SmokeWatch Mount Gambier 2009 Winter Campaign Report

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Summary

- The SmokeWatch program in Mount Gambier is a successful collaborative partnership between the Environment Protection Authority (EPA), the City of Mount Gambier, the Firewood Association of Australia (FAA) and the Australian Home Heating Association (AHHA). Since its launch, SmokeWatch has also gained the support of several local schools, businesses and community organisations.
- SmokeWatch 2009 is the first phase of a three year program that integrates community education and air science campaigns to address concerns about wood smoke pollution in Mount Gambier, based on previous monitoring and community surveys.
- The partner organisations acknowledge the strong positive responses from newspaper, radio and television stations in Mount Gambier, which have given great support in broadcasting the important messages of the program.
- Monitoring at the Gordon Education Centre undertaken from 1 June–28 September 2009 confirmed previous results of poor winter air quality in Mount Gambier, pointing to the major contributions of wood smoke, in high concentrations of fine $PM_{2.5}$ particles[1], particularly during cold, still weather conditions overnight.
- The monitoring program also recorded episodes of coarser particles from other sources, possibly industry, development and agricultural activities in the region. The EPA is investigating the likely contributors to these episodes and will institute appropriate management programs accordingly. This may include further monitoring at other times of the year.
- Particle concentrations exceeded national standards on nearly one day in ten at the monitoring site during the monitoring period; however concentrations approached the standards on many more days.
- Overall, winter patterns of fine particle pollution are entirely consistent with the dominance of wood smoke on cold winter nights.
- The clear message contained in the monitoring results is that wood smoke is the major winter pollutant in Mount Gambier and indicates that programs to reduce smoke will achieve the most effective improvements in air quality. This provides the partners in SmokeWatch Mount Gambier with a strong focus for subsequent years of the program.

[1] PM can range in size, and for air quality, the most important sizes are PM_{10} and $PM_{2.5}$. PM_{10} particles, are 10 micrometres (µm) in diameter or smaller. $PM_{2.5}$ particles which are even smaller—2.5 µm or less in diameter—are often called ‘fine particles’ and also fit within the PM_{10} class.

1 Background

The SmokeWatch program was launched in the City of Mount Gambier on 24 March 2009 and is a collaborative partnership between the Environment Protection Authority (EPA), the City of Mount Gambier, the Firewood Association of Australia (FAA) and the Australia Home Heating Association (AHHA). Since its launch, SmokeWatch has also gained the support of several local schools, businesses and community organisations.

This program follows on from a pilot project undertaken in the winters of 2006 and 2007 in the Adelaide Hills, which combined community education with air monitoring and aimed at reducing wood smoke caused by the inefficient use of domestic wood heaters in the area. Evaluations of the pilot showed a general increase in efficient wood heater practices. There was also a general increase in the perceived importance of efficient wood heating, however residents still remained generally indifferent to the negative impact of wood smoke (EPA 2007 and 2008).

A revised approach to planning and delivering SmokeWatch is being undertaken from 2009 to 2011 in Mount Gambier, again integrating the education and science components, with the intent to use the science to underpin and reinforce the SmokeWatch key messages.

Ultimately, the program is about engaging the community and other relevant stakeholders to build awareness and understanding of local air quality, and promote broad ownership of wood smoke pollution. This program is not about blaming particular sectors of the community for poor air quality, but about spreading the message that everyone can do something to improve local air quality.

Background information from brief monitoring undertaken in 2001 and 2002, and long involvement of the EPA and its predecessors in Mount Gambier, have raised concerns that winter air quality may be compromised by smoke that can build up on still, cold winter nights, largely due to wood heater emissions.

The messages of the SmokeWatch program are clear: householders can reduce wood smoke from their wood heaters by observing how their wood heaters operate and by taking some simple actions to ensure a good, bright and hot fire. Not only will this improve air quality, but it will also save on fuel.

Air monitoring, as undertaken during 2009, provides Mount Gambier residents with current information to assess the impacts of wood smoke in the area, and provide feedback on the effectiveness of their collective actions in improving air quality over the life of the SmokeWatch program.

2 Objectives

The key objectives of SmokeWatch are to:

- raise community awareness of the environmental and health effects of inefficient wood heating
- build community understanding of the importance of following efficient wood heating practices to reduce unnecessary pollution, maximise home comfort, promote energy efficiency and reduce the health effects of wood smoke pollution
- advise wood heater users of the correct practices for efficient wood heater use
- develop and implement creative solutions to enable wood heater users to easily and conveniently follow the key practices to efficient wood heater use
- engage schools, businesses, organisations and key community groups in promoting clean air messages
- raise awareness amongst the community of the role of the EPA and the City of Mount Gambier in managing wood smoke pollution
- define the magnitude of the wood smoke problem
- measure the effectiveness of actions to reduce wood smoke through air quality monitoring.

3 Actions to date

The first year of SmokeWatch has focused initially on alerting the community to the program, the issue of wood smoke and its potential health effects. This has included:

- delivery of a community information session about the health effects of wood smoke pollution and key wood heater efficiency practices
- development and dissemination of a range of communication materials to wood heater users (including website information)
- publication of weekly air monitoring data through the local newspaper, and daily results available on the EPA website
- professional development sessions for school teachers about air quality (in particular wood smoke) through the AirWatch[2] schools program, and loan of air monitoring equipment to schools to undertake their own monitoring
- provision of opportunities for school students to view the air monitoring station and learn about the various instruments and what they measure
- approaching various stakeholders (relevant business, government and non-government organisations as well as schools) to become supporters of SmokeWatch and assist in the promotion of key messages
- supplying information to local firewood suppliers about becoming certified suppliers of sustainable firewood through the FAA
- undertaking air quality monitoring from 1 June to 28 September 2009.

SmokeWatch 2009 in Mount Gambier is continuing, with further work planned during November and December to build on current achievements. However, with the winter campaign completed, an evaluation of the performance of the 2009 program so far is provided in this report.

