AIR MONITORING ALONGSIDE THE WESTGATE FREEWAY IN BROOKLYN – MARCH TO NOVEMBER 2004

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SUMMARY

The levels of motor vehicle-derived air pollutants were monitored in Brooklyn at a site adjacent to the Westgate Freeway during the period March to November 2004.

Concentrations of air pollutants from the freeway met State and national objectives.

Pollutant concentrations were similar to those measured at EPA air monitoring stations in Footscray and Alphington except for fine particle levels, which were slightly higher.

The results obtained from this study are similar to those from an EPA study completed at the same site in 1996–97.

Air quality along the Westgate Freeway is likely to continue to meet air quality objectives in the foreseeable future.

OBJECTIVES

The objective of this study was to assess the level of motor vehicle-derived air pollutants alongside a major freeway by:

- assessing pollution levels against State and national objectives
- comparing pollution levels with those measured at EPA air monitoring stations
- comparing pollution levels with those measured in an earlier study done at the same site in 1996–97.

BACKGROUND

Motor vehicles are a significant source of air pollutants in Melbourne (EPA 535). Other contributors to air pollution include industry and domestic wood heating. Also natural events such as bushfires and dust storms occasionally impact on local and regional air quality.

EPA has conducted air monitoring for common air pollutants in Melbourne over many years and results indicate that Melbourne has generally good air quality (EPA 951).

EPA has a program to monitor air quality at potential hotspots such as major roads. This site was chosen because it was one of the sites used for an earlier study on the Westgate Freeway in 1996–97 and was a similar distance from the freeway as the nearest residential properties.

An average of 130,000 vehicles per day pass through this section of freeway, approximately 13 per cent being trucks (VicRoads, 2004). This includes vehicles travelling both to and from the city. This compares with 100,000 per day in 1996.

The common air pollutants emitted by motor vehicles are particles (PM_{10}), fine particles ($PM_{2.5}$),

nitrogen dioxide (NO_2)[1], and carbon monoxide (CO). The $PM_{2.5}$ particle fraction is of special interest due to the potential for fine particles to penetrate deep into the human respiratory system and cause long-term health problems.

Motor vehicles also emit volatile organic compounds (VOCs). These include benzene, toluene, xylene and ethylbenzene from petrol. Diesel-powered vehicle exhausts emit semi-volatile organic compounds such as polynuclear aromatic hydrocarbons (PAHs). These compounds are of concern due to their toxicity – particularly benzene, which is a potential human carcinogen. The *National Environment Protection (Air Toxics) Measure* focuses on these pollutants that we have less data about than 'common' air pollutants.

METHODOLOGY

EPA's mobile air monitoring laboratory (Molab II) was used as a platform to monitor air quality.

A monitoring site alongside the Westgate Freeway was selected near the Millers Road on-ramp in Brooklyn (Figure 1). Molab was sited 10 metres from the freeway and 500 metres from Millers Road.

PM_{10} and $PM_{2.5}$ levels were measured using a manual technique. Samples were collected onto a pre-weighed filter over 24-hour periods then analysed in the laboratory. PM_{10} was also measured continuously using a TEOM[2].

NO_2 and CO were measured using continuous instrumental gas analysers.

VOC samples were collected once every three days. VOCs were measured by collecting 24-hour average samples using stainless steel, fused silica coated canisters. Analysis was performed using USEPA method TO-15.

