AIR QUALITY MONITORING REPORT

AT DARLING HARBOUR FOR THE CROSS CITY TUNNEL PROJECT

FOR JUNE AND JULY, 2000

August, 2000

Prepared
for
Roads and Traffic Authority

by

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EXECUTIVE SUMMARY

This brief report presents the results of air quality monitoring which has been undertaken as part of the Cross City Tunnel project. Monitoring of the pollutants carbon monoxide, nitrogen dioxide and particulate matter (PM_{10}) has been carried out at two sites in the project area since June 2000. Monitoring at these sites continues.

The site at the Police Station on Day Street was selected as it is close to the proposed location of the ventilation stack in Darling Harbour. The other site, at the Sydney Art Gallery in Harris Street, Ultimo, was selected as being a site in the Pyrmont / Ultimo area, where high levels of pollutants were likely to occur. The site is close to the viaduct of the Western Distributor and would also be affected by the traffic on Harris Street. The results of the monitoring are compared with air quality goals for the different pollutants measured. These goals are set to protect the most sensitive members of the community. However, there are occasional exceedances in many parts of Sydney.

Details of the results are provided in the report. In summary, the data collected to date shows the following trends:

Police Station site

There have been no exceedances of the air quality goal for nitrogen dioxide over the study period. The maximum value over the study period was 47% of the air quality goal. The average value over the study period was 22% of the air quality goal. There has been one exceedance of the 1-hour goal and two exceedances of the 8-hour air quality goal for carbon monoxide. The average concentration was 24% of the 8–hour air quality goal. There have been 5 exceedances of the air quality goal for PM_{10}. The average value was 58% of the air quality goal.

Harris Street site

There have been no exceedances of the air quality goal for nitrogen dioxide during the study period. The maximum value over the study period was 68% of the air quality goal. The average value over the study period was 33% of the air quality goal. There have been no exceedances of the 1-hour goal and one exceedance of the 8-hour air quality goal for carbon monoxide. The average concentration of carbon monoxide was 29% of the 8–hour air quality goal. There have been 14 exceedances of the air quality goal for PM_{10}. The average value was 72% of the air quality goal.

Both sites are located in heavily trafficked areas where air pollution levels are likely to be high. Further, measurements were made during the time of year when dispersion conditions and hence levels of pollution are likely to be at their worst. Therefore the data presented in this reports are likely to reflect worst-case conditions in the area.

It should be noted that during winter months when dispersion is poor there are exceedances of the PM_{10} goal throughout Sydney, when the general background level of this pollutant is high. The high levels of background concentrations are contributed in part from motor vehicles but also significantly in winter from fuel burning in homes, in particular, the use of wood heaters.

This data will continue to be collected over the next 2 – 3 months while the site for a permanent monitoring station is selected.

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GLOSSARY AND ABBREVIATIONS

CBD	Central Business District
CCT	Cross City Tunnel
CO	Carbon monoxide
$\mu g/m^3$	micrograms per cubic metre
mg/m^3	milligrams per cubic metre
NEPM	National Environment Protection Measures
NHMRC	National Health and Medical Research Council
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
NSW EPA	New South Wales Environment Protection Authority
PM_{10}	particulate matter with equivalent aerodynamic diameter less than 10 μm
ppm	parts per million
pphm	parts per hundred million
RTA	Roads and Traffic Authority of New South Wales
US EPA	United States Environment Protection Agency
WHO	World Health Organisation

1 INTRODUCTION

This report has been prepared by Holmes Air Sciences for the Roads and Traffic Authority of New South Wales (RTA). It presents the results of an air quality monitoring program established as part of the Cross City Tunnel (CCT) project development process. Monitoring commenced in June 2000 and is on-going.

Monitoring is being conducted at two locations near Darling Harbour, to the immediate west of the Sydney CBD. The sites are located at the Sydney Police Station on Day Street and the Sydney Art Gallery on Harris Street, Ultimo. These locations are shown in **Figure 1**. This report discusses the level of concentrations of carbon monoxide (CO), oxides of nitrogen (NO_x) and particulate matter (PM_{10}) at the two sites for June and July, 2000.

2 AIR QUALITY CRITERIA

A full description of the air quality goals adopted by the New South Wales Environment Protection Authority (NSW EPA) is provided in the CCT Environmental Impact Statement (EIS). For completeness, the goals applied to this project and those relevant to the monitoring program are summarised in **Table 1**. The goals shown in bold print are those used to assess the air quality at both monitoring stations.

Table 1: NSW Air Quality Goals and other relevant goals

Pollutant	***Standard****	***Agency***
Carbon monoxide	87 ppm or 108 mg/m^3 (15-minute maximum) **25 ppm or 31 mg/m^3 (1-hour maximum)** **9 ppm or 10 mg/m^3 (8-hour maximum)**	WHO **WHO** **NHMRC, NEPM**
Nitrogen dioxide	16 pphm or 320 μg/m^3 (1-hour maximum) 5 pphm or 103 μg/m^3 (annual mean) **12 pphm or 245 μg/m^3 (1-hour maximum)** 11 pphm or 200 μg/m^3 (1-hour maximum) 3 pphm or 60 μg/m^3 (annual mean)	NHMRC US EPA **NEPM,NSW EPA** WHO, NSW EPA long-term reporting goal NEPM, NSW EPA
Particulate matter < 10 μm (PM_{10})	50 μg/m^3 (annual mean) 30 μg/m^3 (annual mean) 150 μg/m^3 (24-hour maximum) **50 μg/m^3 (24-hour maximum)**	US EPA NSW EPA US EPA **NEPM, NSW EPA**

* *all concentration units have been converted at 0°C*

3 SYDNEY POLICE STATION

The Police Station is located on the western edge of the Sydney CBD, between Liverpool and Bathurst Streets. The monitoring site was chosen as it is near the proposed ventilation stack for the CCT. The height of the monitoring station is at street level. The monitors measure concentrations at 1-minute intervals and log 10-minute averages. The 10-minute average concentration was used to determine longer timeframe averages, such as the 1-hour average. Monitoring of air quality began on the 1st of June, for carbon monoxide and oxides of nitrogen. In July, measurements of nitrogen oxides and carbon monoxide was disrupted from the 14th until the 26th, due to an instrument fault.

