulate matter, as PM_{10}.

APPENDIX 1: WIND ROSES FOR MONITORING SITE

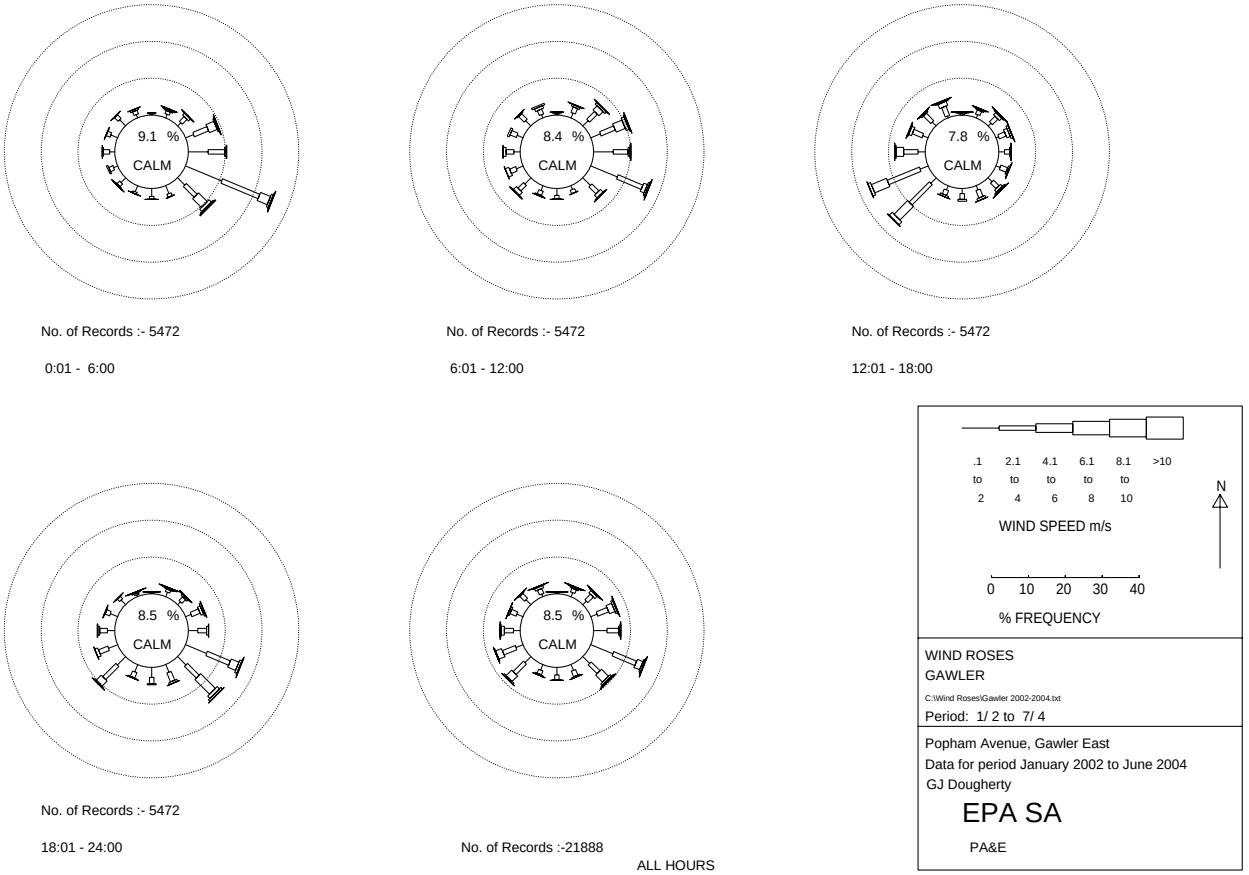

Figure 12: Wind roses for the monitoring period January 2002 to June 2004

APPENDIX 2: MONITORING SITE INFORMATION

Table 20: Metadata for Gawler monitoring site

Site name	Gawler
Map coordinates	
Datum	GDA 94
Projection	MGA 54
Easting	294647.4
Northing	6168702.7
Site elevation	85 metres
Street address	Popham Avenue, Gawler East
Date site established	8 January 2002
Date site terminated	22 October 2004
List of exceptions to siting guidelines (AS 2922-1987)	Trees adjacent along fence line of site
Surrounding land use	Residential; quarry at minimum distance of 600 metres to ESE
Nearby emission sources	Motor vehicles, area sources and quarry
Pollutants monitored	Nitrogen dioxide, ozone and particulate matter, as PM_{10}