This program has been a highly successful collaboration between the EPA, the City of Mount Gambier, the AHHA and the FAA. Programs such as SmokeWatch rely heavily on the support and cooperation of local people, and SmokeWatch has so far shown how effective local participation can be, in initiating the implementation of a dynamic and effective program for change.

The enthusiastic participation of the local media has brought a further dimension of collaboration to SmokeWatch in Mount Gambier. ‘The Border Watch’ provided space for EPA’s weekly smoke graphs and local radio and television actively sought comment from EPA officers on the purpose and progress of the program.

The graphical summaries provided by EPA furnished the local community with up-to-date information confirming that there are times in winter when air quality in Mount Gambier is poor in comparison with national standards, and needs to improve.

[2] AirWatch is a school program also delivered through the EPA.

4 Future actions for 2009

While some community engagement activities have already been undertaken as part of the SmokeWatch program in 2009, a more comprehensive strategy is currently being developed for the next phase of the program to be implemented in November 2009. This is to ensure that the community and other stakeholders are given the opportunity to take an active role in the program, and that future program initiatives encompass aspirations, ideas and concerns from the community. In particular, the engagement process will enable community input into developing a vision statement and key actions, for improving local air quality particularly relating to wood smoke from domestic wood heaters. It will aim to ensure as many sectors of the community and key stakeholders as possible have the opportunity to share their views on local air quality, including the experiences of susceptible groups. Engagement activities will include:

- ‘open house’ displays to be held at central locations within the City of Mount Gambier to raise awareness of the program and gain feedback about community values, concerns and ideas for improving local air quality
- public conversations with local stakeholders to raise awareness about the program, identify any issues that are of relevance to these stakeholders and discuss potential for collaborative involvement in the program
- informal discussion groups and surveys with groups susceptible to wood smoke to explore health effects of wood smoke and subsequent actions.

5 The City of Mount Gambier—a snapshot

Mount Gambier is located in the south east region of South Australia known as the Limestone Coast. With a population of more than 24,000 within the city boundary, it is the largest regional urban centre in the state.

The Limestone Coast is renowned for being part of Australia's most extensive volcanic province (City of Mount Gambier 2009). Situated around a volcanic crater which has been dormant for the last 6,000 years, Mount Gambier's undulating topography means that cool, still conditions experienced in winter can lead to industry and residential emissions settling in the township.

Forestry is the largest industry in the surrounding region with log saw-milling and timber dressing the most common industries of employment in Mount Gambier (ABS 2006). This includes major timber processing plants at the eastern and western ends of the township.

In August 2008 an external research company was contracted by the EPA to undertake a telephone survey of 400 randomly selected residents in the City of Mount Gambier to gain an understanding of wood heater use to inform future education programs and allow for comparisons to be made in evaluating such programs.

The survey (Square Holes 2008) showed that 35% of respondents used wood heaters, of which for 86% used these were their main form of heating, typically the slow combustion heater (91%). This suggests that some 3000 wood heaters are in regular use in Mount Gambier. Of those surveyed, 19% indicated that wood smoke negatively impacts on them during the winter months, mainly in regards to the smell, health (asthma and breathing difficulties) and washing on the line (only 4% of these were wood heater users).

6 Air monitoring

The air monitoring component of SmokeWatch 2009 covered months of June to September, focussing on particles known as PM_{10} and $PM_{2.5.}$ The program encompassed most of the cooler months, during which very still, cold weather, known as 'inversion conditions' most often occur. An inversion acts like a lid, trapping smoke and other pollutants down near ground level, where they can build up to unacceptable levels, and where people can be exposed to them.

Results of this monitoring provide a 'snapshot' of air quality in Mount Gambier during one winter, and will also assist in evaluating improvements in local air quality over the life of the program. That said, actual pollution levels on any day are highly dependent on weather conditions, and weather can vary considerably from year to year, and even within a given year. Because of this, it is necessary to continue monitoring over several years to establish patterns of pollution and to evaluate the performance of management programs.

As noted previously, weekly air monitoring results were published in Mount Gambier's local newspaper, *The Border Watch.* This report details the final air monitoring results, and what these findings mean for future intervention strategies of the SmokeWatch program.

The EPA established the monitoring station at the Gordon Education Centre, in a residential area on the outskirts of the main central business district, as shown in Figure 1. This school was chosen to as far as possible, be representative of a wide area, and so as to avoid being too close to any individual sources of particles. The school sits near the outer western edge of the main valley of Mount Gambier which runs almost east to west and is relatively flat. Generally, winds from the east and west pass the site. With one other school nearby, a considerable number of students go to school in this part of town.

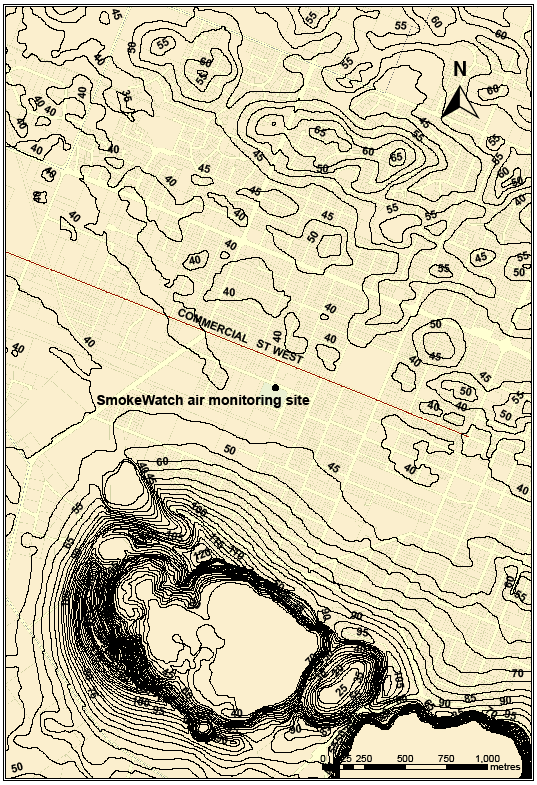

Figure 1 Map showing the SmokeWatch Mount Gambier monitoring site

What are particles?