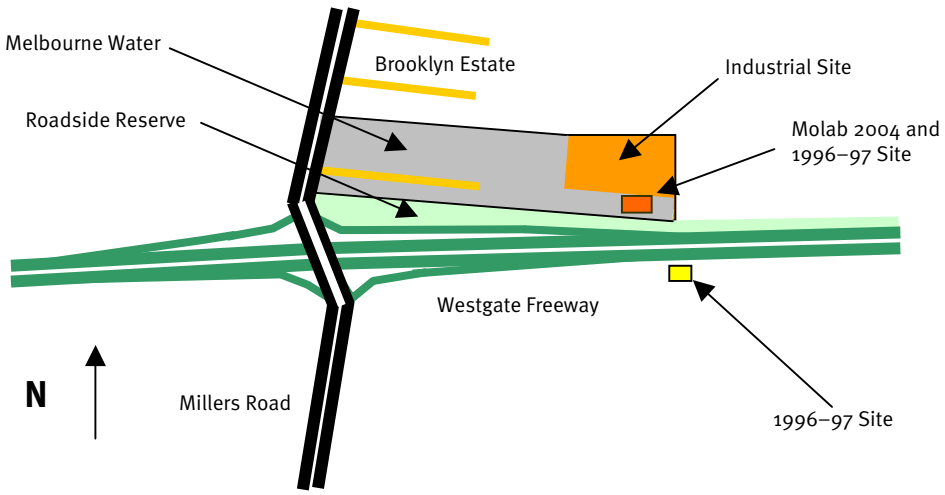

Figure 1: Location of monitoring sites for 2004 and 1996–97

1 NO_2 is a secondary pollutant present in the general environment resulting from the oxidation of NO and is often generated away from the original source of NO.

2 Tapered element oscillating microbalance.

PAH samples were collected once every six days in accordance with the National Measure[3]. Selected PAHs[4] were sampled for 24 hours onto a polyurethane foam plug. Analyses of PAH samples were performed by Gas Chromatography Mass Spectrometry detection (GC/MS).

PM_{10}, $PM_{2.5}$, NO_2 and CO levels were compared against the intervention levels specified in the *State environment protection policy (Ambient Air Quality)* [SEPP (AQM)]. Intervention levels are used to assess whether there are air pollution problems that might represent unacceptable risk to the community. They are trigger levels which, if exceeded, initiate further investigation.

VOCs and PAHs were compared against the National investigation levels (investigation levels are similar to SEPP intervention levels).

The results from this study were also compared to results from monitoring conducted at the same site in 1996–97.

In the 1996–97 study $PM_{2.5}$ was measured on both the north and south sides of the freeway (see Figure 1) using a dichotomous sampler[5] at the southern site and by TEOM at both sites.

PM_{10} was measured by dichotomous sampler on the south site only.

NO_2 was measured at both sites using continuous gas analysers.

VOCs were measured at both sites using canister sampling and analysed using GC/MS.

RESULTS AND DISCUSSION

Fine particles ($PM_{2.5}$)

The 24-hour $PM_{2.5}$ concentrations measured during the study period are shown in Figure 2. The average $PM_{2.5}$ concentration measured at the Westgate site was 9 µg/m^3 and the highest 24-hour concentration was 28 µg/m^3. During the study period the concentrations of $PM_{2.5}$ remained below the 24-hour SEPP (AQM) intervention level of 36 µg/m^3.

Twenty-four hour $PM_{2.5}$ concentrations measured at Westgate in 2004 are compared in Figure 2 to the 24-hour $PM_{2.5}$ concentrations measured during the same period at Alphington and Footscray.

Maximum 24-hour average $PM_{2.5}$ concentrations for the 2004 and 1996–97 Westgate studies and Alphington and Footscray background sites are compared in Table 1.

$PM_{2.5}$ concentrations measured at Westgate in 2004 were typically slightly higher than those measured at Alphington and Footscray. The maximum concentrations measured during 2004 were lower than in 1996–97 (which could be due to different weather conditions) but, overall, $PM_{2.5}$ concentrations were similar.

3 NEP(Air Toxics)M requires one-in-six-day samples for a year or one in three days for six months
4 United States Environmental Protection Agency Compendium Method TO-13, A Determination of Polycyclic Aromatic Hydrocarbons (PAHs) in Ambient Air using Gas Chromatography/Mass Spectrometry (GC/MS). Certain compounds described in this method (acenaphthene, acenaphthylene and naphthene) are not efficiently trapped by polyurethane foam (PUF) and have been omitted from this report.
5 Another gravimetric technique similar to that used in the current study.

