AIR QUALITY DURING THE 2006–07 VICTORIAN BUSHFIRES

Publication 1187 December 2007

EXECUTIVE SUMMARY

Bushfires impact on air quality and human health. Victoria is one of the most fire-prone regions in the world – approximately 1.2 million hectares were burnt during the major bushfires between December 2006 and February 2007. With climate change predictions indicating an increase in the risk and severity of bushfires, large-scale smoke impacts similar to those of the summer of 2006–07 may become more commonplace in Victoria.

During the 2006–07 bushfires, EPA installed additional monitoring stations in populated areas closer to the fires (at Wangaratta and Bairnsdale, augmenting the existing Victorian network of 15 stations) to assess the massive impact these fires had on Victorian air quality. This equipment analysed the level of bushfire smoke and compared these measurements to Victorian and Australian air quality objectives.

EPA collected data to assess the levels of particles smaller than 10 micrometres, visibility-reducing particles and ozone; key indicators of bushfire smoke that affect human health. EPA's air monitoring program during the bushfires assisted people in making informed decisions to protect their health on smoke-affected days.

Prevailing winds and fire conditions meant that a large area of Victoria was impacted by the bushfires. Melbourne, Geelong, the Latrobe Valley and East Gippsland were the worst affected areas.

All regions had high levels of particle pollution. For example, in a typical summer Melbourne would expect to have only one or two days with high levels of fine particles, but during the bushfires 15 days were affected. Melbourne, Geelong and the Latrobe Valley also experienced high levels of ozone.

EPA, with assistance from the Bureau of Meteorology and the Department of Sustainability and Environment, forecast the smoke impacts from the fires. EPA worked with the Department of Human Services to alert Victorians to the potential health effects and cautionary actions that could be taken.

EPA will continue to work with the Department of Human Services to better understand the health impacts of bushfires and to monitor and advise the community.

Figure 1: Melbourne's central business district affected by bushfire smoke during December 2006. **Photo: Paul Rovere courtesy of *The Age***

BUSHFIRES IN VICTORIA

Victoria is one of the most fire prone regions in the world and bushfires are an inherent part of the Victorian environment. In southern Australia major fires generally occur during drought periods, associated with *el Niño* events that have a direct effect on Australia's rainfall.

Victoria has had a number of severe bushfires during the past 100 years, including 1939 (Black Friday), 1983 (Ash Wednesday), 2002–03 (NE Victoria) and the recent 2006–07 bushfires. The 2006–07 bushfires were amongst the most severe bushfires on record. Among the many impacts of these fires were high levels of air pollution across Victoria, including Melbourne (Figure 1).

2006–07 BUSHFIRES

There were numerous major fires in Victoria between December 2006 and February 2007. Lightning strikes on 1 December sparked initial blazes in Victoria's Gippsland and north-eastern regions. Around 50 separate fires joined to form large fire fronts (Great Divide Complex) that burnt until early February. The most severe fire outbreaks occurred on 31 December – 1 January and 21–22 January, when temperatures across the state exceeded 40 °C.

The extent of area burnt in north-east Victoria is shown in Figure 2. Approximately 1.2 million hectares were burnt, with north-east Victoria, Gippsland and the Alpine areas most severely affected. Smoke from large fires burning in Tasmania and King Island also affected Victoria's air quality during the summer of 2006-07.