Wood smoke is a product of incomplete combustion, and consists of very small particles which are made up of a complex mixture of solids, liquids and gases, so tiny they can float in the air for long periods of time. Collectively they are called particulate matter (or PM).

PM can range in size, and for air quality, the most important sizes are PM_{10} and $PM_{2.5}$. PM_{10} particles, are 10 micrometres (µm) in diameter or smaller. $PM_{2.5}$ particles which are even smaller - 2.5 µm or less in diameter - are often called 'fine particles' and also fit within the PM_{10} class.

Many of these fine particles are so small that they can penetrate into the deep areas of the lungs, and lodge in the tiny air sacs, where oxygen is absorbed into the blood stream. They also scatter light very effectively, so they cause the haze that we see in smoky conditions and make it difficult to see distant objects. This is similar to the effect we see as fog or clouds, which consist of tiny particles of water or ice. Wood smoke falls well within the $PM_{2.5}$ range, with particle sizes generally around 0.6 to 1 µm in diameter (Environment Australia 2002).

Particles of sizes between PM_{10} and $PM_{2.5}$ are often called 'coarse particles', and maybe written as PM_{10}-$PM_{2.5}$. Coarse particles may enter the nose and throat and the upper respiratory system, but cannot reach the deepest parts of the lungs. However, they may cause irritation, especially in sensitive people.

Research in Australia and overseas has shown strong associations between concentrations of PM_{10} and $PM_{2.5}$ particles, and respiratory and heart disease in humans.

Particles are emitted by a variety of sources, including domestic wood heaters and backyard burning, vehicle exhausts, many industrial processes and dust storms. Their effects on health depend on many factors including their size, number and their chemical composition.

Winter air quality in Mount Gambier 2009—a summary

SmokeWatch 2009 utilised three different, but complementary methods to characterise particles in Mount Gambier, backed up with continuous weather monitoring. The data was evaluated against national standards for particle air pollution set by the National Environment Protection (Ambient Air Quality) Measure (as amended in May 2004), known as the Air NEPM. This has standards for both PM_{10} and $PM_{2.5}$, and these are based on health risk. However, researchers have not been able to identify a lower limit for effects on humans. That means that there is still a risk to communities from fine particles at concentrations below the national standards.

Results were generally consistent with data obtained from a previous monitoring campaign undertaken in Mount Gambier in 2001-2002. This indicates that a unique combination of pollution sources and weather conditions continue to cause poor air quality in Mount Gambier over the long term. A detailed analysis of 2009 monitoring results is provided in Appendix 1.

Broadly, the monitoring record shows that on some days, both PM_{10} and $PM_{2.5}$ standards were exceeded at the site, while on others, an exceedence of one or the other standard was recorded.

These are important distinctions in understanding the sources of the particles, especially when read in conjunction with weather data. In summary, these results show that two different sources contribute to the results as measured at the site:

1. On those days showing only exceedences of the $PM_{2.5}$ standard, there is clear evidence that the particles are from wood smoke from wide areas of the town, usually on nights when weather conditions are quite still and cold; in other words, when there is an inversion that traps pollutants near the ground.
2. Where exceedences of both standards occur, data records show that this is virtually all attributable to wood smoke.
3. Where there is only an exceedence of the PM_{10} standard, this indicates a contribution from a source of coarse particles (PM_{10}–$PM_{2.5}$). This is generally associated with higher speed winds from directions shown in Figure 6.

The coarse particles are likely to be dust carried from a local industrial activity or brought into the town from wind blown soil. The EPA is investigating possible sources of this dust, and if it is shown to be from local industries, will develop appropriate programs to improve emissions.

Patterns of fine particle pollution are entirely consistent with the dominance of wood smoke on cold winter nights. The clear message contained in the monitoring results is that Mount Gambier's major winter particle pollutant is wood smoke, indicating that programs to reduce smoke will achieve the most effective improvements in air quality.

Figure 2 below is an example of weekly air monitoring results published in *The Border Watch* during the monitoring period.