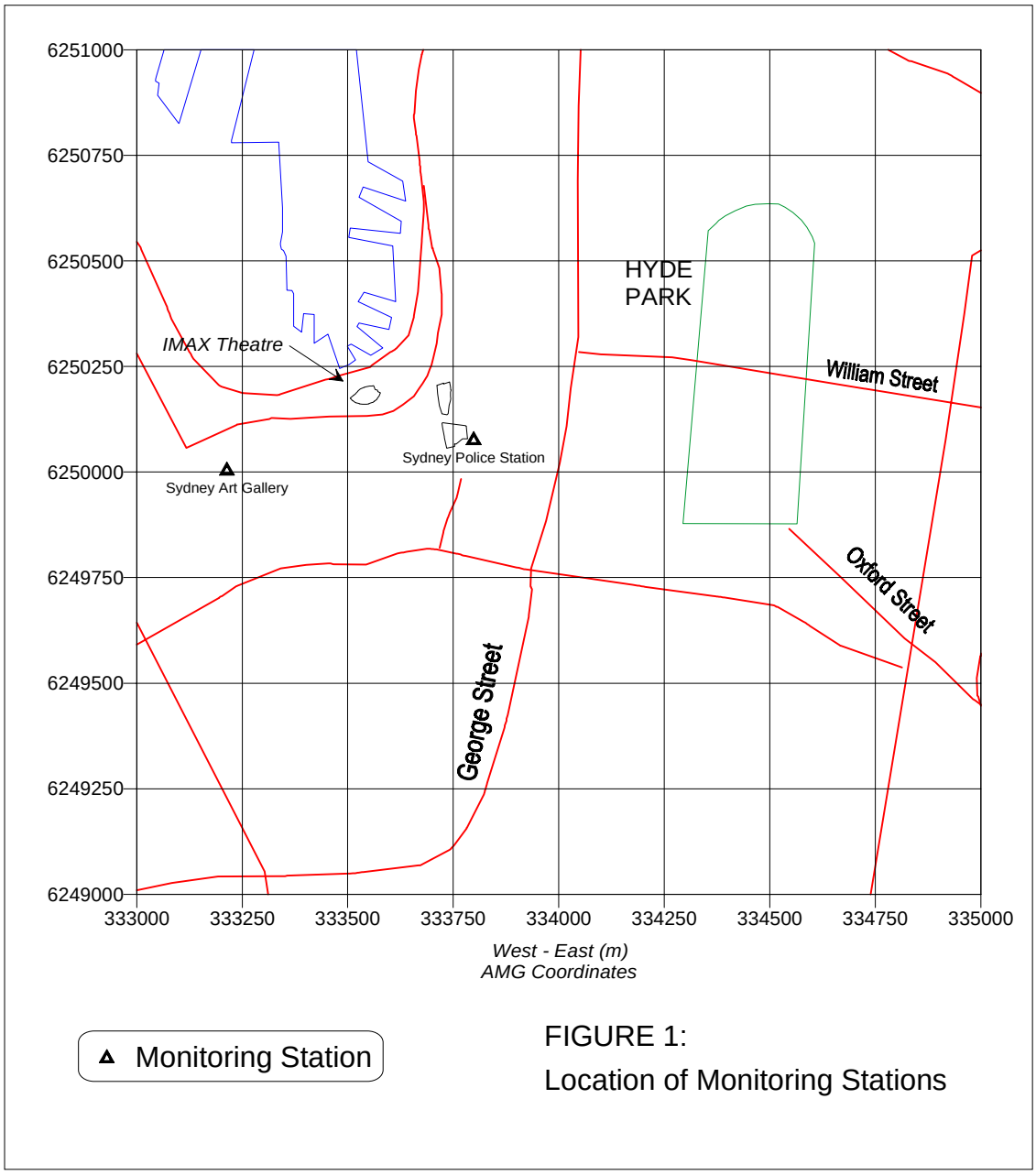

Figure 1: Location of the Police Station and Art Gallery monitoring stations.

3.1 Oxides of nitrogen

Oxides of nitrogen (NO_x) are produced as a result of combustion in vehicles. The two main components of nitrogen oxides (NO_x) are nitric oxide (NO) and nitrogen dioxide (NO_2). Generally at the point of emission, nitric oxide (NO) will comprise the greatest proportion of the emission. Typically at the point of emission 95% (by volume) of the NO_x will be NO and 5% will be NO_2.

The hourly average nitrogen dioxide (NO_2) concentrations display a diurnal (daily) pattern. This pattern exhibits peaks which occur three times per day. The peak concentrations generally coincide with the peak traffic periods of the morning, midday and evening. The results of the 1-hour average concentration of nitrogen dioxide at the Police Station for June and July, 2000 are shown in **Figure 2**.

The mean value of the hourly concentration was 2.5 pphm for the two months of June and July . The maximum concentration was 5.6 pphm, which occurred on the 27th of June and on the 7th of July. The bulk of the results were between 2 and 5 pphm, which can be seen in **Figure 2**. The 1-hour average concentration at the Police Station did not exceed the NEPM goal of 12 pphm.

The results of the 10-minute average concentration of nitrogen dioxide at the Police Station in June and July are shown in **Figure 2**. While these results are not used to determine air quality standards they are also useful in understanding the short term fluctuations that contribute to the hourly average concentration. The maximum 10-minute concentration for June was 6.6 pphm, recorded on the 21st . In July, the maximum 10-minute concentration was 10.6 pphm, recorded on the 5th.

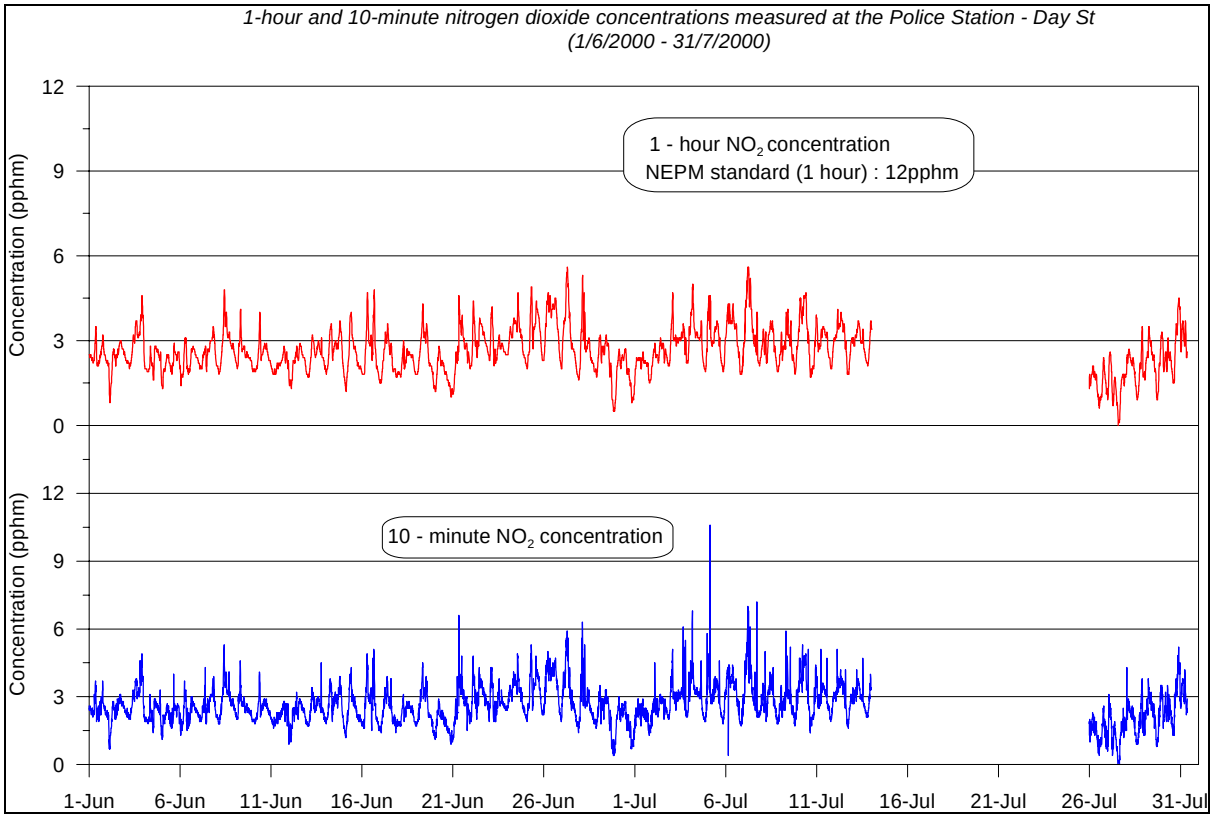

Figure 2: The concentration of nitrogen dioxide at the Police Station for June and July.

Table 2 contains the ten highest hourly averages of NO_x for June and July. In June, the proportion of NO and NO_2 in the oxides of nitrogen was 92.4% and 7.6% at the Police Station for the ten highest concentrations of NO_x. For July, the proportion of NO and NO_2 in the NO_x concentration was 89.0% and 11.0%, respectively. The reason why the proportion of NO concentration is lower than 95% is due to oxidation of nitric oxide that occurs once it is released into the atmosphere.

Table 2: The ten highest hourly average concentrations of nitrogen oxides in June and July and the percentage of NO_2 for the Police Station site.