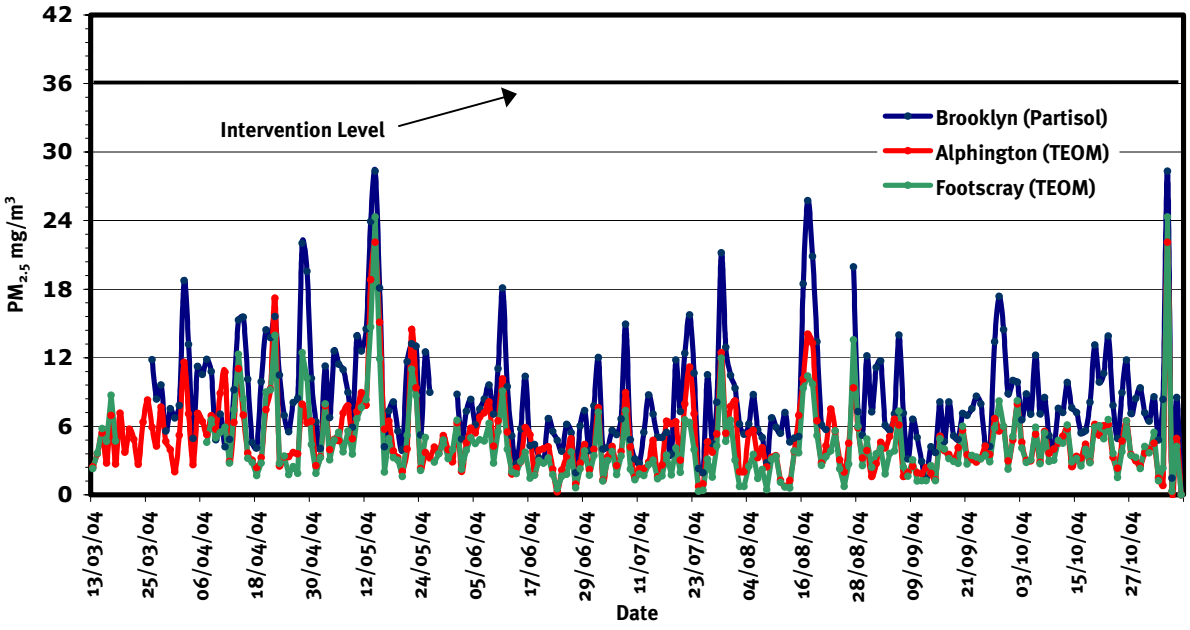

Figure 2: 24-hour average $PM_{2.5}$ concentrations

Site	Westgate (2004)[1]	Alphington[2]	Footscray[2]	Westgate (96–97) South[2,3]	Westgate (96–97) North[2]
Intervention level	36				
Maximum	28	22	24	38	37
Average	9	5	4	11	11

1 Analysis conducted using a partisol sampler.
2 Analysis conducted using a TEOM sampler: note that this method may produce different results than the Partisol method and that comparisons are indicative only.
3 Dichotomous sampler one-in-six-day cycle also at this site: average = 10, maximum 33.

Table 1: $PM_{2.5}$ concentrations (µg/m³) for the 2004, 1996–97 Westgate studies and 2004 Alphington and Footscray air monitoring stations

Particles (PM_{10})

Twenty-four hour PM_{10} concentrations measured during the study period are shown in Figure 3 along with data from EPA air monitoring stations in Footscray and Alphington.

The average PM_{10} concentration measured at the Westgate site was 27 µg/m³ and the highest 24-hour concentration was 83 µg/m³. During the study period the concentration of PM_{10} was above the 24-hour SEPP (AQM) intervention level of 60 µg/m³ on seven occasions.