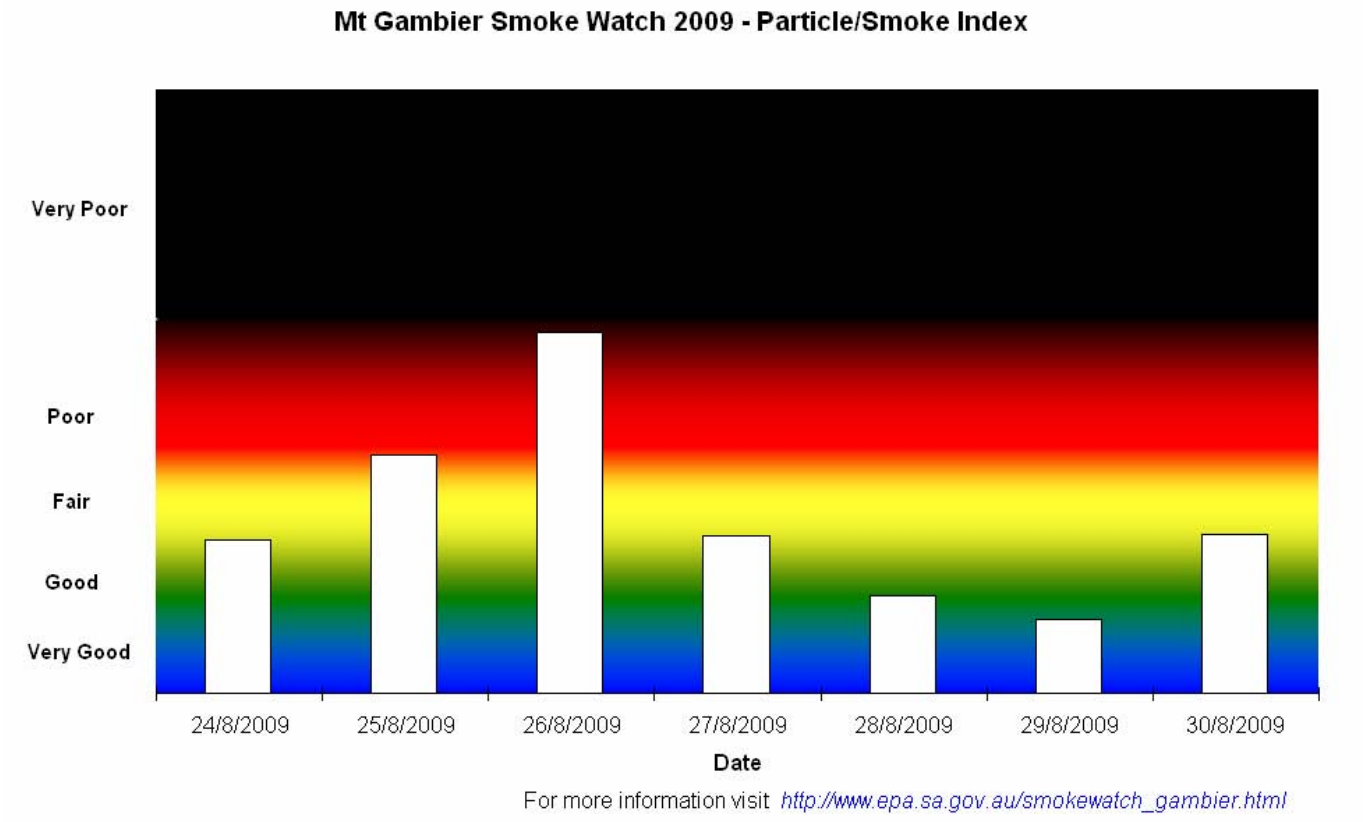

Figure 2 Example of air monitoring results published in *The Border Watch*

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Appendix 1 Air monitoring program

An overview—what does the air monitoring tell us?

The SmokeWatch 2009 winter campaign in Mount Gambier was designed to provide information on air quality over the cooler months of the year. Given this short program, EPA recorded a relatively large number of exceedences for particles at the school, compared with other areas of the State.

In summary:

- one or other, or both of the national 24-hour particle standards were exceeded on almost one in ten days
- recorded concentrations of particle pollution were close to the standards on about one in every four days.

Over half of the exceedences were directly attributable to smoke, most likely from the combustion of wood, from either residential burning or local industrial processes.

High levels of $PM_{2.5}$ from smoke occurred predominantly in the morning and evenings. This is entirely consistent with patterns of wood heater use, as shown by telephone surveys. For example, over half of wood heater users reported using their wood heaters mostly during the early evening (Square Holes, 2008). Vehicle traffic was also investigated as a possible source of particles, but the data indicates that it is not a major contributor to recorded particle concentrations.

Emissions of smoke from most wood heaters are also at their worst during lighting. In combination with still, cold weather (inversion conditions), high concentrations of smoke build up and persist for long periods. This is shown quite clearly by the data—high concentrations of $PM_{2.5}$ were recorded under just such conditions on at least six days.

The findings reinforce the importance of SmokeWatch as part of a broad collaborative strategy to minimise wood smoke pollution within the town. The City of Mount Gambier, the EPA and other partners have achieved much in bringing awareness of air quality issues to the community, but more remains to be done. For example, the 2008 telephone survey showed that many residents were adopting some positive efficiency measures, but less than half reported actually going outside to check their flue for smoke, so were unaware of whether their heaters were operating correctly.

The monitoring system also recorded exceedences of the PM_{10} national standard on four days when $PM_{2.5}$ concentrations were low and wind speeds were high. Clearly, this is coarse material (PM_{10} –$PM_{2.5}$) from other sources, picked up by the wind. Possible sources include industry, agriculture or land development. The EPA is investigating which sources are likely contributors and will institute appropriate management programs. Given the possibility of windy conditions in spring and summer, there may be a case for further ambient monitoring to understand whether PM_{10} is an issue at other times of the year.

SmokeWatch will continue in 2010 and 2011 to further refine the information about fine particles sources and reinforce smoke management programs in Mount Gambier. For example, other patterns of domestic burning such as backyard burning may also contribute significantly to poor air quality at various times of the year.

Analysis and interpretation of the monitoring data

Three types of instruments were used to gain an understanding of how much smoke was present in Mount Gambier during the air monitoring period, each providing different, but complementary information. These are described in more detail in Appendix 2:

- PM_{10} concentrations were measured continuously by an instrument called a TEOM
- $PM_{2.5}$ concentrations were estimated using a nephelometer
- a further instrument called an APS, or Airborne Particle Sizer, was used to record the proportions of various different sizes of particles in the air (called particle size distributions).

Weather monitoring equipment was also installed at the station to provide information on how wind (or the lack of it) influences patterns of pollution within Mount Gambier. The instruments measured wind speed and direction, air temperature and pressure continuously, allowing the EPA to match conditions to the levels and types of particles being recorded. The combination of the three particle monitors with weather instruments assisted the EPA to identify whether particles were from smoke, or whether other sources were also contributing to particle concentrations.

Monitoring data were evaluated in conjunction with continuous records of wind speed and direction and temperature for times of the day when high pollution events were detected. The various pieces of evidence were used to determine patterns of particle levels through out each day; and to indicate their likely sources.

The national standards for air pollution are established in the National Environment Protection (Ambient Air Quality) Measure, known as the Air NEPM. The standards were set on the basis of current knowledge to protect community health.

It is recognised that even if pollutant concentrations comply with the standards, there is still a risk to populations, as no lower level (threshold level) has been found for effects on human health. This is especially true of particles. Even at low levels, fine particle pollution is associated with measures of health effects, such as hospital admissions for respiratory conditions and heart disease.

