REVIEW OF AIR QUALITY NEAR MAJOR ROADS

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SUMMARY

This report reviews EPA Victoria studies over the last four years in which air quality alongside major roads in Melbourne and Geelong has been measured.

These studies support international findings which show that, within a short distance from roads, air quality objectives are generally met. Fine particle levels beside a busy road carrying mainly diesel trucks sometimes did not meet objectives.

Levels of most pollutants were slightly above or similar to background levels.

Motor vehicles are still a major source of air pollution in urban areas. However, despite increased vehicle use, pollution from motor vehicles is reducing, due to improved fuels and vehicle designs. This trend is expected to continue. EPA will continue to track air quality in Victoria and the influence of motor vehicles.

AIM

The aim of this study was to review EPA's recent roadside air monitoring work by:

- assessing pollution levels against State and national objectives
- comparing pollution levels with those measured at EPA air monitoring stations
- comparing findings with national and international studies.

BACKGROUND

EPA has measured air quality in Melbourne and Geelong over many years. Results indicate that air quality is generally good (EPA publication 1000). Fine particles are an issue that have been identified as needing further attention.

In urban areas motor vehicles are a major source of fine particles due to exhaust emissions and road dust. Vehicles are also the major sources of carbon monoxide, nitrogen dioxide and benzene (EPA publication 1000).

To understand the impact of motor vehicles on air quality near major roads, EPA has conducted a number of studies: Hoddle Street, Collingwood; Francis Street, Yarraville; Princes Highway, Corio; corner of Springvale and Whitehorse Roads, Nunawading; and Westgate Freeway, Brooklyn (see Appendix). This report draws on the results of these studies.

EPA's mobile air laboratory (MoLab)

METHODOLOGY

Measurements

EPA's mobile air monitoring laboratory was used as a platform to monitor air quality in each roadside study except for the Hoddle Street trend site in Collingwood, which used a permanent air monitoring station.

PM_{10} and $PM_{2.5}$ particles were measured using a TEOM[1,2] and/or a manual technique, where samples were collected onto a pre-weighed filter over 24-hour periods followed by analysis in the laboratory.

Nitrogen dioxide, carbon monoxide and sulfur dioxide were measured using continuous instrumental gas analysers.

For the roadside sites, benzene samples were collected in stainless steel fused silica-coated canisters and analysed according to USEPA method TO-15. Samples – each of a 24-hour duration – were taken once every three days.

Benzene levels for the background sites were measured by collecting 24-hour average samples using sorbent tubes. Analysis was performed using USEPA method TO-17 (Four Cities Study).

Benzo(a)pyrene samples were collected once every six days in accordance with the National Measure.[3] For the roadside sites, samples were collected for 24 hours onto a polyurethane foam plug. For the comparison sites, samples were collected as PM_{10} onto Teflon-impregnated glass fibre filters using high volume samplers (Four Cities Study). Analysis was performed by gas chromatography mass spectrometry detection (GC/MS).

Data analysis and presentation

Levels of common pollutants were compared to intervention levels specified in the *State Environment Protection Policy (Air Quality Management)*. Intervention levels are used to assess whether air quality needs to be further investigated.

Levels of benzene and benzo(a)pyrene were compared to investigation levels specified in the *National Environment Protection (Air Toxics) Measure*.

The pollutants measured at roadsides were compared to monitoring data from selected EPA air monitoring stations over the same time periods (except as noted in the text). The EPA air monitoring stations selected for comparison were Alphington and Footscray, which were chosen to indicate background air quality away from major roads, on the eastern and western sides of Melbourne respectively. For benzo(a)pyrene there was no data for Footscray so data from the nearby Paisley station was used.

For the Corio roadside site, the Geelong South station was also used for comparison. For the Nunawading roadside site, the Mooroolbark station was also used.

In an urban environment it is impossible avoid all roads. The roads near to comparison sites were minor roads and are not expected to significantly influence air quality.

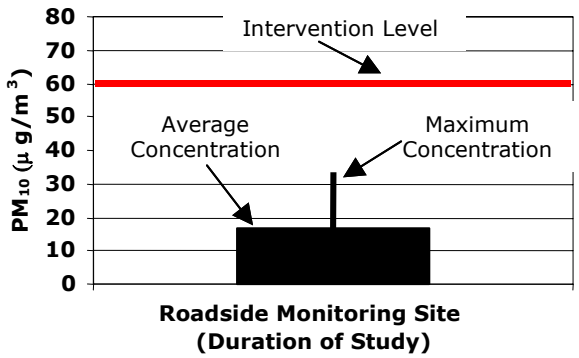
1 Tapered element oscillating microbalance

2 TEOM PM_{10} data quoted in this report have been adjusted according to the default procedure [NEPM T10], using the temperature-dependent formula with a constant value of K equal to 0.04. The resulting adjustments vary from no change at daily average temperatures at or above 15 °C to an increase of 40 per cent at a temperature of 5 °C.

3 NEP(Air Toxics)M requires 1-in-6-day samples for a year or 1 in three days for six months.

To enable the effects of motor vehicles to be assessed against typical background air quality, specific impacts – such as bushfires, dust storms and local industry – have been removed where they could be clearly identified (as noted in the text).

The data for each pollutant in this report is presented graphically. The bar represents the average levels during the study. The vertical black line extending out of the bar represents the highest level measured. The horizontal red line represents the intervention/investigation level.



RESULTS AND DISCUSSION

Particles (PM_{10} and $PM_{2.5}$)

The major sources of particles in Melbourne's air are motor vehicles, road dust, industry, woodsmoke and windblown dust.