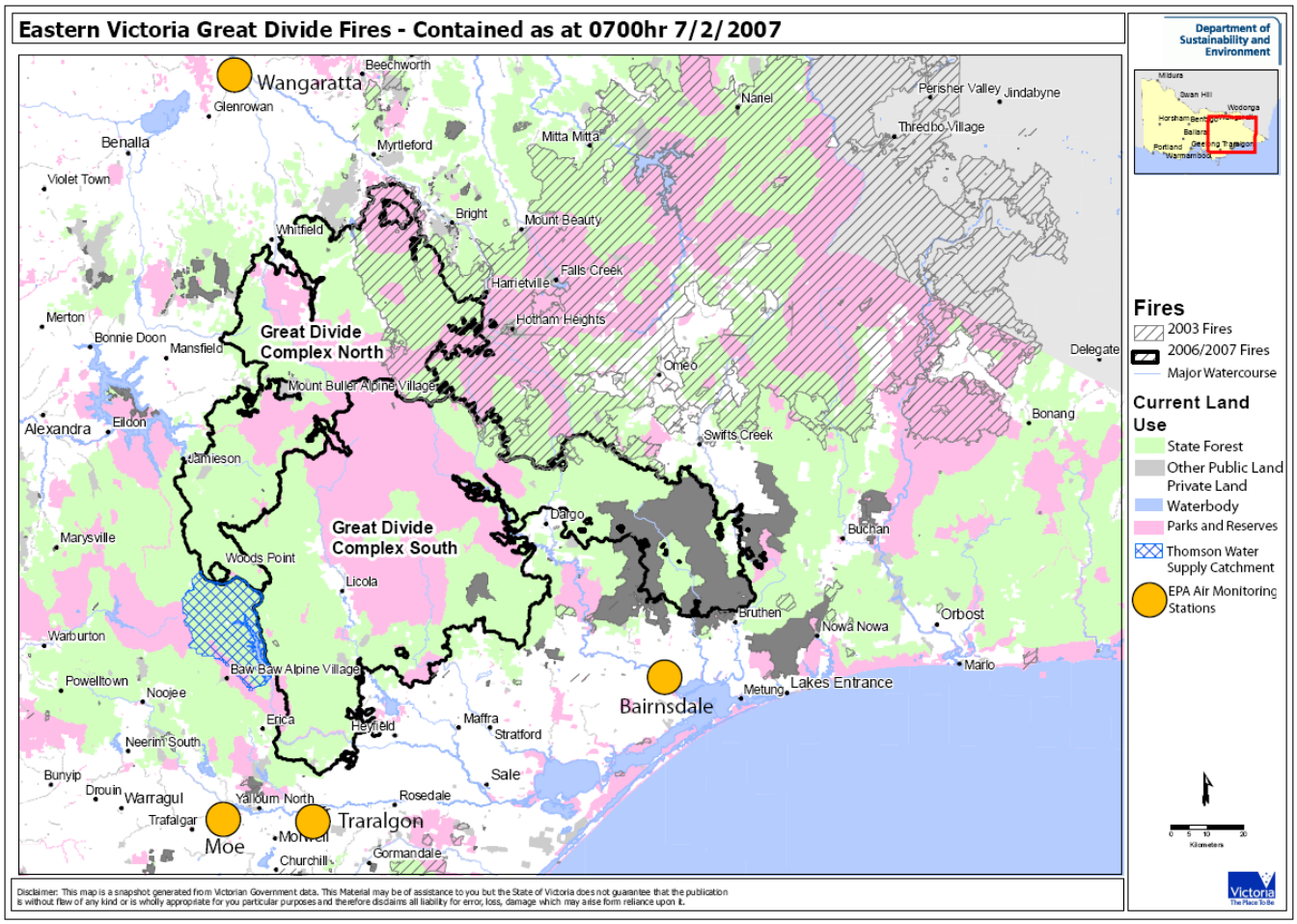

Figure 2: Map of north-eastern Victoria, showing areas burnt during 2006–07 (bold outline) and 2002–03 bushfires (grey cross-hatching). Land use type is shown in colour and EPA air monitoring stations shown by orange dots. (Modified map courtesy of the Department of Sustainability and Environment (DSE) www.dse.vic.gov.au)

EPA VICTORIA

EPA'S BUSHFIRE RESPONSE

1. Where did EPA monitor?

In December 2006 EPA had 15 air quality monitoring stations across Victoria (10 in Melbourne, two in Geelong, two in the Latrobe Valley and one in Warrnambool)[1]. In response to the bushfires, EPA installed air quality monitoring equipment in populated areas close to the fires.

Monitoring commenced at Bairnsdale (Figure 3) on 9 December and Wangaratta (Figure 4) on 13 December. EPA commissioned a further mobile monitoring station at Macleod (a northern suburb of Melbourne) on 19 December, with the potential for deployment to bushfire areas if required. New instrumentation to monitor visibility-reducing particles was also added to the existing monitoring station at Richmond.

Figure 3: Mobile air monitoring station at Bairnsdale, 9 December 2006

Figure 4: Mobile air monitoring station at Wangaratta, 13 December 2006

[1] EPA air monitoring network: www.epa.vic.gov.au/air/bulletins/airmonlc.asp

2. What did EPA monitor?

The key pollutants monitored by EPA during the bushfires were particles (both as PM_{10} – particles smaller than 10 micrometres – and visibility-reducing particles) and ozone. The actual composition of bushfire smoke depends on the vegetation type, the temperature of the fire and wind conditions. Particles and ozone are the main pollutants of interest during bushfire events, as they are indicators of bushfire smoke and its impact on human health.

Particles smaller than 10 micrometres (PM_{10}) can be absorbed into the lungs, which can impact on people's health, especially those who have existing respiratory illnesses or heart disease. Children and the elderly may be more vulnerable to the effects of particles.

Visibility-reducing particles can reduce visual distance and aesthetic enjoyment and, due to their small size, can also be absorbed deep into the lungs and impact on human health. Visibility measurements give an indication of how far the average person can see, with the objective being a minimum visual distance of 20 km.

Ozone is an irritant gas that can impact on the respiratory system. Asthmatics and the elderly are particlularly sensitive to the effects of ozone. It exists naturally in the earth's atmosphere (the ozone layer), but can also cause problems when it occurs in high concentrations at ground level during pollution events.

Due to improved pollution controls on cars and industry, elevated levels of ozone are now uncommon in Melbourne. However bushfires produce the ingredients (oxides of nitrogen and hydrocarbons) necessary to form ozone.