Table 1 summarises the current standards and goals for both PM_{10} and $PM_{2.5}$ in Australia, based on 24-hour averages of monitoring data. $PM_{2.5}$ also has an annual standard, recognising impacts of long-term exposure to this pollutant. The goal sets the number of times the standard can be exceeded in a year, to cater for natural events. If more than the allowed number of exceedences occurs, it is expected that action will be taken to manage emissions.

The $PM_{2.5}$ standards are not ‘compliance standards’, but are nevertheless firmly based on health research, both in Australia and overseas. The Air NEPM is currently being reviewed and it is likely that full compliance standards will ultimately be adopted for $PM_{2.5}$.

Table 1 National air quality standards and goals in Australia

Pollutant	24-hour standard	Goal
PM10	50 μg/m3 [3]	Not more than 5 exceedences in a year
PM2.5	25μg/m3	Not applicable

Results for daily averages of $PM_{2.5}$ measured during the monitoring period ranged from 2.5 to 45.2 $\mu g/m^3$, with an average for the period of 9.4 $\mu g/m^3$. In comparison, results for daily averages of PM_{10} were higher, ranging from 9.9 to 84.6 $\mu g/m^3$, with an average for the period of 29.3 $\mu g/m^3$.

Particle sizes ranged from less than 1 to 15 µm, with a dominance of particles 4 µm and smaller. The particle size distribution did alter frequently throughout the study period however $PM_{2.5}$ dominated the results overall. The different particle sizes identified confirm there are multiple sources contributing to particle pollution in this region.

Exceedences of national air quality standards

Table 2 details the number of occasions when daily concentrations of PM_{10} and $PM_{2.5}$ exceeded the NEPM standards over the monitoring period.

PM_{10} did not meet its NEPM standard during the monitoring period, with seven exceedences of 50$\mu g/m^3$.

[3] $\mu g/m^3$ stands for micrograms per cubic metre.

Table 2 Number of days when particle levels exceeded NEPM standards (between June–September 2009)

Pollutant	Total exceedences of 24-hour standard (out of 120 monitoring days)
PM_{10}	7
$PM_{2.5}$	6

A detailed examination of the data (Table 3) shows that on some days, both standards were exceeded, while on others, an exceedence of one or the other standard was recorded. These are important distinctions in understanding the sources of particles, especially when read in conjunction with weather data.

Remembering that wood smoke falls within the $PM_{2.5}$ size range:

- those occasions when only the $PM_{2.5}$ standard was exceeded point to smoke pollution
- where only the PM_{10} standard was exceeded, this is evidence for another source of particle pollution, in the coarse size range (PM_{10}–$PM_{2.5}$)
- where both standards were exceeded, the evidence indicates that smoke is probably the dominant source.

Table 3 Days when particle levels exceeded NEPM standards

Date	24-hour average (rounded to nearest 1 μg/m^3) (exceedence days shaded)	
	PM_{10}	$PM_{2.5}$ estimate
15/06/2009	85	30
16/06/2009	51	45
17/06/2009	43	43
27/06/2009	49	45
07/07/2009	39	26
16/07/2009	37	32
03/08/2009	59	8
08/08/2009	53	13
12/08/2009	52	24
25/08/2009	53	6
26/08/2009	80	14

These results also indicate on almost one in ten days during the monitoring period, either the PM_{10}, the $PM_{2.5}$ standard or both, exceeded the NEPM standards at the site. In addition, on nearly one in four days, particle concentrations came close to the standards.

The overall values compare well with results of previous monitoring undertaken in Mount Gambier during 2001–2002, indicating that poor air quality is a persistent feature of winter in Mount Gambier.

The effect of weather on particle pollution

Wind speed

The weather patterns for the $PM_{2.5}$ exceedence days were typically cold and calm as is expected in winter, allowing smoke to build up rather than to disperse. An example of these conditions is shown in Figure 3; during periods of low wind speed the $PM_{2.5}$ concentration increases whereas during periods of higher wind speed the $PM_{2.5}$ concentration is almost zero. Note that the highest concentrations of $PM_{2.5}$ particles occur when the wind speeds are low, showing that these are built up during still conditions, especially during cold nights.

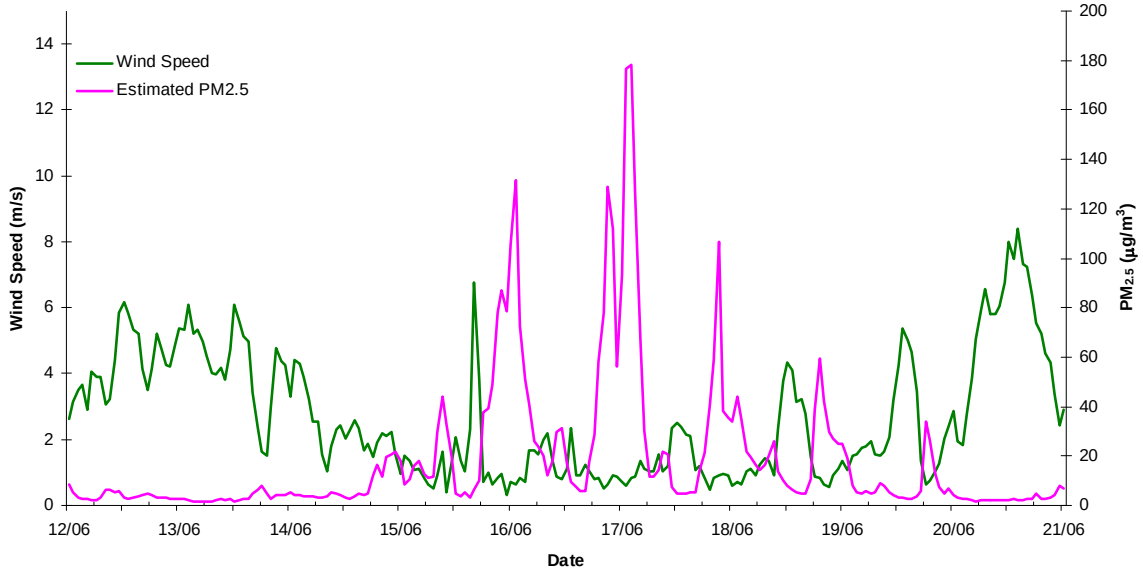


Figure 3 Comparisons of wind speed with $PM_{2.5}$ concentrations

Inversions, typified by cold, still, atmospheric conditions occur most often in June and July; the very weather conditions that trap smoke and allow particles to build up coincide with the periods when wood smoke emissions are generally at their highest, due to the high use of wood heaters.