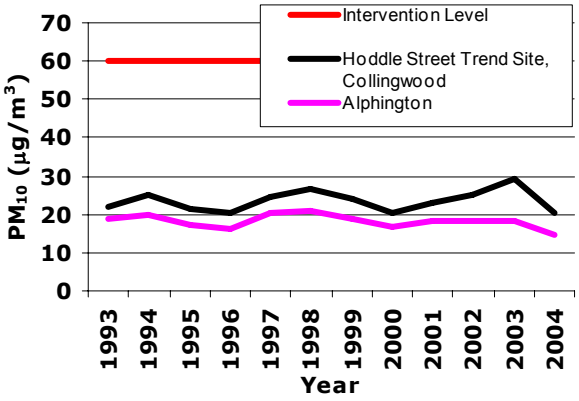
High levels of particles in air can affect people with lung or heart disease.

The peak and average 24-hour PM_{10} and $PM_{2.5}$ particle levels for each roadside site are shown in Figure 1 and Figure 2[4], along with measurements from comparison sites.

PM_{10} and $PM_{2.5}$ particle levels remained below the intervention level at all but one site. Peak particle levels went above the intervention level at Francis Street in Yarraville[5] (EPA publications 821 and 896). Average particle levels were also higher at this site, due to a large proportion of heavy trucks using Francis Street and the monitoring site being only five metres from the road.

Peak and average particle levels next to major roads were similar to or slightly above background levels at other sites.

Annual average PM_{10} particle levels measured at the Hoddle Street trend site in Collingwood are shown below. Particle levels have been consistently higher than those measured at Alphington.



It is expected that particle levels as a result of diesel vehicle emissions will decrease due to the introduction of new diesel fuel quality standards in 2006.

4 Note that $PM_{2.5}$ data from Alphington and Footscray was measured by TEOM, whereas $PM_{2.5}$ data from the mobile air monitoring laboratory was obtained from manual sampling techniques. The two different measurement techniques may give slightly different levels.

5 PM_{10} and $PM_{2.5}$ particle levels went above the intervention level on five and seven out of 163 days respectively.

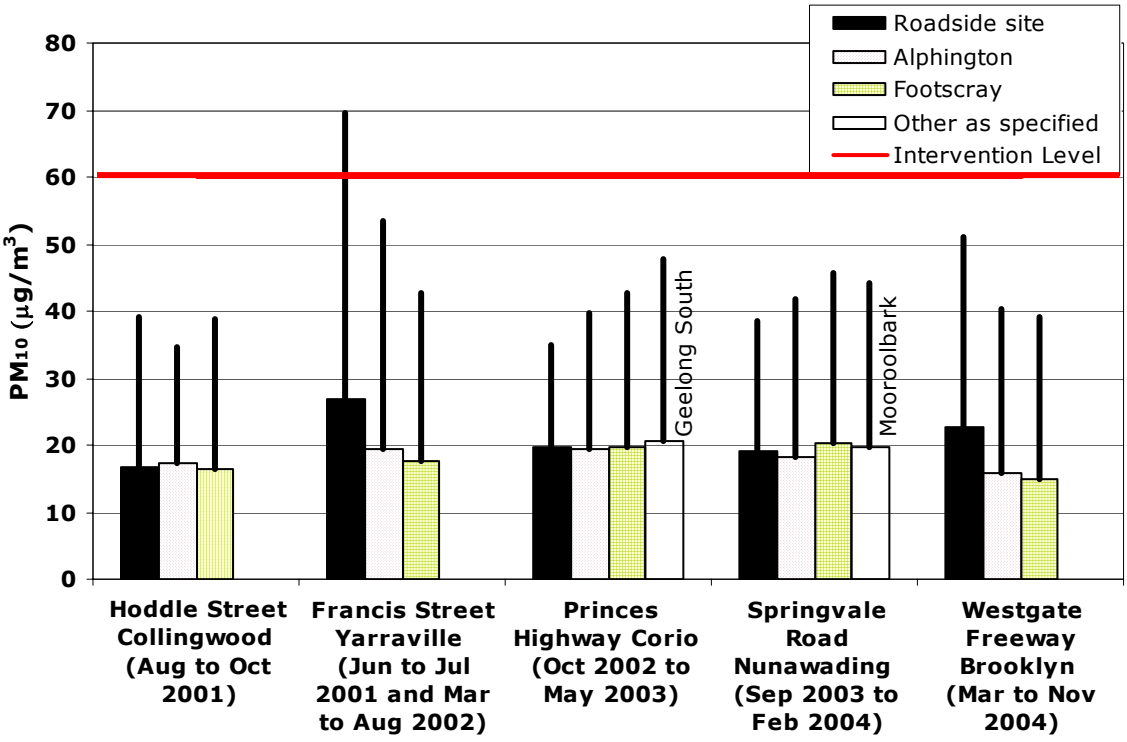


Figure 1: Maximum and average 24-hour PM_{10} levels[6]