Each of these occasions occurred when the prevailing wind was from the north; that is, not blowing from the freeway (PM_{10} levels at nearby Footscray were also generally much lower and $PM_{2.5}$ levels at Westgate remained below intervention levels on these days). This indicates that elevated levels were due to nearby industrial sources rather than the freeway. EPA is requiring reduced dust emissions from a number of industries in Brooklyn.

PM_{10} concentrations measured at the Westgate site in 2004 are compared to PM_{10} concentrations measured in 1996–97 in Table 2. The comparison suggests that PM_{10} concentrations have not changed significantly since 1996–97.

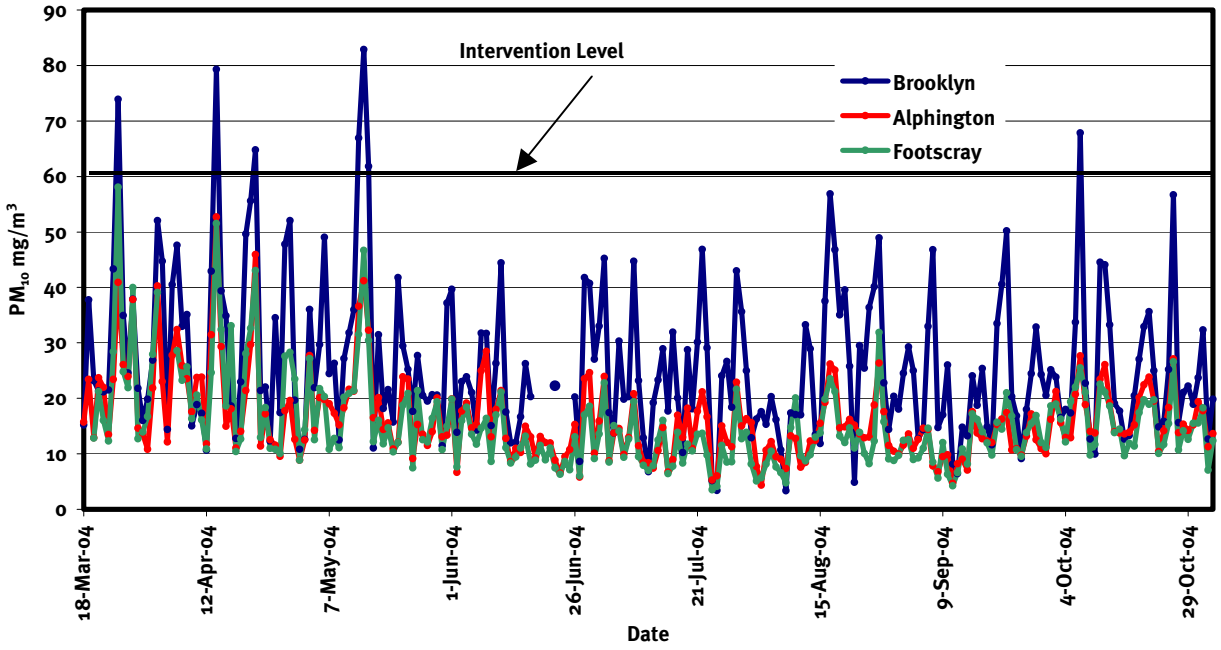

Figure 3: 24-hour average PM_{10} concentrations[6]

Site	Westgate (South) 1996–97[1]	Westgate (North) 2004[2]
Intervention level	60	
Maximum	73	83
Average	27	27

1 Analysis conducted using a partisol sampler
2 Analysis conducted using a dichotomous sampler (one-in-six-day cycle)

Table 2: PM_{10} concentrations (µg/m³) for the 1996–97 and 2004 Westgate studies

Freeway contribution to $PM_{2.5}$ and PM_{10}

To determine the contribution of the freeway, maximum and average $PM_{2.5}$ and PM_{10} concentrations were calculated by only including data when the prevailing wind was from the south; in other words, from the freeway (72 out of a total of 231 days).