With the onset of spring, both wind speed and temperature usually increase, and as summer approaches, drier weather conditions make episodes of wind blown dust more likely. These changes are evident in the monitoring results, with four of the five PM_{10} exceedence days in August not showing a strong component of $PM_{2.5}$. On these days, particle levels would have been made up of local sources of pollution, other than wood smoke, as well as those transported from much further away.

Figure 4 shows that on days of higher wind speed there was more impact from PM_{10}. This suggests industry, land development or regional wind blown dust are possible contributors.

Note that higher PM_{10} concentrations occur while wind speeds are also high, showing that this is most likely coarser material raised by the wind from nearby activities or the soil.

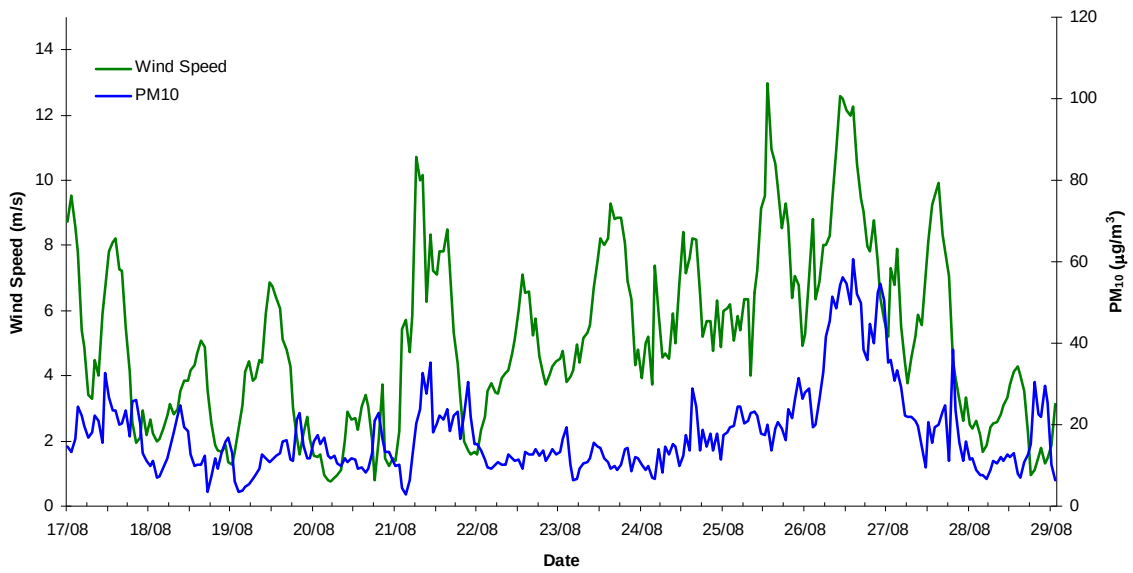


Figure 4 Comparisons of wind speed with PM_{10} concentrations

Wind direction

The wind direction when raised particle concentrations were recorded, also provide supporting evidence for likely sources. Figures 5 and 6 illustrate the quite distinct differences in patterns of PM_{10} and $PM_{2.5}$. They show the directions from which the wind was blowing when higher-than-average particle concentrations were recorded.

Figure 5 shows that $PM_{2.5}$ concentrations were generally increased when the wind blew from the north east than from other directions. Much of the residential area of the town is to the north and north-east of the station. The recorded particle sizes are consistent with smoke, and as most of the episodes also occur when wind speeds are low (Figure 3), the clear implication is that particles are from domestic smoke, most probably from wood heaters.

In contrast, Figure 6 shows that higher concentrations of PM_{10}, representing coarse particles, often occurred when winds were blowing from the west towards the station. There are some industries and agricultural activities to the west, both of which could contribute to coarse particles, especially during windy conditions. The EPA is currently investigating the significance of each, so that appropriate management programs can be put in place.

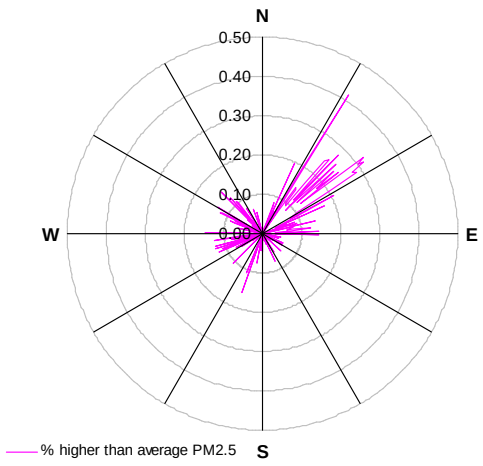


Figure 5 Direction of higher than average $PM_{2.5}$ concentrations for the period 01/05/2009 to 06/09/2009

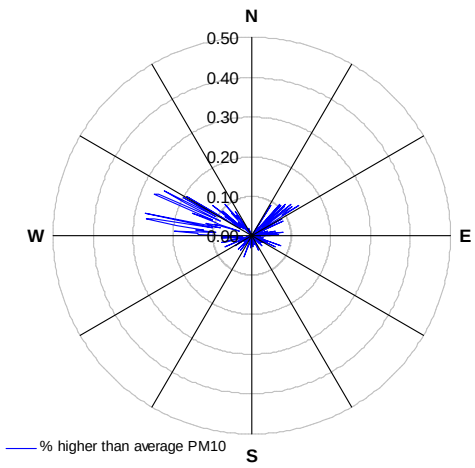


Figure 6 Direction of higher than average PM_{10} concentrations for the period 01/05/2009 to 06/09/2009