Number	Day	Hour	Concentration of oxides of nitrogen (NO_x) (pphm)	Concentration of nitrogen dioxide (NO_2) (pphm)	Percentage of NO_2 in NO_x (%)
June					
1	16th	7:00 pm	67.3	4.2	6.2
2	16th	8:00 pm	57.8	4.0	6.8
3	16th	6:00 pm	50.7	3.6	7.1
4	3rd	10:00 pm	50.4	4.5	9.0
5	3rd	9:00 pm	47.5	3.8	8.0
6	28th	9:00 am	45.8	5.2	11.4
7	14th	9:00 pm	45.1	3.3	7.2
8	3rd	8:00 pm	45.1	3.9	8.6
9	17th	6:00 pm	44.5	2.9	6.5
10	16th	9:00 pm	43.2	2.7	6.2
Average			**49.7**	**3.8**	**7.6**
July					
1	5th	10:00 pm	39.8	3.5	8.8
2	7th	5:00 pm	39.6	5.1	12.8
3	5th	9:00 pm	39.4	3.6	9.1
4	3rd	9:00 am	39.0	4.4	11.2
5	5th	9:00 am	36.6	4.2	11.5
6	9th	7:00 pm	36.3	4.0	10.9
7	4th	11:00 pm	35.1	3.4	9.8
8	7th	6:00 pm	34.8	4.1	11.7
9	8th	10:00 pm	34.8	3.6	10.5
10	12th	10:00 pm	34.5	3.5	10.2
Average			**37.0**	**3.9**	**10.6**

The bimonthly (June and July) average proportion of NO and NO_2 in NO_x concentrations for June was 68% and 32% respectively. As the concentration of nitrogen oxides decrease, (i.e. dilute with ambient air) they also oxidize into a greater proportion of nitrogen dioxide. The rate at which this oxidation takes place is dependent on prevailing atmospheric conditions including temperature, humidity and the presence of other substances in the atmosphere such as ozone. It can vary from a few minutes to many hours. The rate of conversion is quite important because from the point of emission to the point of maximum ground-level concentration there will be an interval of time during which some oxidation will take place. If the dispersion is sufficient to have diluted the emissions from a ventilation stack to the point where the concentration is very low it is unimportant that the oxidation has taken place. However, if the oxidation is rapid then high concentrations of NO_2 can occur.

Table 2 shows that the periods of highest NO_x concentration occur during the evening when traffic is at a peak and the atmosphere is stable. At this time the proportion of NO_2 is lowest.

The 10-minute average concentration of oxides of nitrogen are shown in **Figure 3**. The maximum 10–minute average concentration for oxides of nitrogen in June was 69.9 pphm, recorded on the 16th. In July, the maximum concentration for oxides of nitrogen was 62.0 pphm, recorded on the 8th.

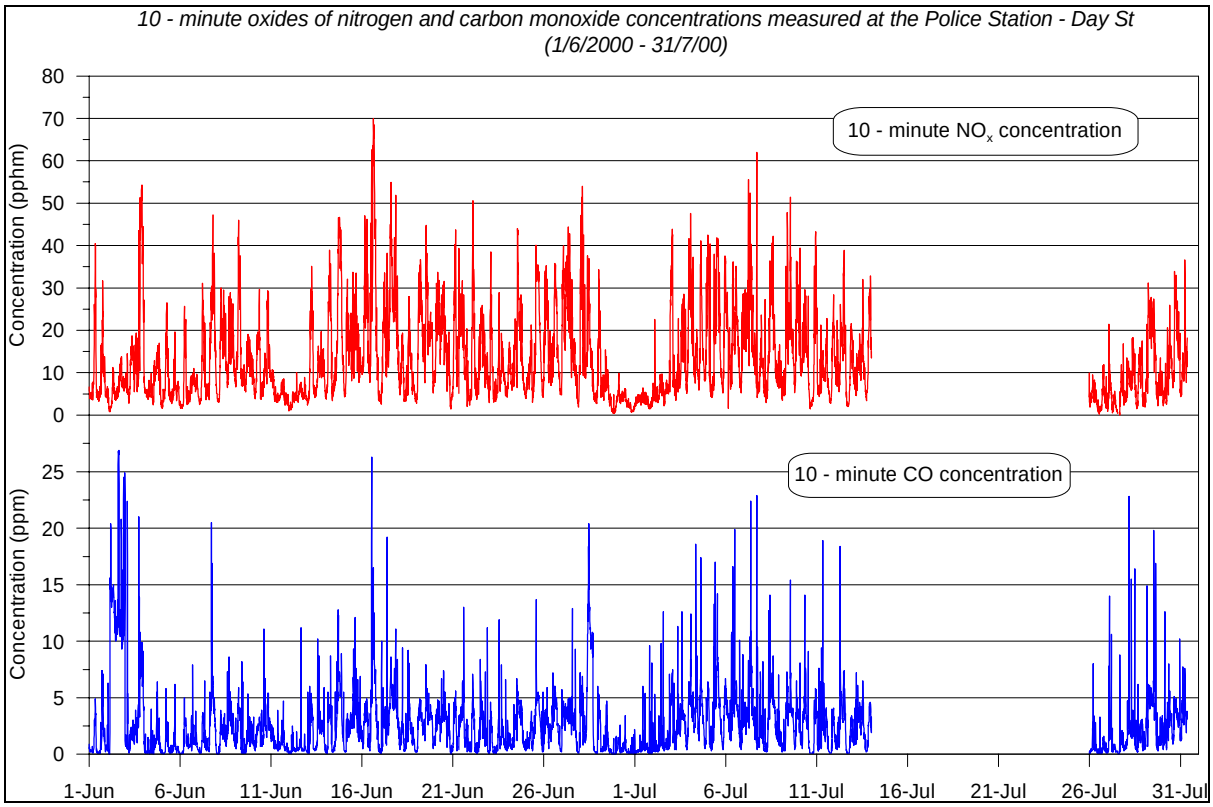

Figure 3: The concentration of carbon monoxide and oxides of nitrogen for June and July.

3.2 Carbon monoxide

Carbon monoxide is produced as a result of combustion of fuels (as well as from other sources). There is a diurnal pattern in carbon monoxide concentrations, with three peaks per day that coincide with peak traffic periods. The 10–minute concentration of carbon monoxide is shown in **Figure 3**. While these results are not used to determine air quality standards they are useful in understanding the short term fluctuations that contribute to longer timeframe concentrations.

The hourly average concentrations of carbon monoxide, which are in **Figure 4** shows periods of high concentrations in June on the 7th, 16th, 28th and especially the 2nd. This sustained period of high carbon monoxide concentration on the 2nd led to an exceedance of the goal of 25 ppm. This exceedance was due to a sharp increase in concentrations to a maximum level of 26.8 ppm on the 2nd, which lasted for approximately an hour. In July, high concentrations were recorded on the afternoon of the 7th, with a July maximum of 22.5 ppm. The mean value of the 1-hour average concentration for June and July was 2.6 ppm.

As mentioned in the executive summary, air quality goals are set to ensure that the whole community, including sensitive members, are not affected by pollutants in the air. An exceedance occasion has occurred when pollutant concentrations in ambient air have risen above the set goals. For certain pollutants, there may be a series of goals, set to varying timeframes.

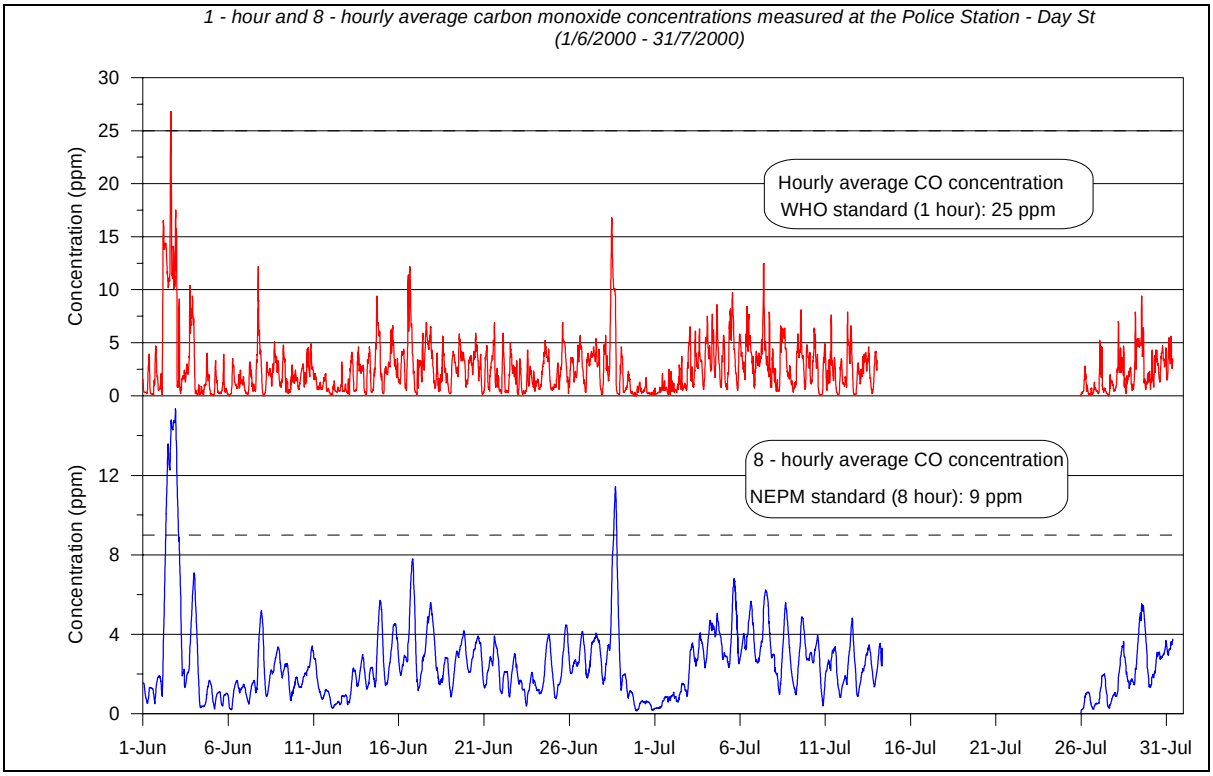

Figure 4: The concentration of 1-minute and 8-hour averages of carbon monoxide at the Police Station for June and July.