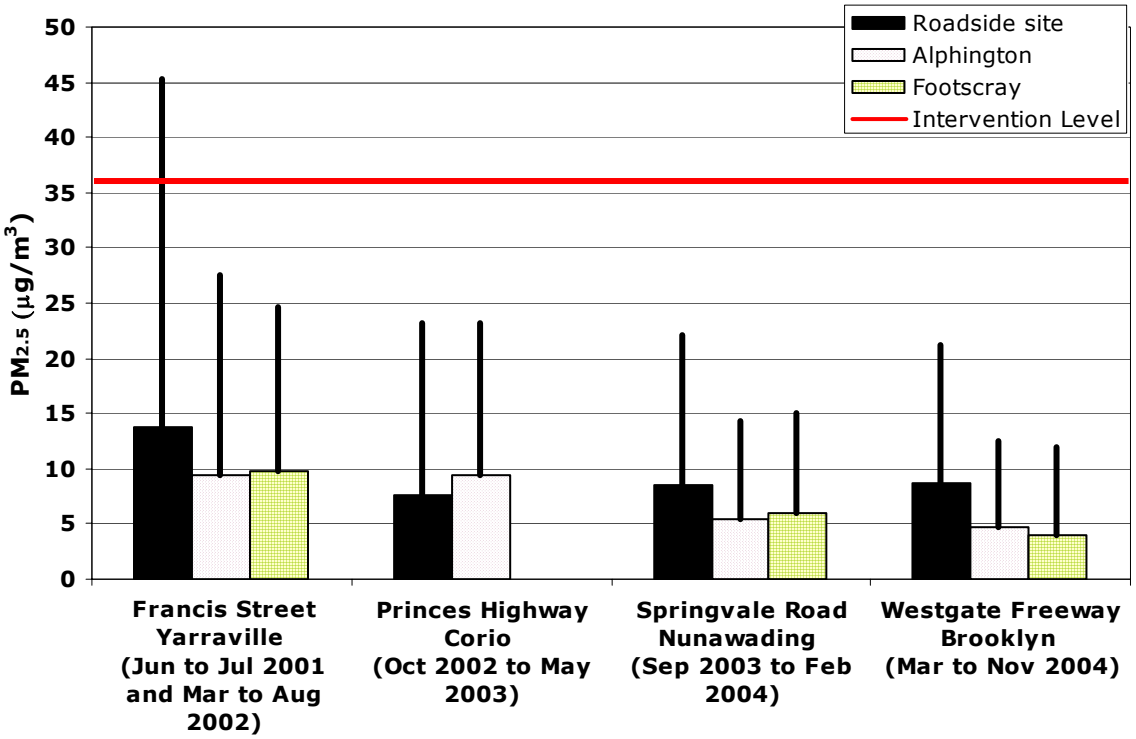


Figure 2: Maximum and average 24-hour $PM_{2.5}$ levels[6]

6 Note that the Princes Highway and Westgate Freeway data sets have been filtered to remove particle contribution from sources other than the road. See Methodology section for further detail.

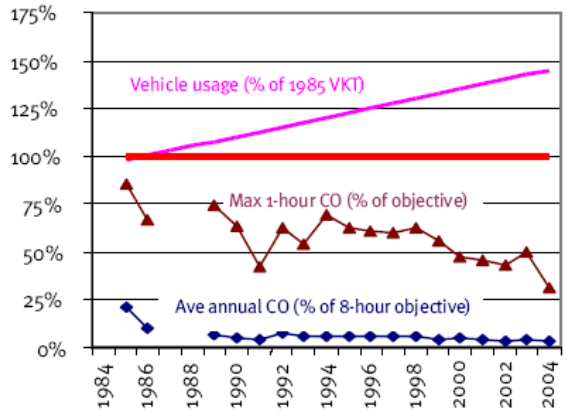
Carbon monoxide

Carbon monoxide is a widespread pollutant that comes from the combustion of carbon containing fuels such as petrol, gas, oil, coal and wood.

Carbon monoxide is readily absorbed into the bloodstream and affects transport of oxygen through the body. People suffering from heart disease are particularly sensitive.

Motor vehicles are still the major source of carbon monoxide in Melbourne, although emissions from well-maintained newer vehicles are much lower than those from older vehicles.

As shown in the chart below, levels of carbon monoxide in Melbourne meet air quality objectives and have decreased over the last twenty years despite increasing vehicle usage (as measured by VKT – vehicle kilometres travelled) (EPA publication 1000)[7].



The peak and average one-hour carbon monoxide levels at roadside and comparison sites are shown in Figure 3.