The results are compared to Alphington and Footscray data in Tables 3 and 4. The data indicates that the freeway did increase $PM_{2.5}$ and PM_{10} concentrations. On average it appears that the freeway contributes around 5 µg/m³ to $PM_{2.5}$ levels and around 8 µg/m³ to PM_{10} levels at a distance of 10 m from the edge of the freeway. PM_{10} and $PM_{2.5}$ contributions from the freeway remained below intervention levels.

6 Due to equipment malfunction PM_{10} data between 27 May and 11 July was unavailable. TEOM data has been used instead.

	Westgate[1] (2004)	Alphington[2]	Footscray[2]
Intervention level	36		
Maximum	21	12	12
Average	9	5	4

1 Analysis conducted using a partisol sampler
2 Analysis conducted using a TEOM sampler

Table 3: $PM_{2.5}$ concentrations (µg/m³) for Alphington, Footscray and Westgate for days where the prevailing winds were from the south

	Westgate (2004)	Alphington	Footscray
Intervention level	60		
Maximum	51	40	39
Average	23	16	15

Table 4: PM_{10} concentrations (µg/m³) for Alphington, Footscray and Westgate for days where the prevailing winds were from the south

Including only data for which the predominant winds were from the freeway, $PM_{2.5}$ particles on average account for 39 per cent of the total particle concentration with a range between 20 and 87 per cent. This range is similar to a previous roadside study conducted in Nunawading[7](EPA 948).

The percentage of $PM_{2.5}$ in particles from combustion sources (such as motor vehicles) is generally higher than the percentage of $PM_{2.5}$ from dust. This appears to be borne out in the above comparison, where we have a higher proportion of $PM_{2.5}$ on days when the wind is coming from the freeway. If we include the north wind data the proportion of $PM_{2.5}$ particles is as low as 10 per cent of the total particle concentration.

Nitrogen dioxide

Daily maximum one-hour concentrations for NO_2 are shown in Figure 4. The highest maximum NO_2 one-hour concentration measured was 65 ppb and the average was 31 ppb. These concentrations are well below the SEPP (AQM) intervention level of 140 ppb.

Daily maximum one-hour concentrations for NO_2 are compared to those measured at the background sites of Alphington and Footscray in Figure 4. The maximum one-hour concentration of NO_2 measured at Westgate (65 ppb) was slightly higher than those measured at the Alphington (48 ppb) and Footscray (55 ppb) monitoring sites.

Note that most NO_2 is not produced directly by motor vehicles: it forms via the gradual oxidation of NO in air, often away from the original source of NO.

NO_2 levels are lower for this project compared to the 1996–97 project, which saw maximums of 107 ppb (north side) and 80 ppb (south side). Averages, of 34 ppb and 32 ppb respectively, were similar to 2004.

The maximums during the 1996–97 study occurred during February. NO_2 concentrations are generally higher in summer because oxidation of NO to NO_2 is facilitated by sunlight and reaction with some VOCs. The 2004 study was conducted over the cooler months and lower maximums would be expected.

7 The only source of particles in Nunawading is the road, due to it being primarily a built-up residential/business area with no significant industrial activity