Levels of pollutants monitored during the bushfires were compared against Victorian and Australian air quality objectives[2] (Table 1). The objectives for PM_{10} and ozone have been set to protect human health and well-being. The objective for visibility-reducing particles has been set to maintain visual amenity. In this report PM_{10} and ozone results that did not meet the air quality objectives during the bushfires are referred to as high. Visibility is referred to as poor when it did not meet the objective.

Table 1: Air quality objectives

Pollutant	Averaging period	Objective
Particles as PM_{10}	24 hour	50 µg/m^3
Visibility-reducing particles	1 hour	20 km
Ozone	1 hour	100 ppb

[2] *State Environment Protection Policy (Ambient Air Quality)* (SEPP), available from www.epa.vic.gov.au/about_us/legislation/sepps.asp

3. What are the health effects of bushfires smoke?

A number of overseas studies have shown health effects from bushfire smoke. These effects are most pronounced in sensitive groups such as those with asthma or other respiratory problems. Studies in Australia have so far been inconclusive, perhaps because of low study populations.

An investigation by the Department of Human Services (DHS) of the north-east Victorian region during the 2002–03 bushfires did not find any noticeable change in hospital admissions for respiratory disease during the smoke-affected periods. However, bushfire smoke is fundamentally a combustion product, similar in many respects to smoke from domestic wood heaters. Smoke from wood heaters is known to cause health problems in both indoor and outdoor environments.

A comprehensive health study of the 2006–07 fires is currently being undertaken by EPA, DHS and St. George's Hospital, London to fully investigate the health effects of the recent bushfires. Further information on bushfire smoke and your health is available from the Emergency Management section of the DHS website[3].

ADVICE TO THE COMMUNITY

1. Forecasting smoke impacts

EPA Victoria provides daily forecasts of air quality for Melbourne and Geelong. During the 2006–07 bushfires EPA expanded this forecasting to include smoke advisories. The Bureau of Meteorology's smoke dispersion model and DSE burn maps were used in conjunction with direct contact with Bureau of Meteorology senior forecasters and DSE fire management officers to assist in forecasting areas likely to be affected by smoke. EPA also used daily satellite imagery from MODIS[4] and Sentinel Hotspot[4] data to track smoke movement across Victoria.

2. Smoke advisories and cautionary advice

EPA worked closely with DHS during the bushfires to issue bushfire smoke advisories and communicate these through the media (Table 2). These advisories were based on visibility and PM_{10} measurements, as they are a good representation of potentially harmful fine particle pollution and can be easily measured and communicated.

[3] Public Health Information: *Bushfire smoke and your health,* available from www.health.vic.gov.au/environment/emergency_mgmnt/

[4] MODIS Rapid Response Project (NASA/GSFC) http://rapidfire.sci.gsfc.nasa.gov/ and Sentinel Hotspot information http://sentinel.ga.gov.au

The advisories (given in Appendix 1) help people to make informed decisions and take appropriate action on smoke-affected days. Further information is available on the EPA[5] and DHS websites

Table 2: Smoke alert categories

Smoke alert category	Visibility (km)
Low	Greater than 10 km but less than 20 km
Moderate	Greater than 5 km but less than 10 km
High	Less than 5 km

Refer to Appendix 1 for cautionary actions and advice.

3. How can I find more information on air quality?

More information on air quality, including real-time information and 24-hour summaries, can be found on the EPA website[6]. EPA issues twice-daily air quality bulletins and forecasts the expected air quality for the next 24 hours for Melbourne and Geelong. Forecasts and air quality summaries are also published daily in the weather sections of *The Age* and *Herald Sun* newspapers.

HOW WAS VICTORIA'S AIR QUALITY AFFECTED?

1. What areas were affected by smoke?

A significant part of Victoria was affected by smoke from the bushfires. Prevailing winds and local weather patterns determined which areas were affected on a day-by-day basis.

Due to the location of the fires, Melbourne and Geelong were predominantly impacted by bushfire smoke when the winds were easterly. North-eastern Victoria was impacted by smoke under southerly winds, while the Latrobe Valley and East Gippsland were impacted by smoke under northerly winds (Figure 5). Warrnambool was also affected by smoke from fires in King Island and Tasmania during February. The MODIS satellite images below show the extent of smoke across Melbourne and eastern Victoria on 9 January 2007 (Figure 6). These photos also show the difference between clouds and smoke as observed from satellite imagery.