The 8-hour average concentrations for June and July is shown in **Figure 4** and is dominated by the very high concentration on the 2nd and 28th of June. The peak concentration in June, on the 2nd, was 15.3 ppm. The NEPM 8-hour average concentration goal for carbon monoxide is 9 ppm, which was exceeded on two occasions, both in June. This is seen in **Figure 4**, with the dashed line indicating the level of the NEPM goal. The first exceedance occurred on the 2nd, lasting for approximately 16 hours. The most noticeable feature about this period is the dramatic increase from approximately 1 ppm to high concentrations in the space of four hours. The second exceedance occurred on the night of the 28th. These concentrations were due to the high levels on the afternoon of the 28th. There were no exceedances of the NEPM goal in July, with the maximum concentration of 6.8 ppm on the 6th. The mean value for the 8-hour average concentration of carbon monoxide was 2.5 ppm over the two month period.

3.3 Particulates (PM_{10})

Particulates is the general term given to all airborne solids and liquids. In order to remain in the air, particles need to be smaller than approximately 50 µm in diameter, otherwise they fall out of the air too quickly. Particulates are derived from many sources including combustion of fuels, industrial processes, surface disturbances (e.g. construction) and from natural sources, such as sea salt. The range of particle sizes is large, ranging from 50 µm to sub-micron diameters. Particles smaller than 10 µm in diameter are referred to as PM_{10}. The diameter of the particle is important primarily for respiratory health effects. Particles larger than 10 µm are generally intercepted before reaching the lungs, by the nose, mouth and throat. Finer particles, referred to as PM_{10}, can enter bronchial and pulmonary regions of the respiratory tract.

The use of wood heaters in urban areas is a source of air pollutants, most notably particulates. As a result, during episodes when meteorological conditions are unfavourable (on clear, calm

winter nights), the EPA requests that wood heaters not be used. These "*Don't Light Tonight*" requests are an attempt to minimise air pollution the following morning. In June and July, the EPA made a "*Don't Light Tonight*" requests on the 14th and 15th of July. While it is noted that particulate concentration did decrease, there is no conclusive evidence that this was due to the EPA request.

The 10–minute average concentration of PM_{10} experienced sustained periods above 50 µg/m^3. The majority of these episodes occurred in mid-June and early July. The measurements where concentrations were above 50 µg/m^3 accounted for 18% of the monitoring period. The mean value of the particulate concentration for the two months was 28.4 µg/m^3. The maximum 10-minute concentration for June was 465 µg/m^3 and is shown in **Figure 5**. In July, the maximum 10-minute concentration was 392 µg/m^3. Both these monthly maximums were recorded on the 16th at 4:20pm. No obvious cause why these high concentrations occurred at the same time and date has been found. Looking past these two periods of anomalous concentrations, the next highest result in June was 164 µg/m^3 on the 19th. The second highest result in July was 164 µg/m^3 on the 7th. The 10-minute average and the 24–hour running average PM_{10} concentrations are shown in **Figure 5**. Neither of these average concentrations of PM_{10} have standards to which air quality is assessed.

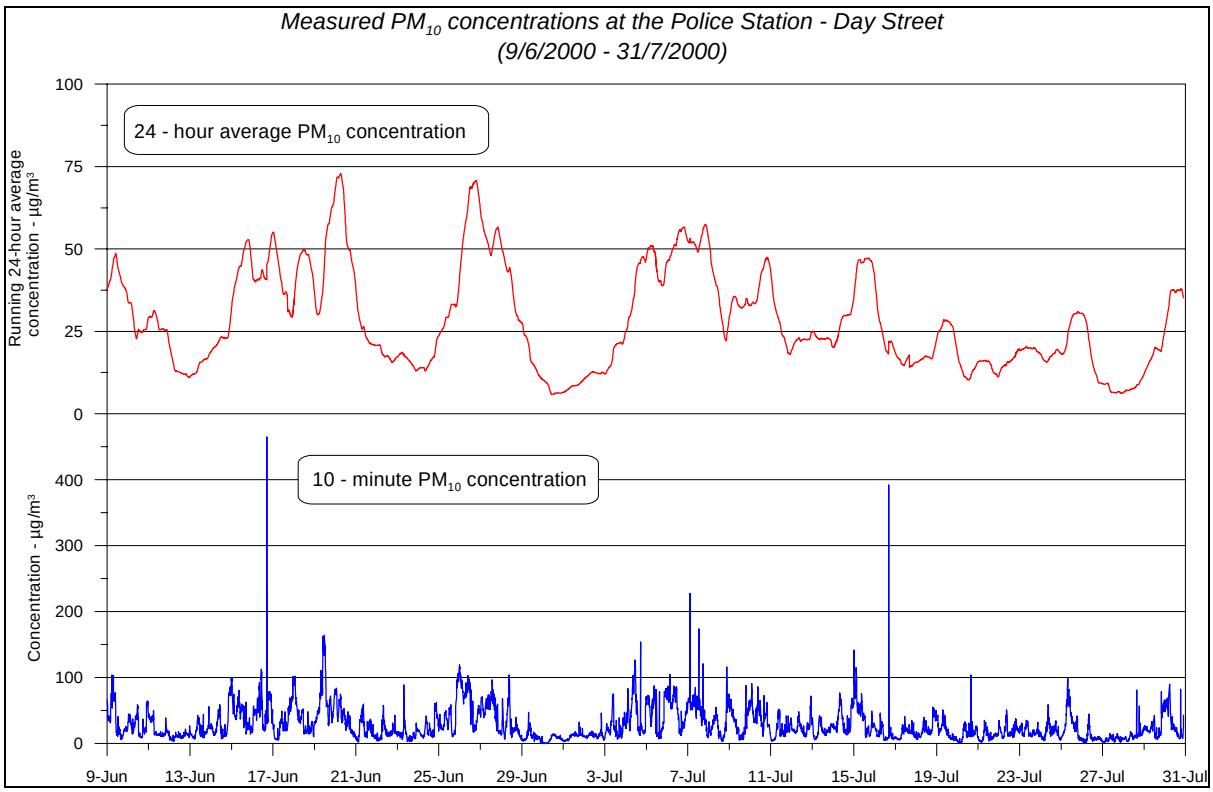

Figure 5: Concentrations of PM_{10} at the Police Station in June and July.

The PM_{10} concentrations (average, minimum and maximum) for three time intervals are shown in **Table 3**. The 24-hour moving average and the daily average measure the PM_{10} concentration over a 24 hour period. The daily average differs in that it measures the 24–hour average from midnight to midnight on the following day (eg. from midnight on the 9/6/00, until midnight on the 10/6/00). The daily concentration is calculated once a day at midnight. The 24–hour moving average measures the average PM_{10} concentration from a particular time for the next 24

hours (eg. from 1:40pm on the 9/6/00, until 1:40pm on the 10/6/00). As a result the 24–hour moving average is calculated every 10 minutes.

Table 3: The PM_{10} concentrations for three time intervals at the Police Station in June and July.