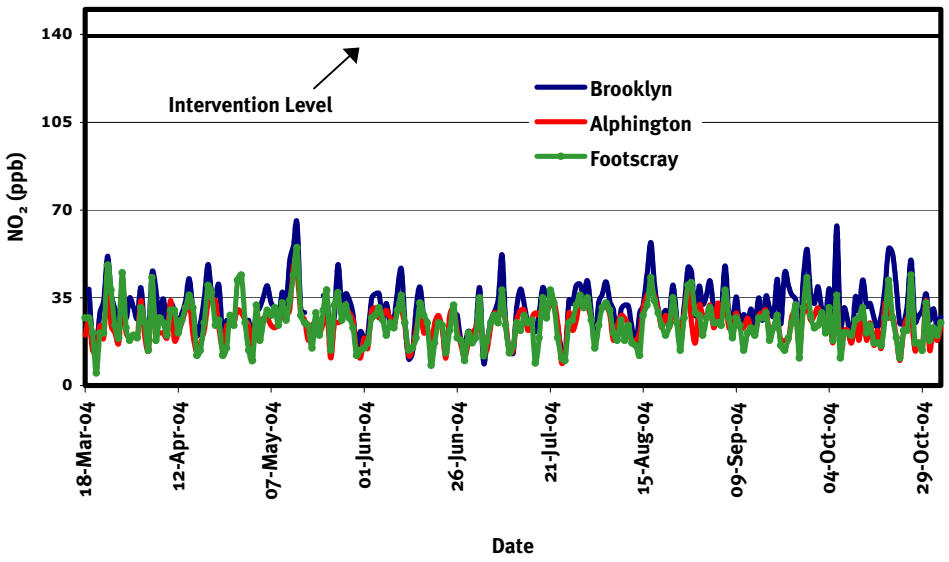

Figure 4: Daily maximum (one-hour) NO_2 concentrations at the Westgate monitoring site

Site	Westgate (2004)	Alphington	Footscray
Intervention level	29		
Maximum	3	4	3
Average	1	1	1

Table 5: Daily maximum (one-hour) CO concentrations (ppm) at the Westgate monitoring site

VOC	Westgate 2004		Westgate 96–97		Nunawading 2003		Investigation level NEP(Air Toxics)M
	Max.	Avg.	Max.	Avg.	Max.	Avg.	
1,3-butadiene	<0.2[1]	<0.2	ND[2]	ND	0.7	0.2	NS[3]
Benzene	2.3	0.8	4.5	1.7	3.2	1.7	3[4]
Toluene	11.5	6.0	19.3	4.4	6.6	3.1	1000[5]
Ethylbenzene	1.1	0.5	1.8	0.4	0.8	0.4	NS[6]
m&p-xylene	3.5	1.1	7.6	1.3	3.4	1.3	250[5]
o-xylene	1.2	0.5	2.2	0.4	1.5	0.5	

1 <0.2 indicates concentration was below detection limit.
2 ND = not determined.
3 NS = not specified. 1,3-butadiene is less toxic than benzene and an annual average investigation level would be of a similar order but higher than benzene. The one-hour average SEPP(AQM) intervention level is 50 ppb.
4 Annual average [NEP(Air Toxics)M]
5 24-hour average [NEP(Air Toxics)M]
6 NS = not specified. Ethylbenzene has a similar toxicity to toluene and an annual average investigation level would be similar to toluene. The three-minute average SEPP(AQM) design criteria is 3300 ppb.

Table 6: Maximum, minimum and average 24-hour concentrations (ppb) of VOCs compared with national guidelines [NEP(Air Toxics)M].

Carbon monoxide

Daily maximum one-hour concentrations for CO are shown in Table 5 along with those measured at the background sites of Alphington and Footscray. These concentrations are well below the SEPP (AQM) intervention level of 29ppm. Daily maximum one-hour concentrations of CO measured at Westgate were similar to those measured at the Alphington and Footscray monitoring sites. CO was not monitored in the 1996-97 study

Volatile Organic Compounds (VOCs)

Maximum and average VOC concentrations measured during the study are compared in Table 6 with the investigation levels, the 1996–97 Westgate study and a roadside study conducted in Nunawading in 2003–04.

For the duration of the study VOC concentrations were well below investigation levels. The average concentration (0.8 ppb) of benzene for the monitoring period was well below the investigation level of 3 ppb. VOC levels measured at Westgate are similar to levels measured in the 1996–97 Westgate study and the roadside study in Nunawading in 2003-04 (EPA 948)

Polynuclear Aromatic Hydrocarbons (PAH)

Maximum and average PAH concentrations measured during the study are shown in Table 7. The most abundant PAH was phenanthrene, followed by pyrene.