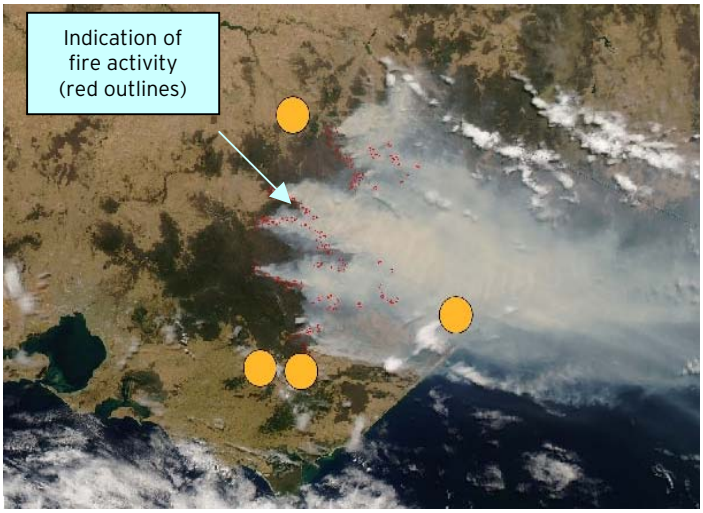

Figure 5: Bushfire smoke transport over eastern Victoria under north-westerly winds, 18 December 2006. Red outlines indicate fires (not actual size). EPA regional monitoring stations are shown by orange dots (Melbourne and Geelong not shown). (Images courtesy of MODIS Rapid Response Project at NASA/GSFC)

2. Particle pollution

All monitored regions experienced high levels of particle pollution as a direct result of the bushfires (Figure 7). The maximum PM_{10} particle levels recorded were up to five times greater than the objective of 50 µg/m^3 (Table 3).

The greatest impacts were seen in north-east Victoria and the Latrobe Valley, which were closest to the fires. In a typical summer, Melbourne would expect to have only one or two days of high PM_{10} particle pollution.

Fine particle pollution also heavily affected local visibility in all regions (Figure 8). North-east Victoria experienced nine consecutive days of poor visibility (below 20 km of visual distance) from 13–21 December. These extended periods heavily impacted on daily activities in the smoke-affected areas. The poorest visibility was recorded in Wangaratta on 13 December with local visibility being reduced to approximately 400 m (Table 3).

[5] Further information on 'Bushfires and Air Quality' is available at www.epa.vic.gov.au/air/bushfires/

[6] EPA air quality bulletins are available at www.epa.vic.gov.au/air/bulletins/default.asp

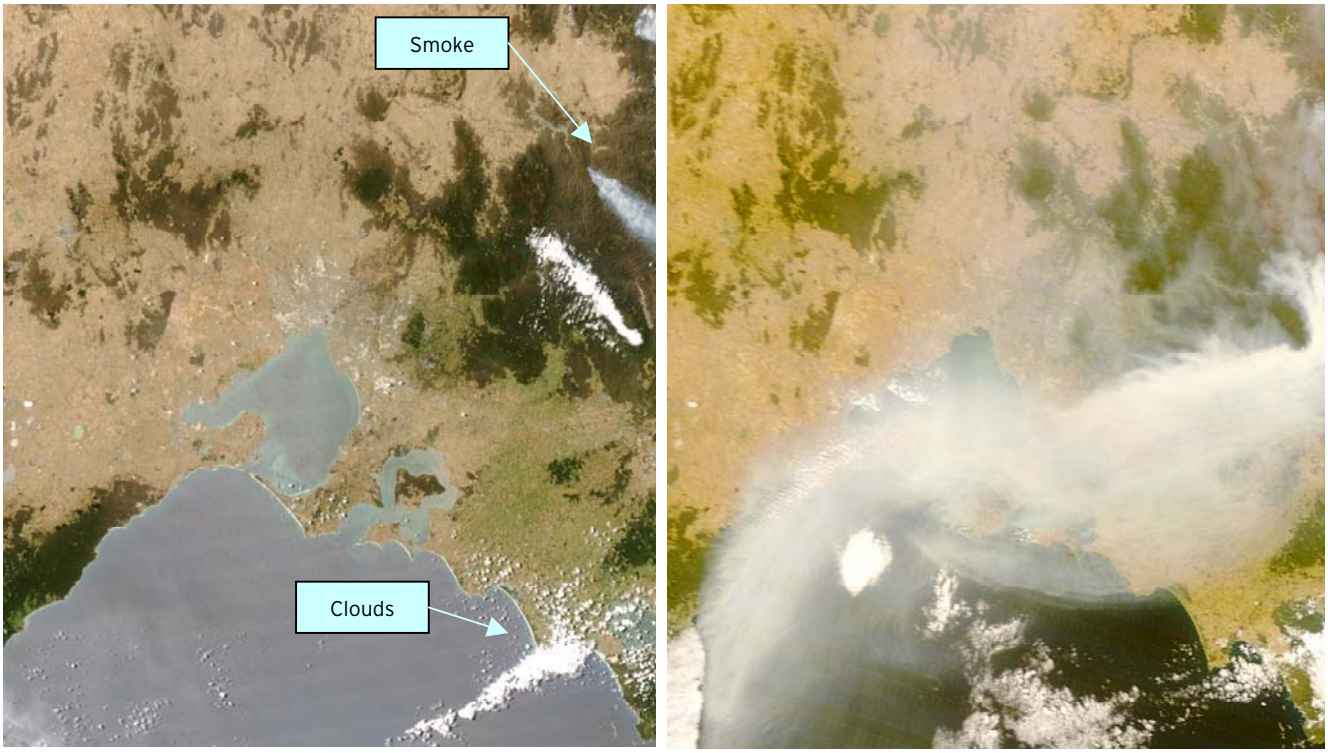

Figure 6: Satellite images of smoke from fires in north-eastern Victoria:
a) Clear skies over Melbourne, 6 December 2006 b) Bushfire smoke over Melbourne, 9 January 2007
(Images courtesy of MODIS Rapid Response Project at NASA/GSFC)