Measurement Interval	Mean µg/m³		Minimum µg/m³		Maximum µg/m³		Day of maximum concentration		Time of Maximum Concentration	
	June	July	June	July	June	July	June	July	June	July
10–Minute Average	31.6	26	0.0	1.0	465	392	16th	16th	4:40 pm	4:20 pm
24–Hour Moving Average	32.3	25.6	5.8	6.2	72.9	57.4	20th	7th	6:10 am	8:30 pm
Daily Average	32.3	25.6	7.3	7.3	62.3	53.0	26th	7th	N / A	N / A

The daily average concentration of PM_{10} is monitored in accordance to the NEPM goal of 50 µg/m³. This 50 µg/m³ goal corresponds to a visual distance of approximately nine kilometres (**EPA, 2000**). In June, the goal was exceeded on three occasions at the Police Station. In July, there was two exceedances. These exceedances are shown in **Figure 6**, where concentrations are above the 50 µg/m³ dashed line.

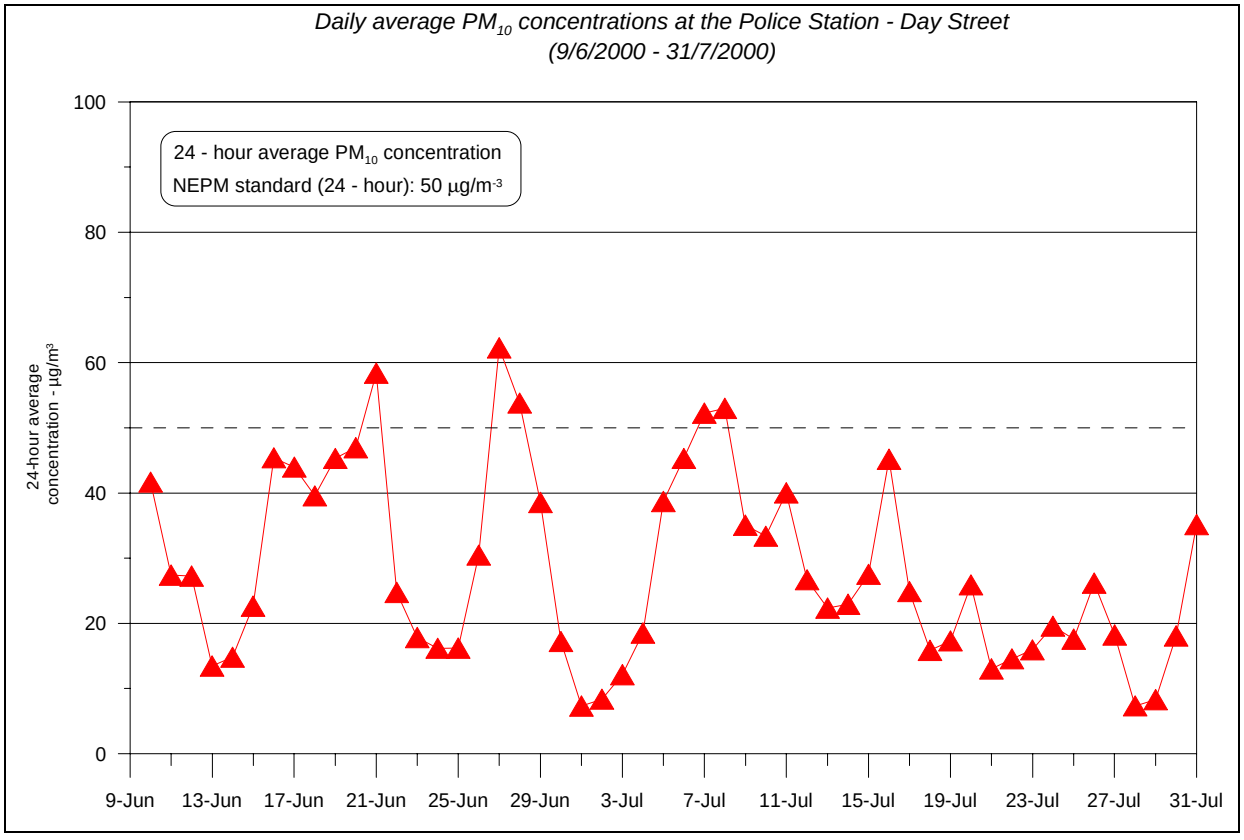

Figure 6: Daily concentration of PM_{10} at the Police Station in June and July, 2000.

The first exceedance in June was on the 20th, where the daily average concentration of 58.4 µg/m³. This was followed on the 26th with an daily average concentration of 62.3 µg/m³, the June maximum. This elevated concentration was due to high levels recorded from midnight on the 26th until midday (on the same day). The high concentrations in the morning were enough

to exceed the daily goal of 50 μg/m^3. The last exceedance occurred on the 27th with an average concentration of 53.8 μg/m^3. This exceedance was due to levels slightly above 50 μg/m^3 throughout the 27th. This is shown in the 10-minute average concentration (**Figure 5**) which showed low variability throughout the day and the average being just above 50 μg/m^3.

The first exceedance in July was on the 6th, where a daily average concentration of 52.3 μg/m^3. This was followed on the 7th with an average concentration of 53.0 μg/m^3, the July maximum. This elevated concentration was due to concentrations rising the afternoon prior to the 7th and remaining high over the entire day, decreasing later in the night. The exceedance occasions in June and July are summarised below in **Table 4**.

Table 4: Summary of PM_{10} exceedance occasions at the Police Station in June and July.

Measurement Interval	Exceedance Occasion	Average Concentration μg/m^3	Day of Exceedance
June			
Daily Average Concentration	1	58.4	20th
	2	62.3	26th
	3	53.8	27th
July			
Daily Average Concentration	1	52.3	6th
	2	53.0	7th

4 SYDNEY ART GALLERY

Air quality monitoring began at Sydney Art Gallery on the 15th of June. The monitoring site is located on the first floor of the Sydney Art Gallery building (approx. 4m above street level). This location is near the intersection of Harris Street with the Western Distributor, which is a major traffic node. Monitoring of carbon monoxide, nitrogen oxides and particulates is being carried out at this monitoring station. The monitors measure concentrations at 1-minute intervals and log 10-minute averages. The 10-minute average concentration was used to determine longer timeframe averages.

In July, measurements of nitrogen oxides and carbon monoxide were disrupted from the 14th until the 21st, due to an instrument fault.

4.1 Oxides of nitrogen

The 1-hour average concentration of nitrogen dioxide has higher values than at the Police Station, with a diurnal (daily) pattern coinciding with the morning, noon and afternoon peak traffic periods.

The maximum 1-hour average concentration for nitrogen dioxide was 8.2 pphm which occurred in June (on the 15th) and July (on the 7th). This high concentration can be seen in **Figure 7**, which includes the graph of the 10–minute average concentration for nitrogen dioxide. The bimonthly mean of the 1-hour average concentration was 4.0 pphm. From **Figure 7**, a vast majority (90%) of concentration values are lower than a moderate concentration of 6 pphm. There were no exceedances at the Art Gallery of the 1-hour average concentration goal of 12 pphm in June and July.