The investigation level is based on benzo(a)pyrene as a marker for PAHs. The investigation level is 0.3 ng/m^3 as an annual average. (Benzo(a)pyrene is chosen as a PAH marker due to its being a potential human carcinogen.) The average benzo(a)pyrene concentration during the eight-month monitoring period was 0.2 ng/m^3 and was below the investigation level.

PAHs were not monitored in the 1996–97 study.

Site	Westgate		Nunawading		Yarraville	
Compounds	Max.	Avg.	Max.	Avg.	Max.	Avg.
Anthracene	7.6	2.1	2.4	1.1	7.9	4.1
Benz (a) anthracene	2.1	0.5	0.9	0.2	3.7	1.4
Benzo a pyrene	***0.8***	***0.2***	***0.6***	***0.1***	***3.7***	***1.2***
Benzo (b) fluoranthene	1.1	0.3	1.1	0.2	2.5	0.9
Benzo(ghi) perylene	0.6	0.2	1.0	0.2	2.2	0.8
Benzo (k) fluoranthene	0.8	0.2	0.4	0.1	2.2	0.9
Crysene	3.6	0.8	1.1	0.3	4.3	1.6
Dibenz (ah) anthracene	‹0.1*	‹0.1*	‹0.1*	‹0.1*	‹0.1*	‹0.1*
Fluoranthene	14.0	3.7	4.3	2.0	14.0	7.2
Fluorene	5.3	2.2	4.0	1.2	20.7	7.2
Indeno (123-cd) pyrene	0.4	0.2	1.5	0.2	1.4	0.5
Phenanthrene	45.5	13.0	15.8	6.3	61.0	32.7
Pyrene	15.2	3.9	6.2	2.7	17.1	9.0

* Detection limit is 0.1 ng/m^3

Table 7: Daily average PAH concentrations (ng/m^3) at the Westgate, Nunawading and Yarraville monitoring sites

CONCLUSIONS

Fine particles

- For the study period, particles measured as $PM_{2.5}$ were consistently below intervention levels set in the *State environment protection policy (Air Quality Management)*. Levels of particles measured as PM_{10} were below intervention levels when the prevailing wind was from the freeway. When the prevailing wind was from the north PM_{10} intervention levels were exceeded on seven occasions, probably due to localised industrial emissions, which are being addressed.
- $PM_{2.5}$ and PM_{10} levels close to the freeway were higher than levels measured at EPA fixed-site monitoring stations in residential areas of Alphington and Footscray.
- $PM_{2.5}$ and PM_{10} concentrations were similar to those measured during the 1996–97 project.

Nitrogen dioxide and carbon monoxide

- For the study period NO_2 and CO concentrations were well below intervention levels set in the *State environment protection policy (Air Quality Management)*.
- NO_2, and CO levels were similar to levels measured at EPA fixed-site monitoring stations in residential areas of Alphington and Footscray.
- NO_2 concentrations were similar to those measured during the 1996–97 project (CO was not measured in 1996–97).

Volatile organic carbons and polycyclic aromatic hydrocarbons

- VOC and PAH levels were below investigation levels as set in the *National Environment Protection (Air Toxics) Measure*.
- VOC and PAH concentrations were similar to those found in Nunawading in 2003–04.
- VOC concentrations were similar to those measured during the 1996–97 project (PAHs were not measured in 1996–97).

Overall conclusion

- This study supports findings of other studies that show that, within a short distance from the road, air quality objectives are generally met.
- There has not been a significant change in the concentration of pollutants from 1996–97 to 2004. There has been an increase in the number of vehicles being driven on the Westgate Freeway (from 100,000 to 130,000 per day). The level of emissions from individual vehicles has decreased in the past decade, due to measures such as improving fuel quality and general modernisation of the vehicle fleet.

REFERENCES

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