Table 3: Number of high days of particle pollution for each monitored region between 1 December 2006 and 31 January 2007. High PM_{10} days are days greater than 50 µg/m³. Poor visibility days are days of visibility less than 20 km.

	PM_{10}		Visibility Reduction	
Region	**Number of high PM_{10} days**	**Highest 24-hour average PM_{10} reading (µg/m³)**	**Number of poor visibility days**	**Minimum visibility (km)**
NE Victoria (Wangaratta)	17	213 µg/m³ (19-Dec-06)	23	0.4 (13-Dec-06)
Latrobe Valley	16	254 µg/m³ (14-Dec-06)	20	0.5 (21-Dec-06)
Melbourne	15	220 µg/m³ (20-Dec-06)	24	1.2 (10 Jan-07)
Geelong	11	116 µg/m³ (22-Dec-06)	15	1.9 (21-Dec-06)
East Gippsland (Bairnsdale)	9	194 µg/m³ (14-Dec-06)	Not monitored	Not monitored
SW Victoria (Warrnambool)	3	67 µg/m³ (21-Dec-06)	7*	4.7 (10-Jan-07)

* Visibility did not meet the objective on a further three days at Warrnambool due to fires burning in Tasmania and King Island in February 2007.

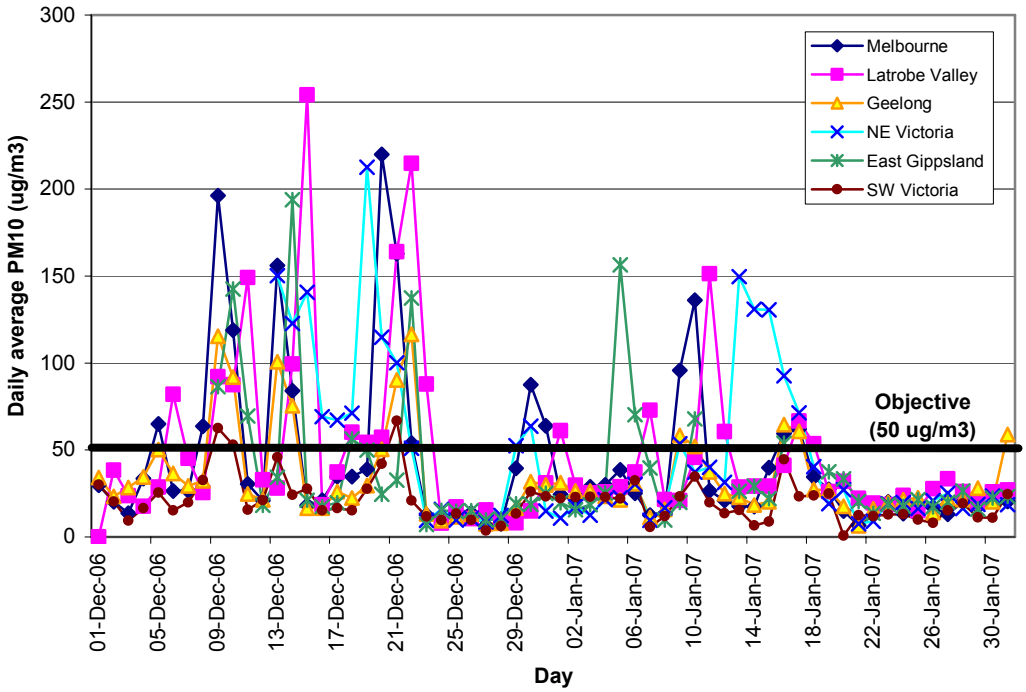

Figure 7: Highest daily average PM_{10} for each region during December 2006 and January 2007. Extended periods above the objective due to bushfire smoke occurred between 9 and 22 December 2006 for all regions.

