REPORT TO EXAMINE ADEQUACY OF CBW AND CBE AIR QUALITY DATA FOR THE LANE COVE TUNNEL AGAINST MCoA 165

For

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By

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EXECUTIVE SUMMARY

The MCoA 165 calls for 2 years of ambient air quality data from the Community Based Monitoring Stations (CBMS's) as a basis for the description of the air quality in the area before the opening of the Lane Cove Tunnel (LCT). The contracted tunnel completion date, which was set as a target when the construction contract was agreed in December 2004, was May 2007 and monitoring at the CBMS's commenced in May 2005.

It is likely however that the tunnel may be completed, to enable its earlier use by motorists before May 2007. This report examines the possibility that the data set captured prior to tunnel opening (which may be less than 2 years) will be satisfactory on which to enable a comparison with the post operational period (after the tunnel opening).

Such comparative information is useful in determining the net impact of any improvements to the regional air shed or otherwise; and in the assessment of elevated air quality readings

In relation to this, the Minister's Conditions of Approval (MCoA) require:

a) MCoA 168 calls for validating the ambient air quality assessment for the tunnel ventilation system after an initial period of operation;

b) MCoA 170 calls for a Report to the Director General within 10 days if an exceedence of the LCT ambient air quality goals for Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), or Particulate matter (PM_{10}) occurs. This Report is to consider the cause and major contributors in such cases; and

c) MCoA 173 calls for a Report to the Director General within 10 days if an exceedence of the LCT in stack air quality goals for CO, Oxides of Nitrogen (NO_x), PM_{10} or Volatile Organic Compounds occurs. This Report is also to consider the cause and major contributors in such cases.

In essence all three conditions relate to the viability of using the air quality data recorded before the tunnel is operational as a basis for representing air quality before tunnel opening.

This report is prepared by the Independent Air Quality Auditor to the Lane Cove Tunnel, Team Ferrari Environmental, who is approved as independent auditor for the project under MCoA 180.

This report examines:

- The data in the first 12 months of monitoring at the CBMS sites; and
- The air quality at two sites operated by the NSW Department of Environment and Conservation (DEC) over 2 years from May 2004.

The monitoring conducted at the two sites, Community Based stations West (CBW) and East (CBE), has been independently audited on two occasions (November 2005 and May 2006 Audit Reports). The monitoring is carried out by the approved independent operator (under MCoA 165), Ecotech, conforming to Australian Standards and best practice. Ecotech technicians operating the stations are NATA Accredited. The audits found the monitoring was conducted in a professional manner and the data to be robust. The air quality data from the stations met the 90 percent availability target, nominated in the Project Deed.

The DEC sites used for comparative purposes in this report, were chosen in consultation with their experts to provide similar parameters and appropriate siting to the CBMS's. This study examined the 50, 90, 99 and 100 (maximum) percentiles at each site for the period May 2004 to April 2005 and for the period May 2005 to April 2006 (the period so far available for the LCT sites).

The study showed:

> *"Statistical analysis of the wind speed data from the two years at Chullora and at Rozelle indicates the dispersion on both years May 2004 – April 2005 and May 2005 – April 2006 was virtually identical. This was evident at all levels of percentiles.*
>
> *Statistical analysis of the 1-hour air quality data by means of the monthly and annual 50 percentiles, 90 percentiles, 99 percentiles and the maxima from both sites showed there was a high degree of similarity of the data collected between May 2004 – April 2005 and the following year May 2005 – April 2006.*
>
> *The analysis showed NO_2 and $PM_{2.5}$ data were virtually identical at all levels of percentiles.*
>
> *The analysis showed CO and PM_{10} were virtually identical at the 50 percentile, the 90 percentile and the 99 percentile. Only at the 100 percentile, or maximum value, were there variations - in each case the level measured in 2004/5 was slightly higher than that at 2005/6.*
>
> *The assessment of the 2 years of data from the 2 DEC sites Chullora and Rozelle indicates very little difference between the data for the two years. It is reasonable to say therefore that the probability is that a full 2 years of data from the CBMS's would be unlikely to significantly change the air quality description of the area based on the current data collected and that expected to be collected before the tunnel opening".*

The dispersion modelling of the Tunnel impact on the local and regional air quality predicts only minor increments for the pollutants of concern namely: CO, NO_2 and PM_{10}, $PM_{2.5}$. These increments are small and would generally be within the normal range of pollutant variations ("noise") from period to period (hour to hour, day to day, year to year, etc.). It is not unlikely that these increments will not manifest themselves in any noticeable change to the air quality as measured "pre" or "post" tunnel operation.

If the modeling is correct, this means that any amount of data before or after the tunnel opening is not likely to provide definitive answers to the question of the impact of the tunnel to local or regional air quality.