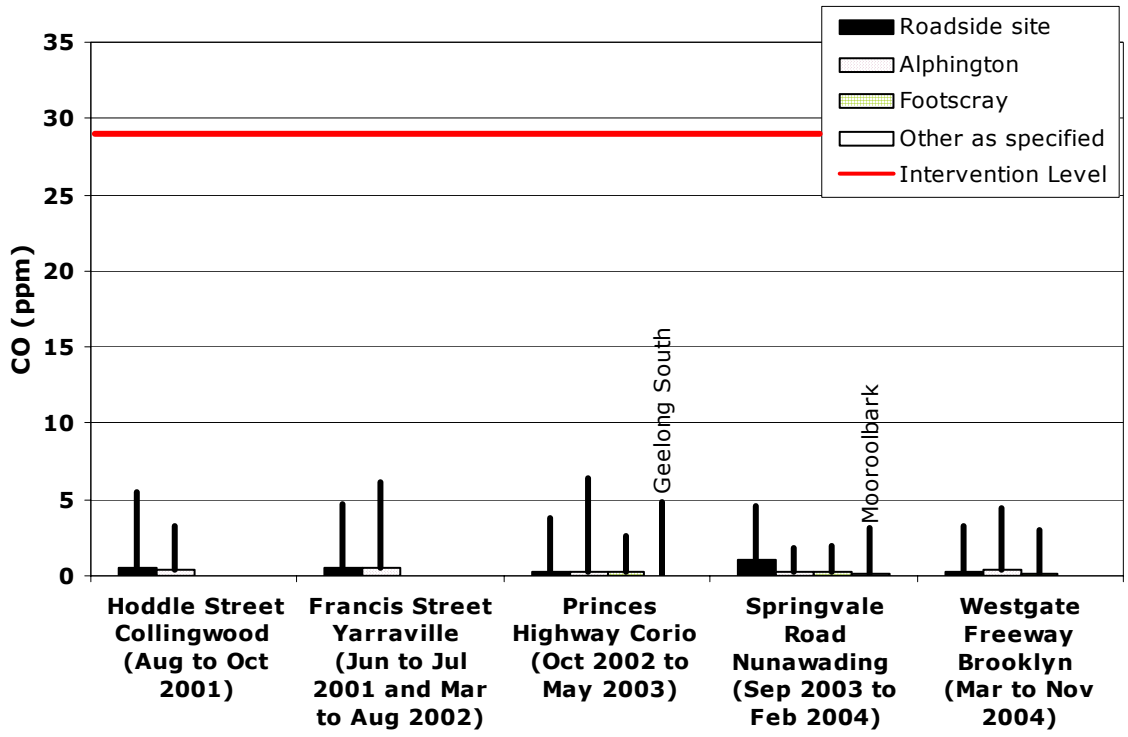


Figure 3: Maximum and average one-hour carbon monoxide levels

7 Results shown are an average of all Melbourne monitoring stations. The *State Environment Protection Policy (Ambient Air Quality)* objective is being compared to.

During the studies the levels of carbon monoxide were well below the intervention level (29 ppm) at all sites.

Peak and average carbon monoxide levels measured next to major roads were generally similar to those at comparison sites.

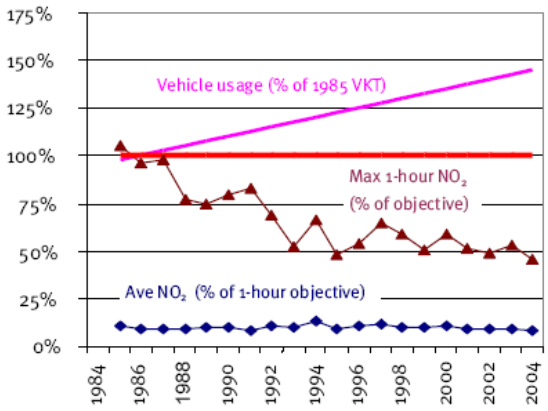
Nitrogen dioxide

As with carbon monoxide, nitrogen oxides in urban air come mainly from motor vehicles and other combustion sources. Nitrogen dioxide affects breathing and the body's defence mechanisms. Some nitrogen dioxide is emitted directly from vehicles, the rest forms in air as relatively harmless nitrogen monoxide emissions react with oxygen.

Levels of nitrogen dioxide in Melbourne are decreasing in a similar way to carbon monoxide levels, due to emission controls on newer motor vehicles as shown below.

The peak and average one-hour nitrogen dioxide levels for each roadside monitoring site are shown in Figure 4.

During the studies the levels of nitrogen dioxide were below the intervention level (140 ppb) at all sites.



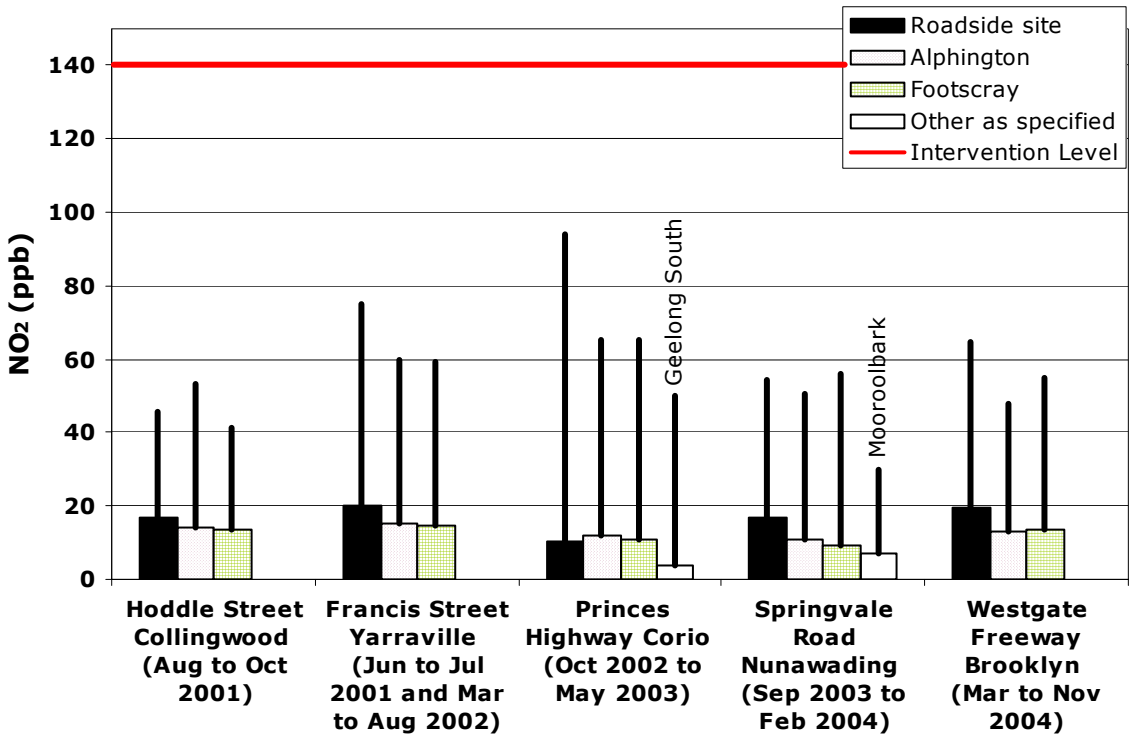


Figure 4: Maximum and average one-hour nitrogen dioxide levels

Peak and average nitrogen dioxide levels measured next to major roads were slightly above those at comparison sites.[8]

Sulfur dioxide

The main source of sulfur dioxide in Melbourne is industry. Petrol and diesel contain some sulfur so vehicles also emit sulfur dioxide. The levels of sulfur in fuels are being reduced over time.