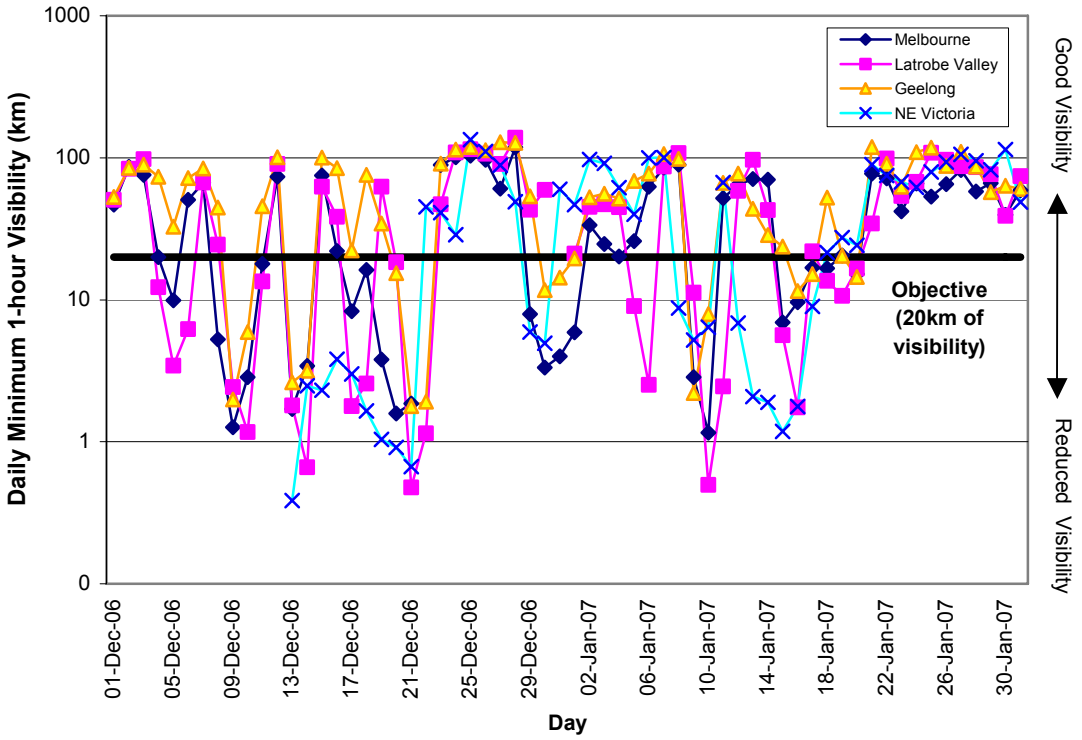

Figure 8: Minimum daily visibility for each region during December 2006 and January 2007.

3. Ozone (O_3)

Melbourne, Geelong and the Latrobe Valley all experienced high levels of ozone as a result of the bushfires (Figure 9). The highest 1-hourly ozone concentration (169 ppb) was recorded at Geelong on 9 December (Table 4). This was the highest hourly ozone concentration recorded in the Melbourne and Geelong region since 1993 and the highest ever recorded at EPA's Geelong monitoring station.

In the Latrobe Valley region four days were monitored above the ozone objective. These were the first ever recorded at EPA's Latrobe Valley monitoring stations.

Table 4: Number of high ozone days (one-hour average greater than 100 ppb) and highest recorded value for each monitored region between 1 December 2006 and 31 January 2007.

Region	Number of days of high ozone	Highest one-hourly ozone concentration (ppb)
Melbourne	4	138 (20-Dec-06)
Latrobe Valley	4	138 (10-Dec-06)
Geelong	2	169 (09-Dec-06)
NE Victoria (Wangaratta)	0	91 (19-Dec-06)
SW Victoria (Warrnambool)	0	65 (09-Dec-06)