Time of day for increased particle levels

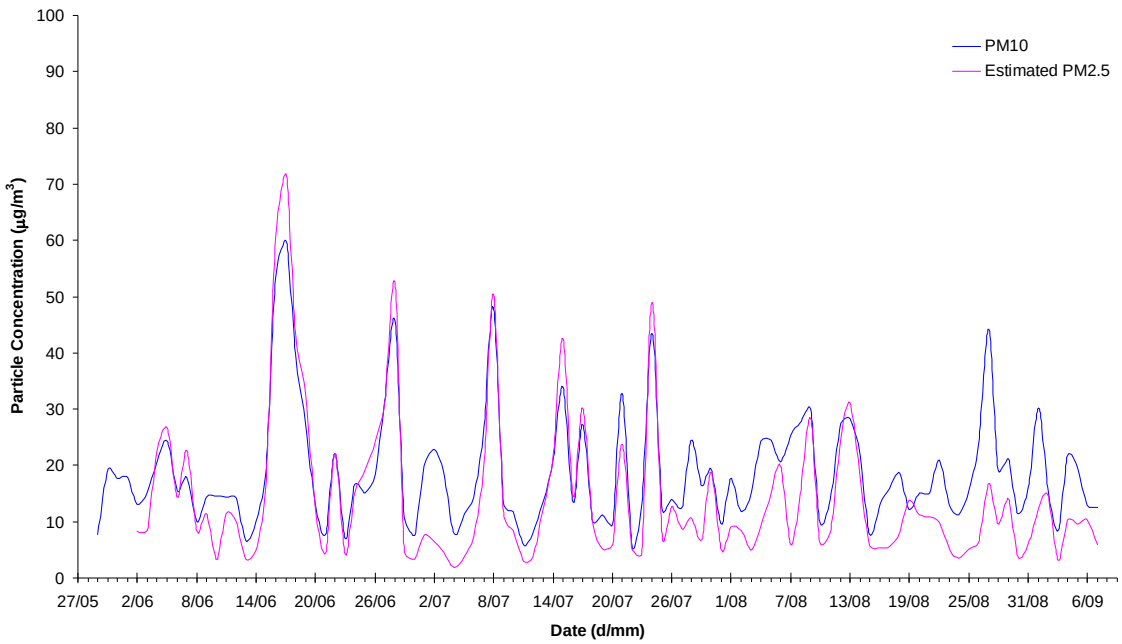
Figures 7 and 8 show the different patterns of particle pollution during the evening and daytime.

Figure 7 shows a very strong match between PM_{10} and $PM_{2.5}$, indicating that on many evenings the particles recorded at the station are virtually all $PM_{2.5}$.

Figure 8 still shows a match in the timing of PM_{10} and $PM_{2.5}$ peaks during the day, but $PM_{2.5}$ concentrations are clearly much less than those recorded for PM_{10}. This indicates that domestic wood burning makes less of a contribution to particle pollution during the day, probably for two reasons:

- people use their heaters less during the day
- temperatures and wind speeds are higher during the day, allowing the smoke to be blown away or disperse more effectively than at night.

These observations provide further evidence that this is smoke from fires being started during the evening, when people normally light-up their wood heaters. This pattern of wood heater use is supported by 2008 telephone survey results.



Note: estimated $PM_{2.5}$ does show $PM_{2.5} > PM_{10}$, describing events that are entirely $PM_{2.5}$.

Figure 7 Particle events during the evening (4 pm to midnight)