Sulfur dioxide is an irritant gas that affects breathing.

The peak and average one-hour sulfur dioxide levels for each roadside monitoring site are shown in Figure 5.

During the studies the levels of sulfur dioxide were well below the intervention level (210 ppb) at all sites.

Peak and average sulfur dioxide levels measured next to major roads were generally similar to those at comparison sites.[9]

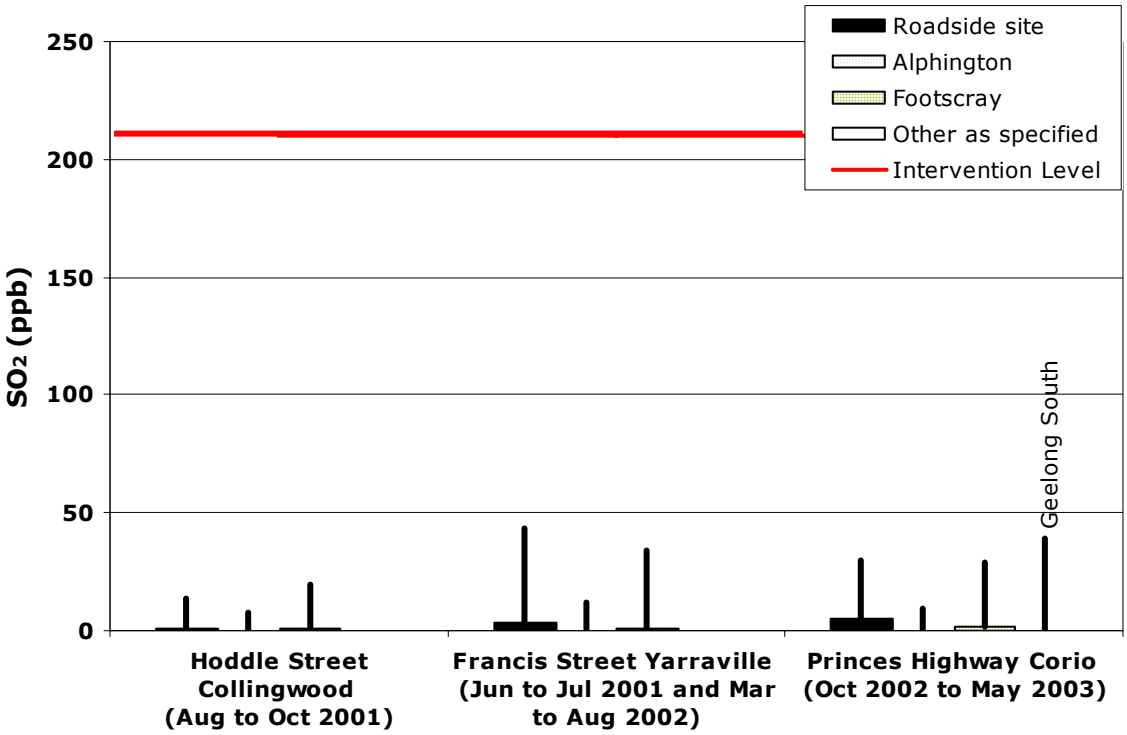


Figure 5: Maximum and average one-hour sulfur dioxide levels

8 The highest levels of nitrogen dioxide were measured at Princes Highway in Corio where there was some industrial contribution (EPA publication 911).

9 Note that the sulfur dioxide maximum level for Princes Highway in Corio is estimated (industrial contribution removed) and the average level includes motor vehicles and industry.

Benzene

In Victoria, motor vehicles are the main source of benzene emissions to air (Benzene Health Review). Benzene is an aromatic hydrocarbon found in petrol.

Benzene is classified as a human carcinogen. Long-term exposure to benzene can cause bone marrow depression and acute myeloid leukaemia.

National cleaner fuel standards require that refineries reduce benzene levels in petrol from around four per cent to less than one per cent from 2006 (Fuel Standard (Petrol) Determination 2001). This will reduce benzene emissions.

The average 24-hour benzene level for each roadside site is shown in Figure 6, along with data from comparison sites (note different time periods).

For all sites benzene levels were below the annual average investigation level of 3 ppb.

Benzene levels measured near roads were higher than those measured at comparison sites.

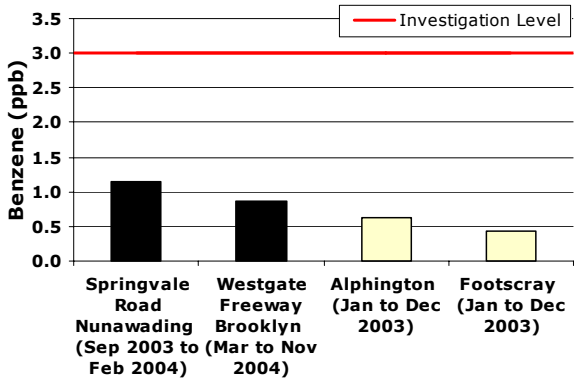


Figure 6: Average 24-hour benzene levels

Benzo(a)pyrene

Benzo(a)pyrene is one of the more toxic of a group of compounds called polycyclic aromatic hydrocarbons (PAHs) and is used as an indicator of the group.