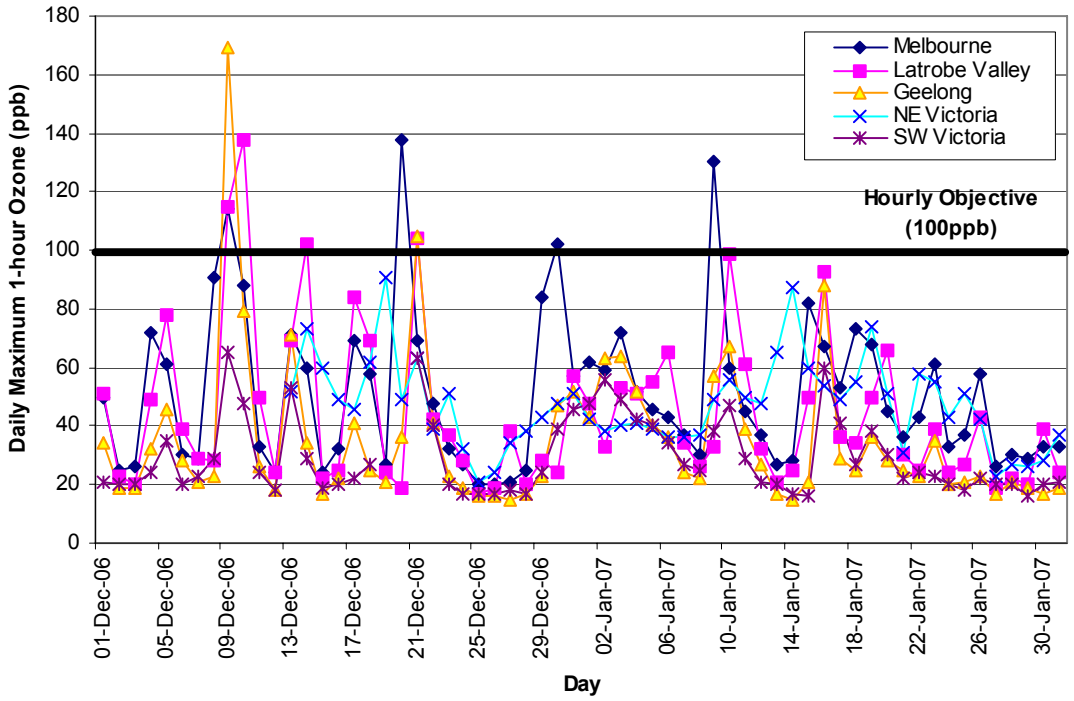

Figure 9: Highest daily one-hour ozone (ppb) for each region during December 2006 and January 2007.

4. How did 2006–07 compare with the 2002–03 bushfires?

Both in duration and magnitude the 2006-07 bushfires had a greater impact on Victoria's air quality than the 2002-03 fires[7]. The most recent bushfires impacted on all regions for longer and resulted in more days that did not meet the air quality objectives (Table 5). Maximum concentrations of 24-hour PM_{10} were higher in all regions during 2006–07 except for NE Victoria (Wangaratta) (Table 6). Visibility was significantly reduced during the most recent fires, with the poorest visibility being recorded in north-east Victoria (Wangaratta).

All regions were exposed to greater ozone levels during the most recent fires. Geelong and the Latrobe Valley both recorded high ozone levels during the 2006–07 fires. This was the first time that ozone has not met the objective in the Latrobe Valley since EPA began monitoring in 1979. Geelong recorded its highest hourly averaged ozone concentration since ozone monitoring began at that site in 1991.

BUSHFIRES AND CLIMATE CHANGE

One of the predicted impacts of climate change is an increase in the number of severe fire weather days in south-eastern Australia. This change is likely to result in increased bushfire activity that can adversely impact on Victoria's air quality.

A recent report commissioned by The Climate Institute of Australia indicates that south-eastern Australia is likely to become hotter and drier in future as a result of climate change[8]. There has been a general trend towards more fire weather in Victoria over the past 30 years, with the most severe fire weather on record occurring during the 1997, 2003 and 2007 summer seasons.

The report examined the potential impacts of climate change on fire-weather at 17 sites in south-east Australia and found that the number of 'very high' and extreme' fire danger days could increase by as much as 4–25 per cent by 2020 and 15–70 per cent by 2050. The increase in fire activity and severity over the last few years, particularly the 2006–07 fire season, provides an indication of how Victoria may be impacted in the future.

Table 5: Comparison of the number of days not meeting the air quality objectives for each pollutant during 2002–03 and 2006–07 bushfires.

Region	Number of high days of PM_{10} (above 50 μg/m^3)		Number of poor visibility days (less than 20 km)		Number of high days of ozone (above 100 ppb)	
	2002–03	2006–07	2002–03	2006–07	2002–03	2006–07
Melbourne	10	15	16	24	2	4
Geelong	6	11	9	15	0	2
Latrobe Valley	10	16	12	20	0	4
NE Victoria (Wangaratta)	16	17	Not monitored	23	Not monitored	0
East Gippsland (Bairnsdale)	Not monitored	9	Not monitored	Not monitored	Not monitored	Not monitored
SW Victoria (Warrnambool)	Not monitored	3	Not monitored	7	Not monitored	0

[7] *Air quality during Victorian bushfires of 2002–03*, EPA publication SR5, is available for download from the Publications section of EPA website, www.epa.vic.gov.au/publications.

[8] Lucas, Hennessy, Mills and Bathols (2007), *Bushfire Weather in Southeastern Australia: Recent Trends and Projected Climate Change Impacts*. Consultancy Report prepared for The Climate Institute of Australia, by Bushfire CRC, Australian Bureau of Meteorology and CSIRO Marine and Atmospheric Research. Available at www.climateinstitute.org.au

Table 6: Comparison of levels recorded in each region for each pollutant during 2002–03 and 2006–07 bushfires.