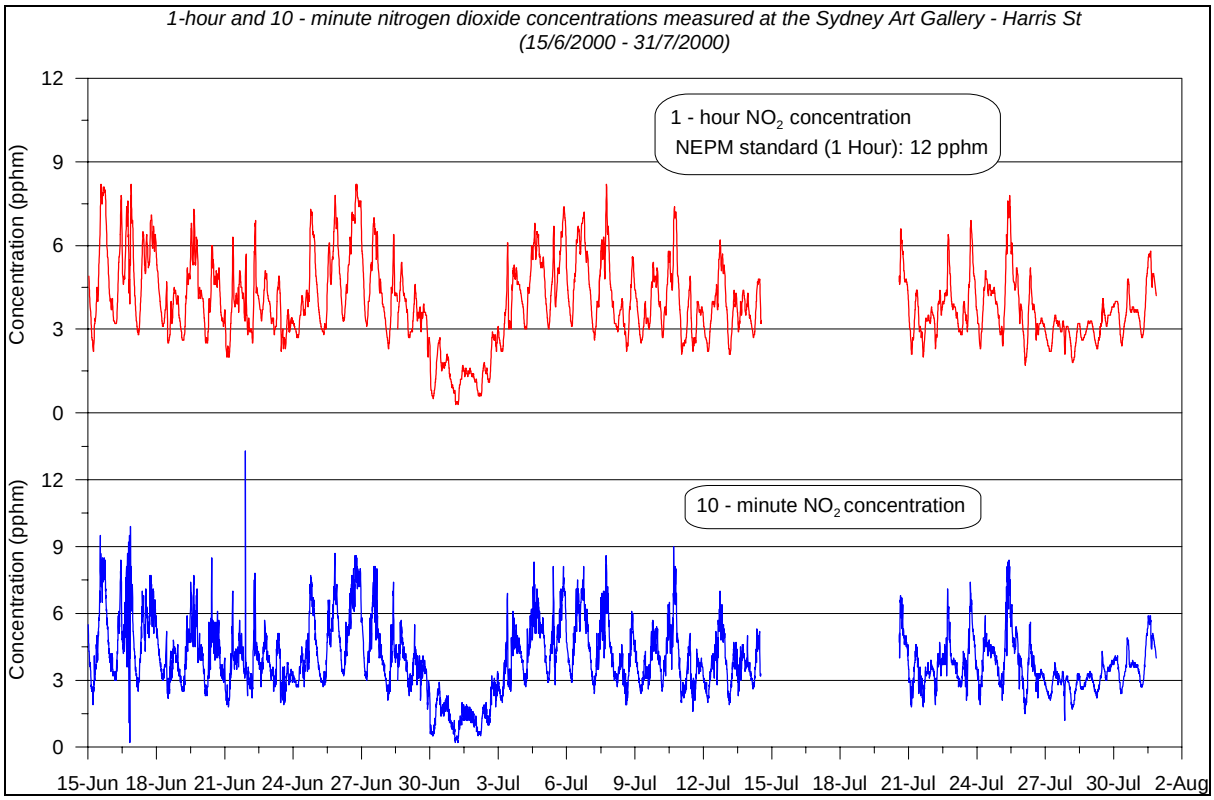

Figure 7: The concentration of nitrogen dioxide at the Art Gallery for June and July, 2000.

The maximum 10–minute concentration of nitrogen dioxide for June was 13.3 pphm. The maximum concentration in July was 9.0 pphm. The bimonthly mean was 4.0 pphm. The results are shown in **Figure 7**. As mentioned for the Police Station site, 10-minute average concentrations of nitrogen dioxide are not used in assessing air quality.

The ten highest hourly oxides of nitrogen concentrations for June and July at the Art Gallery site are shown in **Table 8**. For the two months of June and July, the proportion of NO and NO_2 within the ten highest total oxides of nitrogen concentrations was approximately 91% and 9% respectively.

Table 5: The ten highest concentrations of nitrogen oxides and the percentage of NO_2 at the Art Gallery in June and July.

Number	Date	Hour	Concentration of oxides of nitrogen (NO_x) (pphm)	Concentration of nitrogen dioxide (NO_2) (pphm)	Percentage of NO_2 in NO_x (%)
June					
1	16th	7:00 pm	105.0	3.2	3.0
2	16th	6:00 pm	103.1	4.8	4.6
3	16th	8:00 pm	96.4	7.5	7.8
4	15th	4:00 pm	82.6	8.1	9.8
5	16th	5:00 pm	82.4	7.6	9.2
6	22nd	7:00 am	80.4	6.8	8.5
7	15th	3:00 pm	79.7	8.1	10.1
8	16th	4:00 pm	77.0	6.7	8.7
9	20th	7:00 pm	74.0	7.6	10.3
10	17th	5:00 pm	67.7	6.9	10.2
Average			**84.8**	**6.7**	**7.9**
July					
1	25th	7:00 am	85.7	6.1	7.1
2	7th	5:00 pm	80.0	7.8	9.7
3	20th	3:00 pm	63.7	6.5	10.2
4	25th	8:00 am	60.4	7.4	12.3
5	20th	4:00 pm	60.0	6.1	10.2
6	6th	3:00 pm	59.7	6.8	11.3
7	6th	4:00 pm	59.5	6.9	11.6
8	7th	7:00 pm	59.3	6.7	11.2
9	8th	9:00 pm	58.7	5.6	9.5
10	3rd	9:00 am	58.5	6.1	10.4
Average			**64.5**	**6.6**	**10.2**

At the Art Gallery, the bimonthly average percentage of nitric oxide (NO) concentration is 65% of the oxides of nitrogen. While nitrogen dioxide concentrations account for 35% of the oxides of nitrogen concentration.

The 10-minute concentration of oxides of nitrogen are shown in **Figure 8**. In June, the maximum 10-minute concentration for oxides of nitrogen was 108 pphm, recorded on the 16th. The July 10-minute average concentration of oxides of nitrogen was 104 pphm, measured on the 25th.

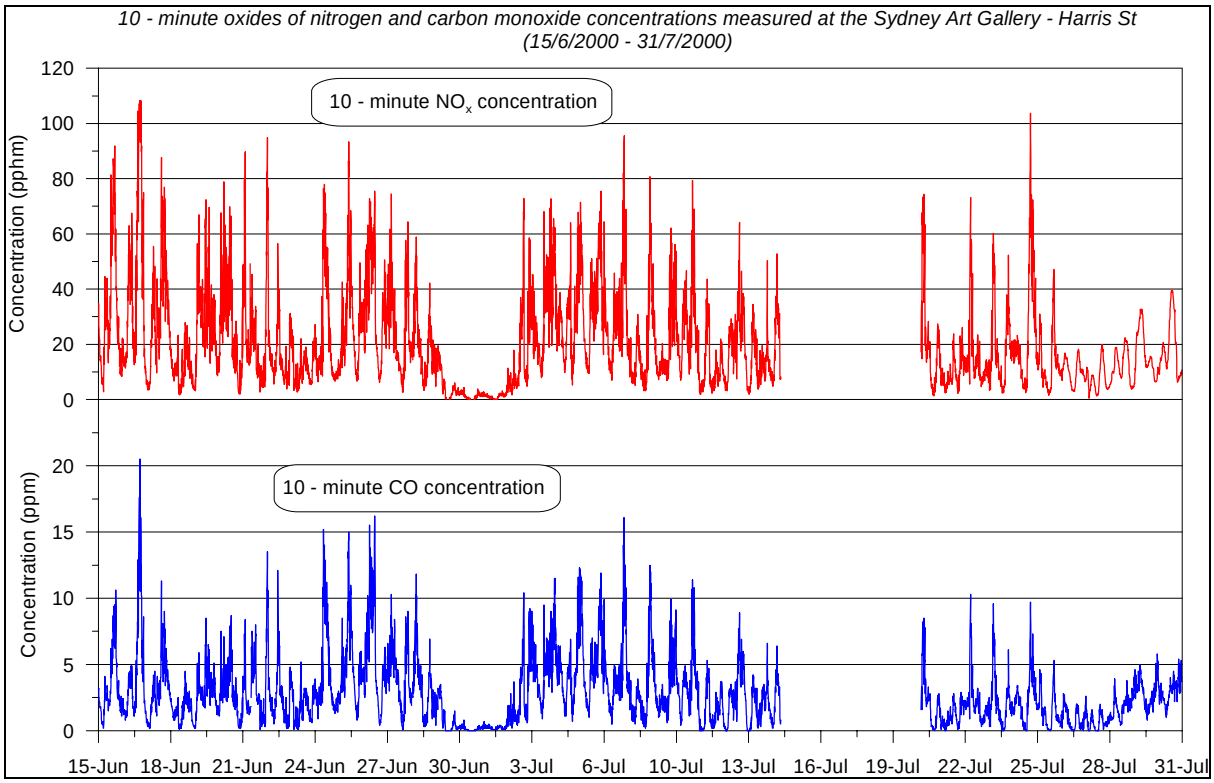

Figure 8: The concentration of carbon monoxide and oxides of nitrogen at the Art Gallery for June and July, 2000.

4.2 Carbon monoxide

The 10–minute concentration of carbon monoxide is shown in **Figure 8**. While these results are not used to determine air quality standards they are useful in understanding the short term fluctuations that contribute to longer timeframe concentrations.

The results of the 10-minute average concentrations are shown in **Figure 8**. The maximum 10-minute average concentration for June was 20.5 ppm on the 16th (at 7:20pm). In July, the maximum 10-minute average concentration was 16.1 ppm on the 7th (at 5:30pm).