In urban air major sources of benzo(a)pyrene are motor vehicles and woodsmoke (Four Cities Study). Benzo(a)pyrene is found on fine combustion particles.

Benzo(a)pyrene has been determined to be carcinogenic to humans and animals (PAHs Health Review).

The average 24-hour benzo(a)pyrene level for each roadside monitoring site is shown in Figure 7, along with data from comparison sites (note different time periods).

For the sites shown, benzo(a)pyrene levels were below the annual average investigation level of 0.3 ng/m^3.

Benzo(a)pyrene levels at these sites were similar to those at EPA air monitoring stations at Alphington and Paisley.

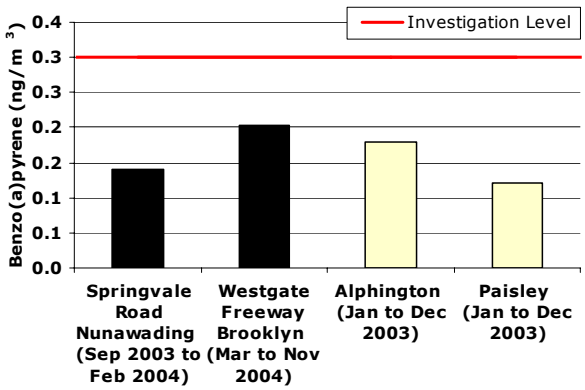


Figure 7: Average benzo(a)pyrene levels

The limited data available on levels of benzo(a)pyrene at Francis Street suggests that levels are higher than at other sites (the average result from seven samples in mid-2002 was 1.2 ng/m^3). This is consistent with the elevated levels of fine particles due to heavy trucks as discussed earlier.

As particle levels from diesel vehicles are reduced in 2006 (see particles) benzo(a)pyrene levels may also decrease. EPA is going to conduct further monitoring to gain a better understanding of benzo(a)pyrene in air.

COMPARISON WITH INTERNATIONAL AND NATIONAL FINDINGS

A number of national and international air monitoring studies have been conducted near various roads and a general conclusion has been reached that there is a reduction in pollutant level as distance from the road increases.

Models used to assess roadside air quality predict a rapid decrease in pollutant level as distance from the road increases. For example, the level of PM_{10} particles as a function of distance from a major road, as predicted by the AusRoads model, is shown in Figure 8. The model predicts a rapid decrease in level within 20 m of the edge of the road.

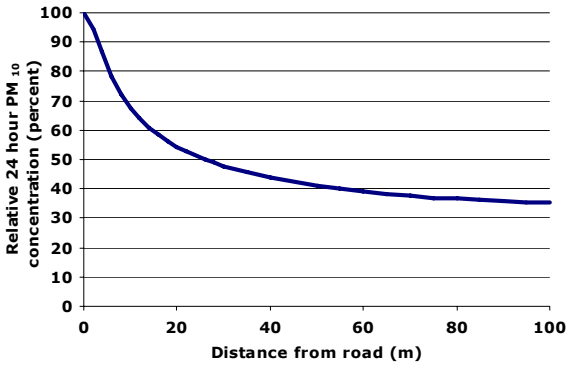


Figure 8: AusRoads prediction of reduction in PM_{10} level with distance from a road[10]

The model prediction is supported by international and national monitoring studies that have shown there is a rapid decrease in pollution level with increased distance from the road. For example:

- a study on road proximity and PM_{10} particle levels in Sacramento, California found that levels approached background levels within 100 m (Ashbaugh et al.).
- a study conducted near a freeway in Southern California found that PM_{10} particle and carbon monoxide levels declined by 60 per cent within 100 m of the roadside (Zhu et al.).
- a study conducted near various types of roads throughout the United Kingdom found that there was a sharp decline in nitrogen dioxide and nitrogen monoxide levels over the first 5–10 m, with levels close to background beyond 20 m. A similar result was found for PM_{10} (Laxen et al.).
- a study of 13 roadways in south-east Queensland between 1994 and 1997 showed that open roadside sites did not exceed policy levels even at distances of 10 to 20 meters from the edge of the road (Neale et al.).

10 The model has been run for a typical 100,000-vehicle-per-day road with four lanes (two each way, no median strip) and symmetric diurnal traffic profile, background 20 ug/m^3.
The graph is a worst-case scenario to be expected in a year for the conditions modelled.

CONCLUSION

Particles

- Particles measured as PM_{10} and $PM_{2.5}$, generally remained below intervention levels.
- In general particle levels were similar to or slightly above background levels.

Carbon monoxide, nitrogen dioxide and sulfur dioxide

- Carbon monoxide, nitrogen dioxide and sulfur dioxide levels were below intervention levels next to all roads monitored.
- Carbon monoxide, nitrogen dioxide and sulfur dioxide levels were similar to background levels at all sites monitored.
- Levels are expected to continue to remain below air monitoring objectives in the future.

Benzene

- Average benzene levels were below investigation levels
- Benzene levels were above background levels.
- Reduction of benzene in petrol in 2006 is expected to result in a reduction of benzene levels in Melbourne.

Benzo(a)pyrene

- Benzo(a)pyrene levels were found to be below investigation levels and similar to background levels.
- Further study is required to determine benzo(a)pyrene sources and levels near roads.

General conclusion

- This study supports findings of other studies which show that, within a short distance from the road, air quality objectives are generally met.
- Motor vehicles are still a major influence on air quality in urban areas.

Future directions

- Improved fuel standards and vehicle design is expected to improve air quality near roads despite increased vehicle usage.
- EPA will continue to operate its smoky vehicle reporting program[11] and to encourage the community to take steps to reduce vehicle emissions (such as vehicle maintenance, smooth driving techniques and alternative transport).
- Further air quality monitoring will also be undertaken, particularly to improve knowledge on particles, benzene and benzo(a)pyrene levels.
- EPA will continue to assess national and international research on the effects of motor vehicles on air quality.