Region	Highest 24-hour average PM_{10} ($\mu g/m^3$)		Minimum one-hour visibility (km)		Highest one-hour ozone concentration (ppb)	
	2002–03	2006–07	2002–03	2006–07	2002–03	2006–07
Melbourne	125	220	3.7	1.2	112	138
Geelong	112	116	4.6	1.9	81	169
Latrobe Valley	178	254	4.9	0.5	83	138
NE Victoria (Wangaratta)	276	213	Not monitored	0.4	Not monitored	91
East Gippsland (Bairnsdale)	Not monitored	194	Not monitored	Not monitored	Not monitored	Not monitored
SW Victoria (Warrnambool)	Not monitored	67	Not monitored	4.7	Not monitored	65

SUMMARY

Both in duration and magnitude the 2006–07 bushfires had a greater impact on Victoria's air quality than the 2002–03 fires. Particles (PM_{10} and visibility) and ozone levels were all significantly elevated in all monitored regions, and record levels were recorded as a result of bushfire smoke during December 2006 and January 2007. Climate change predictions indicate that bushfire frequency and intensity will increase in Victoria, increasing the potential for major air quality impacts to be experienced across the state.

EPA Victoria expanded its monitoring network and worked closely with numerous state and commonwealth agencies to provide regular updates to the media and general public on air pollution levels, including advice to the community on measures to reduce the impact of bushfire smoke on their health. EPA is working with the Department of Human Services to better understand the health effects experienced by the Victorian community as a result of the bushfires.

Further information on bushfires and air quality can be found on the EPA website at:

www.epa.vic.gov.au/air/bushfires

ACKNOWLEDGEMENTS

EPA Victoria would like to acknowledge the work and support provided by the Bureau of Meteorology, DHS, DSE and other emergency services during the bushfires. In particular, EPA thanks the Wangaratta Police and Bairnsdale DHS for allowing the mobile monitoring stations to be housed at their offices.

APPENDIX 1: SMOKE ALERT CATEGORIES, POTENTIAL HEALTH EFFECTS AND CAUTIONARY ACTIONS ADVISORIES ISSUED DURING THE 2006–07 BUSHFIRE SEASON

Smoke alert and air quality categories	Potential health effects and cautionary actions
Smoke alert category: Low **Air quality**: Unhealthy for sensitive groups	Likelihood of respiratory symptoms and aggravation of pre-existing heart or lung conditions such as asthma. Sensitive groups include people with heart or lung conditions, children and the elderly. **Cautionary actions** **Sensitive groups:** People with lung or heart conditions, the elderly, and children should: • **limit** prolonged or heavy physical activity • **limit** time spent outdoors in the smoke (when possible) • asthmatics – follow your personal asthma management plan • take medication as prescribed, and pay attention for symptoms • seek medical advice if symptoms occur.
Smoke alert category: Moderate **Air quality:** Unhealthy (all)	Increased likelihood of respiratory symptoms and aggravation of pre-existing heart or lung conditions such as asthma. Likelihood of respiratory symptoms in the general population. **Cautionary actions** **Sensitive groups:** People with lung or heart conditions, the elderly and children should: • **avoid** prolonged or heavy physical activity • **stay** indoors (when possible) • asthmatics – follow your personal asthma management plan • take medication as prescribed, and pay attention for symptoms • seek medical advice if symptoms occur. **General population:** • Limit prolonged or heavy physical activity. • Limit time spent outdoors in the smoke (when possible). • Anyone experiencing breathing problems or chest pains should seek medical advice. **Everyone:** • If your home gets too hot to be comfortable, or is letting in outside air, and it is safe to do so, consider leaving the area until the smoke clears. • Shopping centres and local community facilities (e.g., libraries) can provide short-term relief from smoke and heat. • When travelling in your car, switch the air conditioner to recycle to reduce smoke. • Take medication with you.

Smoke alert and air quality categories	Potential health effects and cautionary actions
Smoke alert category: High **Air quality:** Very Unhealthy (all)	Significant increase in respiratory symptoms and aggravation of lung or heart conditions such as asthma. Increasing likelihood of respiratory effects in the general population. **Cautionary actions** **Everyone:** • **Avoid** prolonged or heavy physical activity. • **Stay** indoors (when possible). • Outdoor sporting events should be postponed. • If your home gets too hot to be comfortable, or is letting in outside air, **and** it is safe to do so – consider leaving the area until the smoke clears. • Shopping centres and local community facilities (eg. libraries) can provide short-term relief from smoke and heat. • When travelling in your car, switch the air conditioner to recycle to reduce smoke. • Seek medical advice if symptoms occur. Anyone experiencing breathing problems or chest pains should seek medical advice immediately.
Air quality: Hazardous (all)	Serious aggravation of heart or lung conditions. People with cardiopulmonary disease and the elderly are particularly at risk. Serious risk of respiratory effects in the general population. **Cautionary actions** **Everyone should** • **Avoid** prolonged or heavy physical activity. • **Stay** indoors (when possible). • Outdoor sporting events should be postponed. • If your home gets too hot to be comfortable, or is letting in outside air, **and** it is safe to do so – consider leaving the area until the smoke clears. • Shopping centres and local community facilities (e.g., libraries) can provide short-term relief from smoke and heat. • When travelling in your car, switch the air conditioner to recycle to reduce smoke. Anyone experiencing breathing problems or chest pains should seek medical advice immediately.

Bushfire smoke advice is available at www.epa.vic.gov.au/air/bushfires