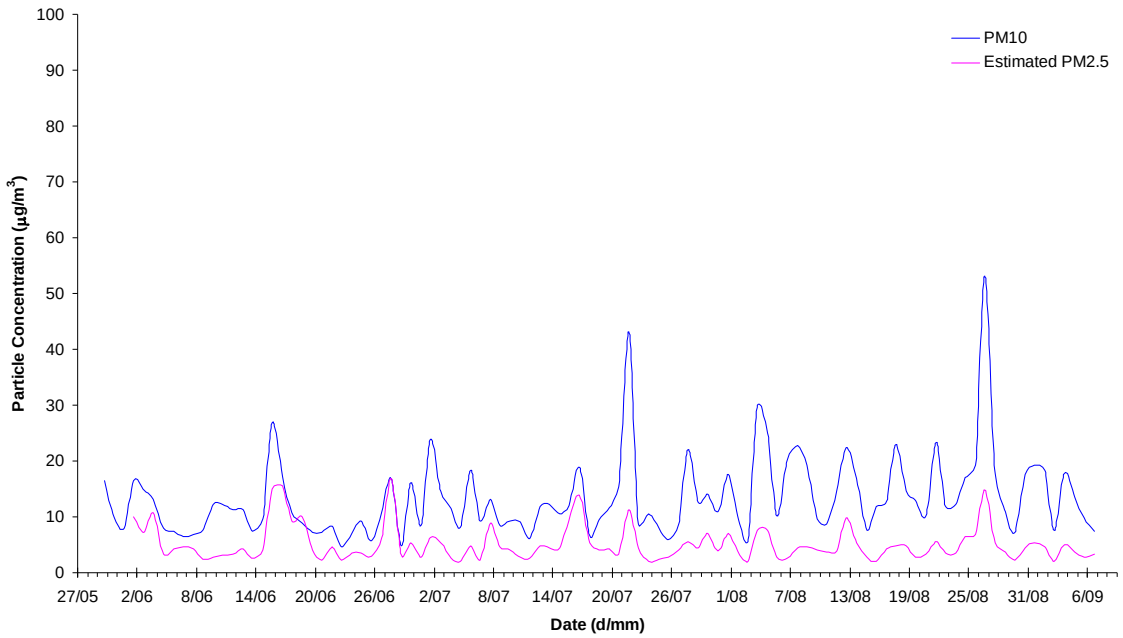


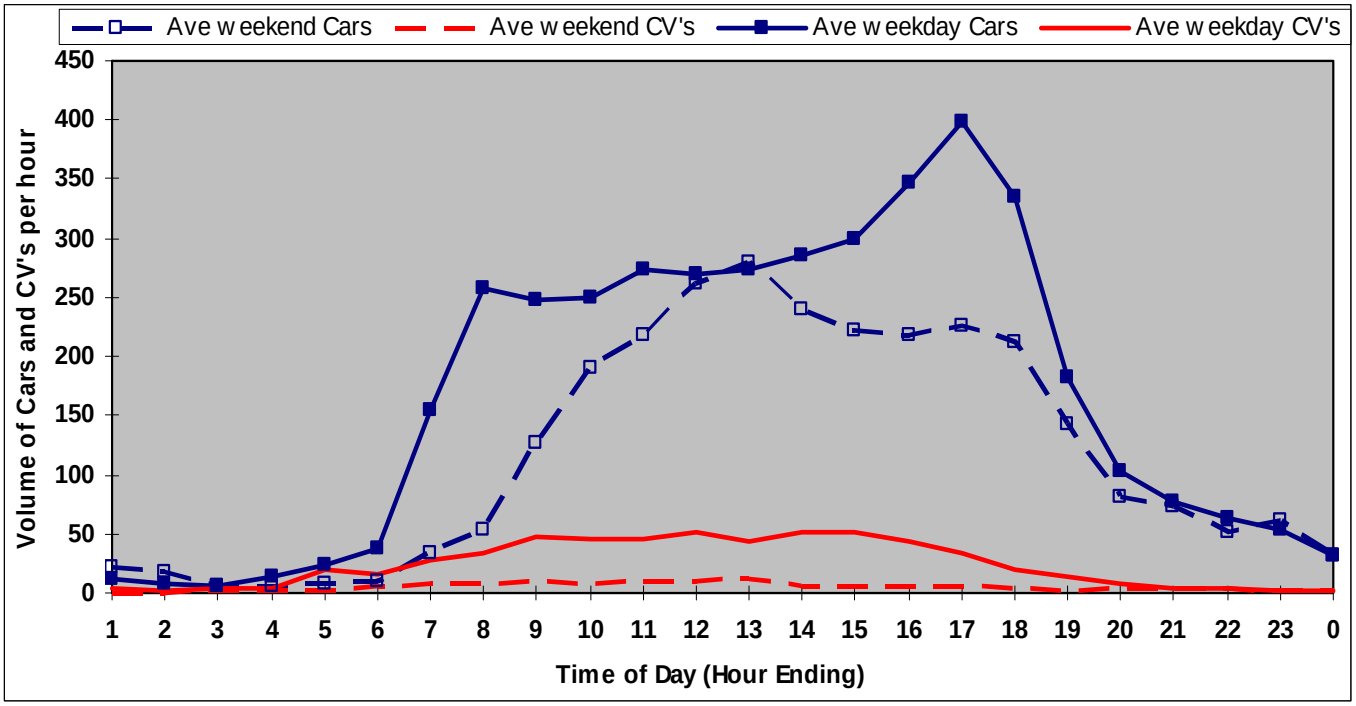
Figure 8 Particle events during the day (8 am to 4 pm)

The effect of traffic on particle pollution

Vehicles are also a source of $PM_{2.5}$ particles, so the potential contribution of traffic was investigated using estimates based on an analysis of survey[4] data obtained from the Department for Transport, Energy and Infrastructure (DTEI) for the monitoring period.

Figure 9 shows the results of this analysis, providing a snapshot of average traffic flows for weekdays and weekends. The pattern of traffic for cars and commercial vehicles (CV's) between 7 am and 7 pm suggests that some exhaust emissions may be trapped by the inversion in the critical period from 8 pm to midnight, but the major vehicle activity is during the day. It is argued that traffic emissions build up too late in the morning and taper off too late in the evening to contribute significantly to morning or evening $PM_{2.5}$ episodes.

[4] DTEI 2009, 7-day classification count VD775149/Site no. 5722, 8/7/09–14/7/09



(DTEI, 2009, 7-day classification count VD775149/Site no. 5722, 8/7/0–14/7/09)

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Figure 9 Average weekday and weekend traffic flow

Appendix 2 Glossary

PM_{10}	Particle matter less than 10 μm (micrometres) in aerodynamic diameter (includes $PM_{2.5}$). Also includes the fraction between $PM_{2.5}$ and PM_{10} referred to as the coarse fraction.
$PM_{2.5}$	Particle matter less than 2.5 μm in aerodynamic diameter
NEPM	National Environment Protection Measure

Appendix 3 Instruments and methods

Monitoring undertaken in Mount Gambier used the following instrumentation:

PM_{10}

TEOM 1400a Tapered Element Oscillating Microbalance (AS 3580.9.8–2001)

The TEOM was used to determine the PM_{10} concentrations in air. The values were adjusted for temperature as per the National Peer Review Committee recommendations as to the use of a TEOM in climates that are cold and likely to have smoke. A site specific adjustment was made as per the technical paper.

$PM_{2.5}$

Nephelometer—Radiance Research (AS 2724.4–1987)

The nephelometer was used as a surrogate method to determine a value for $PM_{2.5}$ within a smoke prone region. The nephelometer measures the scatter of light and through a mathematical conversion is able to estimate the $PM_{2.5}$ mass concentration. This was further confirmed by the Aerodynamic Particle Sizer.

Particle sizes

TSI APS 3321—Aerodynamic Particle Sizer

This instrument was used to obtain a particle size distribution in the air. It allows us to determine the particle size that is most prevalent and provide some information as to the nature of the particles in the air. It was also used to confirm the accurate determination of the conversion of the nephelometer values to $PM_{2.5}$.

Weather conditions

Vaisala Meteorology Equipment (AS 2923–1987)

A Vaisala ultrasonic anemometer was used to determine the wind speed and direction near the site. The height of the tower used was 10 metres to provide a more accurate measurement of regional air movements.