11 If you see a smoky vehicle call Smoky Vehicle Reporting Line on (03) 9695 2755 in the metropolitan area, or 1800 444 051 outside the metropolitan area. You can also report smoky vehicles online at www.epa.vic.gov.au/reporting/smokyvehicle.asp.

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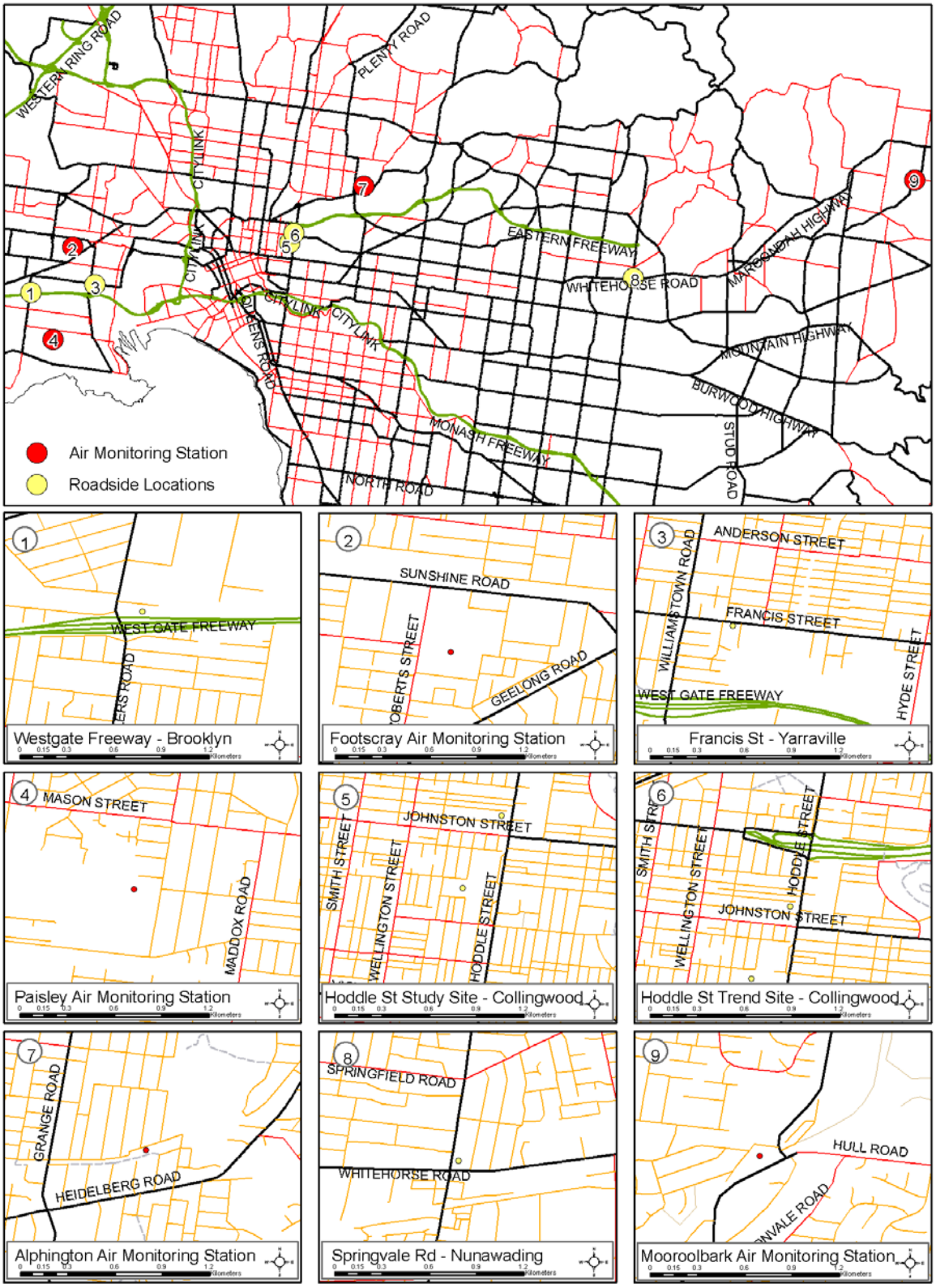
APPENDIX