On that basis, the 12 months of data collected so far from the CBMS sites, together with the further data that will be collected before the tunnel opening, will provide a robust set of data for later comparison. It is not uncommon for the initial few months or so of data from new monitoring stations to have "teething" problems which make the initial data less reliable. This has not been seen on this project (as evidenced by the audits) and so there is a benefit from not having to discard or ignore any data. It is unlikely if that data, or the 2 years of data called for in the MCoA 165 or even 3 years of pre-operational data would be detailed enough to detect the small predicted increments of change. The body of data that will be collected before the tunnel opening, even if it is less than 2 years, will be sufficient to detect significant impacts on air quality from the tunnel operation. Before the tunnel is opened there will be data from 2 winter periods. Since winter generally has higher levels of pollution, a detailed comparison of winter periods could be done that would provide 2 periods to compare to, after opening. In addition there will likely be more data from the Ground Based Monitoring Stations (GBMS) and Elevated Receptor Monitoring Stations (ERMS) than required in the MCoA, thus adding more data for comparison to after opening.

In the first year of monitoring at the LCT, no exceedence of the air quality goals has occurred at either of the CBMS's. Occasional exceedences can occur in Sydney and it is possible they could occur at a CBMS either before or after the tunnel has opened. If an exceedence occurs at a CBMS after tunnel opening it will require detailed analysis to assess whether it is due to the emissions from the ventilation stacks, or other factors termed "extra-ordinary events" such as bush fires, dust storms etc (as defined in an approved Extraordinary Events Protocol) are the cause or major contributor.

Len Ferrari, Principal

29 July 2006

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1. INTRODUCTION

The MCoA 165 calls for 2 years of ambient air quality data from the Community Based Monitoring Stations (CBMS's) as a basis for the description of the air quality in the area before the opening of the Lane Cove Tunnel (LCT).

The tunnel proposed completion date is May 2007 and monitoring commenced in May 2005. It is likely however the tunnel may be ready for completion before May 2007. This report examines the possibility that the data captured at the CBMS's in a lesser period than 2 years, will be satisfactory to adequately describe the air quality in the area.

It is common practice to require that adequate ambient air quality monitoring be carried out before major developments. The monitoring is required to act as a basis for examining, at a later date, if the development has had an impact on air quality. Ambient air quality is determined as a result of two major factors – Emissions and Dispersion of those emissions. The regional emissions of air pollutants in the Sydney area vary only incrementally from month to month but the ambient air quality does vary from day to day and from season to season. The major reason for this variation is generally a result of daily and seasonal meteorology particularly dispersion by winds as measured by horizontal wind speed. While it is always ideal to have as much air quality data as possible before a major development, the period usually required is 1 year to cover daily and seasonal variations. In this case the Minster's Conditions of Approval (MCoA) asks for 2 years. If the LCT opens before May 2007 there will be less than 2 years of data from the Community Based stations West (CBW) and East (CBE).

While air quality data is being continually measured, at the time of writing this report, it is appropriate to examine data from the first year of monitoring from the LCT CBMS's and data from other areas in Sydney over the last 2 years. Team Ferrari Environmental is the Independent Auditor for the air monitoring in Lane Cove Tunnel and has been approved under MCoA 180.

2. THE PROTOCOL

As only 13 months of data are available from the CBMS's it is appropriate to examine the first year of data – namely May 2005 to April 2006 in some detail and assess this with a knowledge of the pollution levels measured at two NSW Department of Environment and Conservation (DEC) sites in the Sydney area over the last 2 years.

In order to examine the air quality in Sydney over the last two years, discussions were held with the DEC to consider data availability from appropriate DEC monitoring stations. The LCT stations measure the following air pollutants: Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), and Particulate Matter (PM_{10} and $PM_{2.5}$) as well as meteorological parameters. Few DEC stations measure all of these parameters but the two stations that offered the most were Chullora and Rozelle. These stations were the closest in proximity with similar urban environments to LCT stations and measured the parameters required. Chullora measures all these parameters and Rozelle measures all except $PM_{2.5}$.

A consideration of air pollution levels in ambient air needs to examine the upper end levels measured over a given time period. In any body of air quality data the large majority of values will be low or around the average and thus will not approach air quality standards. It is the upper percent of values that are important to examine as they may approach levels of concern. These upper levels may be as a result of local emissions or unique dispersion conditions. Displays of air quality levels usually include maximum single value, lowest value, and averages of various time periods. The average value can be useful in determining very long-term trends and the maximum values are also of interest. However maximum values tend to be somewhat random and often are not very descriptive of the air quality of a site – just a "one off" occurrence. The minimum value is of little use. The most valuable statistics for describing air quality levels are the upper percentiles of hourly or in some cases daily (for PM_{10} and $PM_{2.5}$) levels.

The assessment of air quality levels for this report are based on the 50 percentile (median), 90 percentile, 99 percentile and the 100 percentile (maximum) values. These percentiles for CO, NO_2, PM_{10} and $PM_{2.5}$ and Wind Speed are derived from the hourly values (and sometimes daily values for PM_{10} and $PM_{2.5}$) expressed over periods of 1-month and 1-year.