Table 21: Australian Standard methods used at Gawler monitoring site

Nitrogen dioxide	AS 3580.5.1-1993 *Methods for sampling and analysis of ambient air – Determination of oxides of nitrogen – Chemiluminescence method*
Ozone	AS 3580.6.1-1990 *Methods for sampling and analysis of ambient air – Determination of ozone – Direct reading instrumental method*
Particulate matter, as PM_{10}, by TEOM	AS 3580.9.8-2001 *Methods for sampling and analysis of ambient air – Determination of suspended particulate matter, PM_{10} – Continuous direct mass method using a tapered element oscillating microbalance analyser*

Table 22: Data for instrumentation used at Gawler monitoring site

Pollutant monitored	Nitrogen dioxide
Instrument type	Nitrogen oxides monitor
Make	Monitor Labs/Ecotech
Model	EC 9841B
Serial number	Various (as maintenance and calibration requirements need)
Minimum detection level	0.1 parts per billion (ppb)
Measuring units	Parts per million (ppm)
Logging interval	10 minutes average
Clock adjustment	Australian Central Standard Time (without daylight saving)
Pollutant monitored	Ozone
Instrument type	Ultraviolet photometric ozone analyser
Make	Thermo Electron Corporation
Model	49C
Serial number	Various (as maintenance and calibration requirements need)
Minimum detection level	1 part per billion (ppb)
Measuring units	Parts per million (ppm)
Logging interval	10 minutes average
Clock adjustment	Australian Central Standard Time (without daylight saving)
Pollutant monitored	Particulate matter, as PM_{10}
Instrument type	Tapered element oscillating microbalance (TEOM)
Make	Rupprecht & Patashnick Co., Inc.
Model	1400 AB
Serial number	Various (as maintenance and calibration requirements need)
Minimum detection level	0.1 Pg/m^3
Measuring units	Micrograms per cubic metre (Pg/m^3)
Logging interval	10 minutes average
Clock adjustment	Australian Central Standard Time (without daylight saving)

ABBREVIATIONS

Air NEPM	National Environment (Ambient Air Quality) Protection Measure
ACST	Australian Central Standard Time: GMT plus 9½ hours
EPA	South Australian Environment Protection Authority
NEPM	National Environment Protection Measure
$PM_{2.5}$	particulate matter with an equivalent aerodynamic diameter of 2.5 Pm or less
PM_{10}	particulate matter with an equivalent aerodynamic diameter of 10 Pm or less
ppb	parts per billion (by volume)
ppm	parts per million (by volume)
PRC	Peer Review Committee of the National Environment Protection Council
TEOM	tapered element oscillating microbalance
TSP	total suspended particles
Pg/m^3	micrograms per cubic metre
Pm	micrometre

GLOSSARY

Average	Arithmetic mean: the sum of all the values in a set of data, divided by the number of values in the set
Exceedence	An occasion when a standard set under the National Environment (Ambient Air Quality) Protection Measure has been exceeded
Maximum	The largest value in a set of data
Median	The middle value in a set of data that has been placed in order from smallest to largest, or for a set with an even number of values the average of the middle two values
Percentile	A statistical parameter that represents the distribution characteristics of a set of data by using a value on a scale of 100 that indicates the percentage of the data points that are equal or lesser in value, e.g. 90% of the data points are equal to, or less than, the 90^{th} percentile
Tapered element oscillating microbalance	A method for determining airborne particulate matter

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