There is a diurnal pattern in carbon monoxide concentrations, with three peaks per day as seen at the Police Station. The hourly average concentrations of carbon monoxide are shown in **Figure 9**. The hourly concentrations had high levels near the start of the reporting period on the 16th. Concentrations increased on the 24th and continued to produce high peak concentrations until the 29th. The hourly concentrations had very low levels near the start of July. This was followed by moderate to high concentrations from the 4th to the 8th.

The maximum 1–hour average concentration for June was 16.5 ppm which was recorded on the 16th. In July, the maximum 1–hour average concentration reading was 15.0 ppm which was recorded on the 7th. The mean for the two months combined was 2.9 ppm. The 1–hour goal of 25 ppm was not exceeded at the Art Gallery site in June and July.

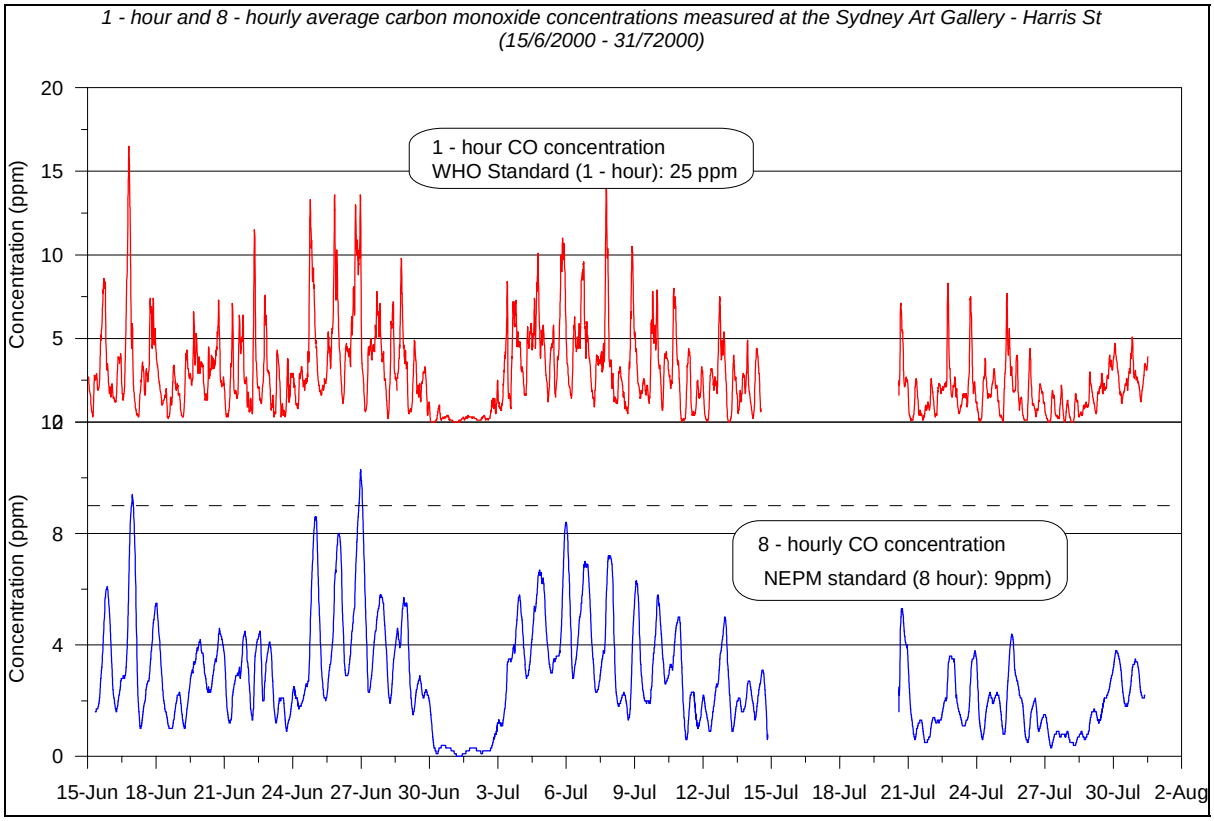

Figure 9: The concentration of 1-minute and 8-hour averages of carbon monoxide at the Art Gallery for June and July, 2000.

The results for the 8-hour average concentrations show high values at the start of the monitoring period in June. On the 24th the concentrations increased to high levels and remained high for approximately 3 days. The mean 8-hour carbon monoxide concentration for the two months was 2.9 ppm. The June maximum concentration was 10.3 ppm measured on the 26th. The maximum reading for July was 8.4 ppm recorded on the 6th.

The NEPM 8-hour average concentration goal for carbon monoxide is 9 ppm, which was exceeded on two occasions in June. The goal is not exceeded in July. The exceedances in June are shown in **Figure 9**, with the dashed line indicating the level of the NEPM goal. The first exceedance occurred on the night of the 16th (about 10:30pm). The maximum concentration during this period was 9.4 ppm. The first exceedance was due to the large increase in 10-minute concentrations on the evening of the 16th (at around 6:00pm), which lasted for 3 hours. The second occasion where the 8-hour goal was exceeded occurred on the 26th. The maximum concentration during this period was 10.3 ppm, which was the 8-hour maximum for June. The second exceedance occasion was due to elevated values on the night of the 26th from 5:00pm until midnight.

4.3 Particulates (PM_{10})

The 10-minute average PM_{10} concentrations were relatively low in June, except for three episodes of elevated concentrations. These occurred for sustained periods starting on the 9th, 15th and 26th. July also experienced periods of elevated PM_{10} concentration near the 4th, 15th, 25th and 30th.

The highest reading for the June 10-minute average concentration was 199 µg/m^3. This was recorded on the 19th (at 12:10pm). The highest reading for the July 10-minute average concentration was 195 µg/m^3, recorded on the 31st. The average concentration for June and July was 36.3 µg/m^3. Ten minute average concentrations are shown in **Figure 10**.

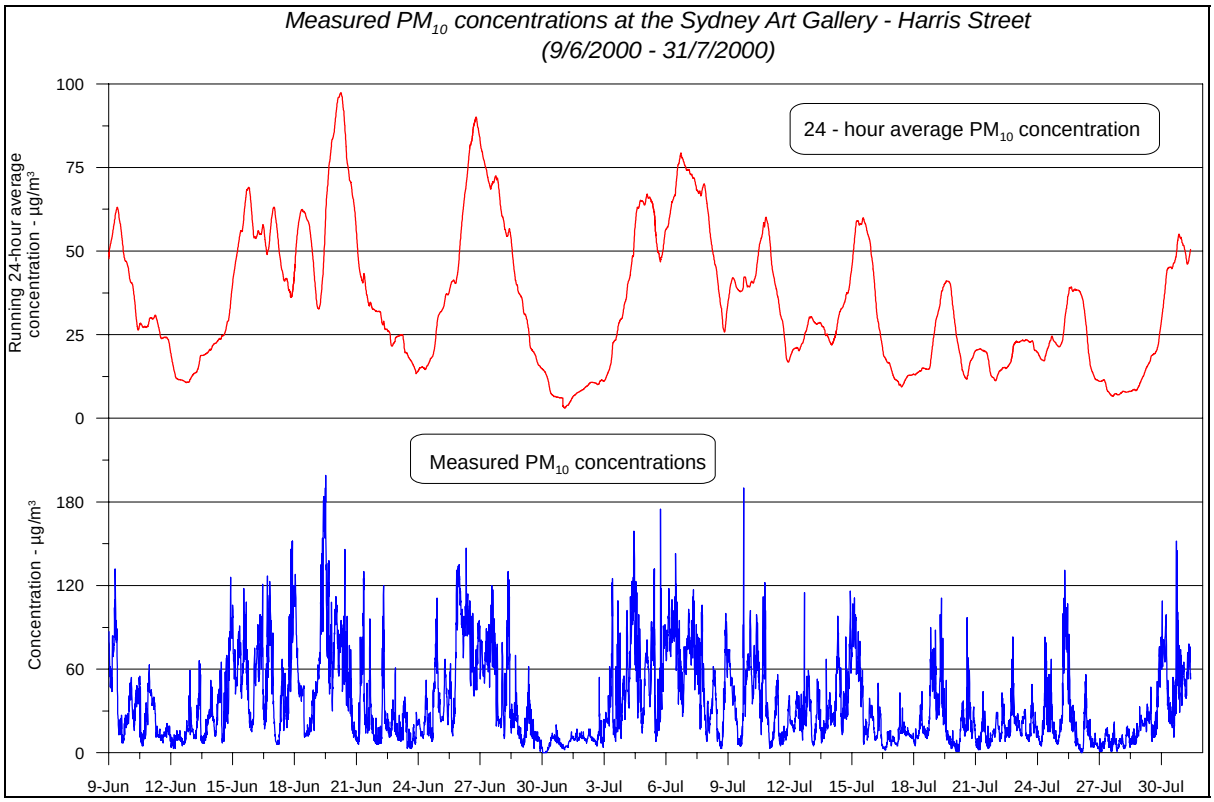

Figure 10: Concentrations of PM_{10} at the Art Gallery in June and July, 2000.