Roadside site details

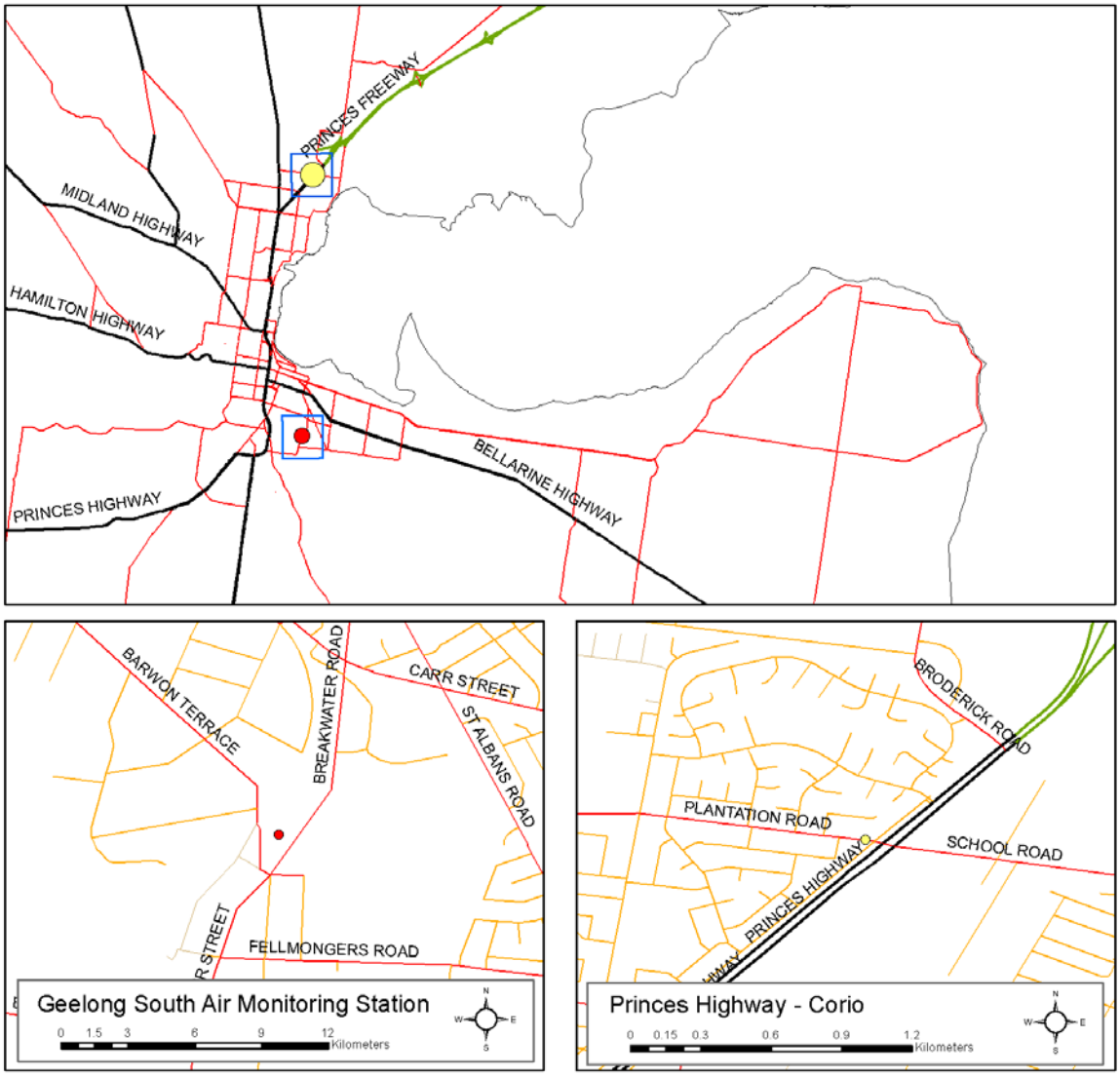
Study name	Duration of study	Location	Approx. vehicle numbers per day	Distance from major road	Pollutants measured	Reference
Hoddle Street trend site, Collingwood	1993 to 2004	Collingwood Community Health Centre, Sackville St, Collingwood	40 000	10m	PM_{10} (1 in 6 days)	
Hoddle Street Study, Collingwood	August to October 2001	Collingwood College, Collingwood	40 000	60m	PM_{10}, NO_2, CO, SO_2	EPA publication 874: *Air monitoring at Collingwood College during August–October 2001*
Francis Street, Yarraville	June to July 2001 March to August 2002	Yarraville Community Centre, Yarraville	16 000	5m	$PM_{2.5}$, PM_{10}, NO_2, CO, SO_2	EPA publication 821: *Air monitoring at Francis Street, Yarraville* EPA publication 896: *Air monitoring at Francis Street, Yarraville during 2002*
Princes Highway, Corio	October 2002 to May 2003	Corner of Princes Highway and Plantation Road, Corio	37 000	15m	$PM_{2.5}$, PM_{10}, NO_2, CO, SO_2	EPA publication 911: *Air monitoring at Corio – October 2002 to May 2003*
Springvale Road, Nunawading	September 2003 to February 2004	Near Springvale Road and Whitehorse Road intersection, Nunawading	150 000	6m	$PM_{2.5}$, PM_{10}, NO_2, CO, benzene, benzo(a)pyrene	EPA publication 948: *Air monitoring at Nunawading – September 2003 to February 2004*
Westgate Freeway, Brooklyn	March to November 2004	Alongside city-bound Millers Road on-ramp, Westgate Freeway, Brooklyn/Altona North	130 000	10m	$PM_{2.5}$, PM_{10}, NO_2, CO, benzene, benzo(a)pyrene	EPA publication 974: *Air monitoring alongside the Westgate Freeway in Brooklyn – March to November 2004*

Comparison site details.

Site name	Location	Approximate distance to nearest major road	Pollutants measured
Alphington	Railway Lot 6, Wingrove St, Fairfield	200 m from Heidelberg Road	PM_{10}, $PM_{2.5}$, NO_2, CO, SO_2, benzene, benzo(a)pyrene
Footscray	Hansen Reserve, Roberts Street, Footscray	1000 m from Princes Highway	PM_{10}, $PM_{2.5}$, NO_2, CO, SO_2, benzene
Paisley	Bayside College, Paisley Campus, Blenheim Road, Altona East	500 m from Masons Street	benzo(a)pyrene
Mooroolbark	Balcombe Avenue, Mooroolbark	1500 m from Maroondah Highway	PM_{10}, NO_2, CO
Geelong South	Breakwater Road, Breakwater	80 m from Breakwater Road	PM_{10}, NO_2, CO, SO_2



Roadside sites and comparison site locations in Melbourne



Roadside sites and comparison site locations in Geelong