The daily average displays sustained periods of high concentration near the middle and towards the end of June. These elevated concentrations continue into the start of July, after which they begin to decline. The daily average concentrations are shown in **Figure 11**. The significant concentrations (average, minimum and maximum) for each time interval are shown in **Table 6**.

Table 6: The PM_{10} concentrations for three time intervals at the Art Gallery in June and July.

Measurement Interval	Mean µg/m3		Minimum µg/m3		Maximum µg/m3		Day of maximum concentration		Time of Maximum concentration	
	June	July	June	July	June	July	June	July	June	July
10–Minute Average	39.5	32.1	0.0	0.0	199	195	19th	31st	12:10 pm	8:00 pm
24–Hour Moving Average	40.5	31.1	6.0	3.0	97.4	79.3	20th	6th	5:50 am	5:20 pm
Daily Average	40.5	31.1	8.8	6.0	80.9	70.1	20th	7th	N / A	N / A

The average daily concentration of PM_{10} was 35.8 µg/m^3 for the two months. The maximum 24-hour concentration for June was 80.9 µg/m^3, which was recorded on the 20th. The maximum daily concentration for July was 70.1 µg/m^3, recorded on the 7th. The dashed line in **Figure 11**

refers to the NEPM 24-hour goal. In June, this goal was exceeded on eight occasions. Six exceedances were recorded in July.

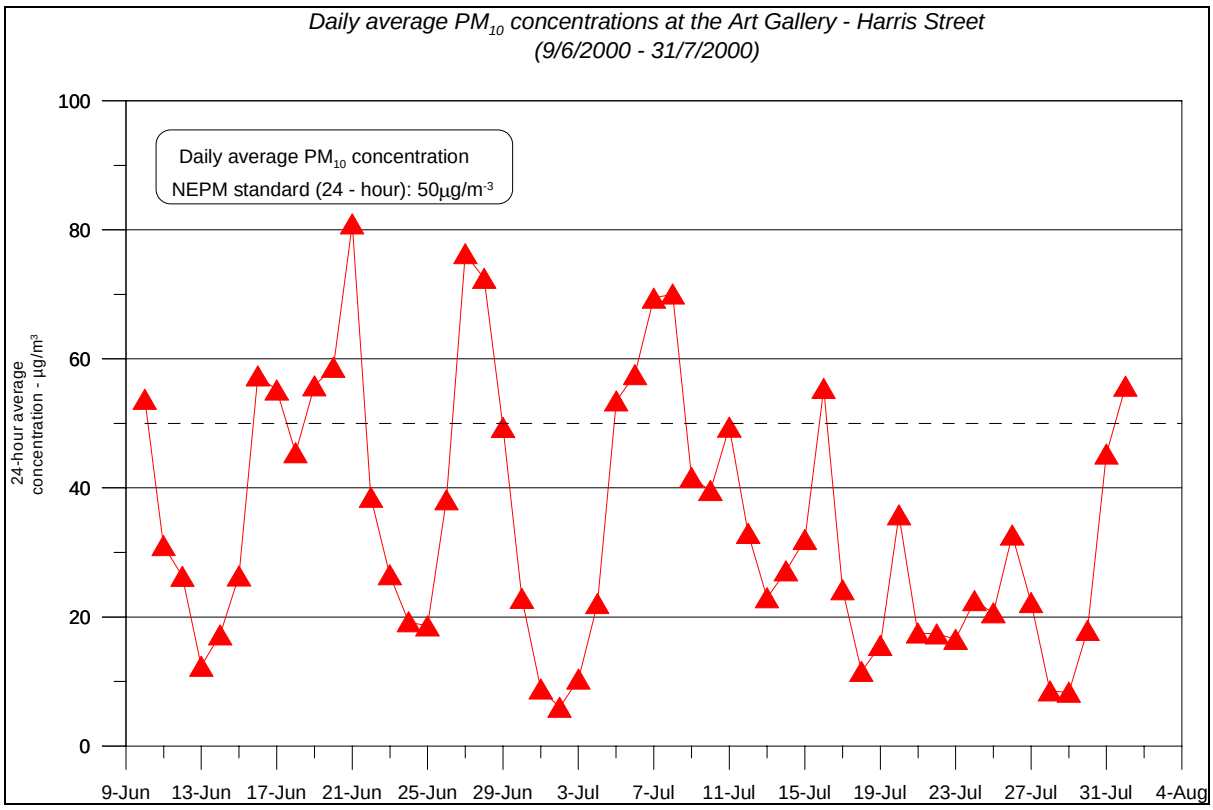

Figure 11: Daily concentration of PM_{10} at the Art Gallery in June and July, 2000.

The first exceedance in June was on the 9th, where the daily average concentration was 53.8 µg/m^3. The daily concentration exceeded this goal primarily because of the high levels during the morning of the 9th.

The second exceedance was on the 15th with an average concentration of 57.4 µg/m^3. This elevated concentration was due to high levels recorded from midnight on the 15th which continued all day of the 15th.

The fourth exceedance occurred on the 18th with a daily average concentration of 55.8 µg/m^3. This exceedance was also due to high concentrations in the early morning. On this occasion, the morning concentrations were high enough to compensate for lower levels in the afternoon. This exceedance was followed the next day (19th) with another daily concentration above 50 µg/m^3. The maximum concentration for the exceedance period on the 19th was 97.4 µg/m^3. The average concentration during this period was 58.7 µg/m^3. From the 19th, there were elevated concentrations until the 21st. This led to an exceedance on the 20th, that had a daily average concentration of 80.9 µg/m^3.

The sixth exceedance period occurred on 26th, with a daily average concentration of 76.3 µg/m^3. The high concentration on the 26th was due to a rapid increase in concentration levels around midnight on the 26th, which remained at high levels, until a rapid decrease in concentrations on the night of the 27th. This episode resulted in the two consecutive days (26 and 27th) exceeding the NEPM goal. The daily average concentration for the 27th was

72.5 μg/m^3 and was the last exceedance for June. The exceedance occasions for June and July are summarised below in **Table 7**.

Table 7: Summary of PM_{10} exceedance occasions at Art Gallery in June and July.

Measurement Interval	Exceedance Occasion	Average Concentration μg/m^3	Day of Exceedance
June			
Daily Average Concentration	1	53.8	9th
	2	57.4	15th
	3	55.2	16th
	4	55.8	18th
	5	58.7	19th
	6	80.9	20th
	7	76.3	26th
	8	72.5	27th
July			
Daily Average Concentration	1	53.5	4th
	2	57.6	5th
	3	69.4	6th
	4	70.1	7th
	5	55.4	15th
	6	55.8	31st

The first exceedance in July was on the 4th, where the daily average concentration of 53.5 μg/m^3 was recorded. The daily concentration exceeded this goal primarily because of the high levels during the mid-morning of the 4th.

The second exceedance was on the 5th with an average concentration of 57.6 μg/m^3. This elevated concentration was due to high levels recorded on the morning and night of the 5th. Concentrations continued to rise leading to the exceedance on the 6th. The daily concentration for the 6th was 69.4 μg/m^3. This exceedance was due to high concentrations throughout the entire day.

The fourth exceedance occurred on the 7th with a daily average concentration of 70.1 μg/m^3. This exceedance was also due to high concentrations throughout the day, particularly in the early morning. The average concentration for the exceedance period on the 15th was 55.4 μg/m^3. The concentrations on the morning of the 15th were particularly high.

The last exceedance occasion occurred on the 31st, with a daily concentration of 55.8 μg/m^3. This exceedance was due to concentrations, which kept increasing from the 29th, to levels above 50 μg/m^3.

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