The percentiles for the selected parameters from the DEC sites of Chullora and Rozelle are compared at each site over the two years May 2004 to April 2005 and May 2005 to April 2006 to examine the variation in levels at each site and between the two years. It needs to be noted the 2006 data from the DEC is not yet validated. This is not likely to affect the analysis although it is possible some minor amendments may be made in the validation process.

3. THE ANALYSIS OF THE PERCENTILES

Analysis by the use of upper percentiles for comparing the two years is very meaningful at the 90 and 99 percentile but, as noted above, the maximum value (100 percentile) has limited use in the comparison as it is can be a unique or random level resulting from a particular set of circumstances - it is only one value in a month or year of data. The 50 percentile, while it is more meaningful than the mean, has limited value but is presented for completeness.

In this analysis, the data from each of the two DEC stations is analysed specifically to compare the data from the two years (May 2004 to April 2005 and May 2005 to April 2006). In addition, the one year of CBMS data currently available is analysed to verify its similarity and consistency with the DEC data.

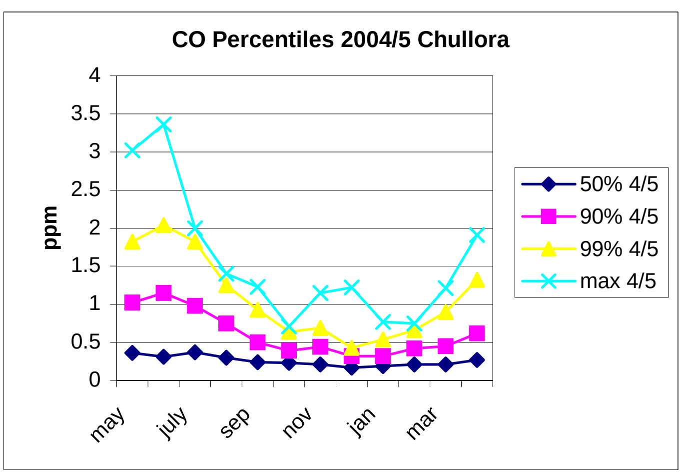
3.1. DEC Chullora

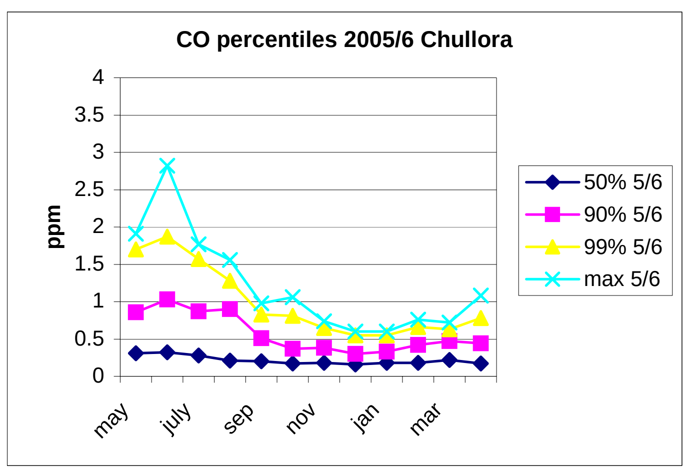
3.1.1. CO

Table 1 shows the 50, 90 and 99 percentiles and maximum values for the months from May to April in each year. The values show the common trends of higher values in winter and lower values in the warmer months. This is very evident in the Figure 1 and Figure 2 below.

Table 1. Monthly Percentiles for CO in 2005/6 and 2004/5 for Chullora

2005/6	CO												
	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	avg
50% 5/6	0.31	0.32	0.28	0.21	0.20	0.17	0.18	0.16	0.18	0.18	0.22	0.17	0.215
90% 5/6	0.86	1.03	0.87	0.90	0.51	0.37	0.38	0.30	0.33	0.42	0.47	0.44	0.573
99% 5/6	1.70	1.87	1.57	1.28	0.83	0.81	0.65	0.55	0.55	0.66	0.63	0.78	0.990
max 5/6	1.91	2.82	1.77	1.56	0.98	1.06	0.74	0.60	0.60	0.76	0.72	1.08	1.216
2004/5	CO												
	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	avg
50% 4/5	0.36	0.31	0.37	0.30	0.24	0.23	0.21	0.17	0.19	0.21	0.21	0.27	0.256
90% 4/5	1.02	1.15	0.98	0.75	0.50	0.39	0.44	0.32	0.32	0.42	0.45	0.62	0.613
99% 4/5	1.82	2.04	1.82	1.25	0.93	0.64	0.69	0.43	0.54	0.66	0.90	1.32	1.087
max 4/5	3.02	3.36	2.00	1.40	1.23	0.71	1.15	1.22	0.77	0.75	1.21	1.91	1.561





Figures 1 & 2. Monthly Percentiles for CO in 2005/6 and 2004/5 for Chullora

Figure 3 plots the monthly 50 and 99 percentiles and Figure 4 plots the monthly 90 percentile and the maxima over the two years. The plots over the two years show remarkable agreement with only a slight variation at the maxima values. This is reinforced with Figure 5 showing excellent agreement between the two years with only a variation above the 99 percentiles.

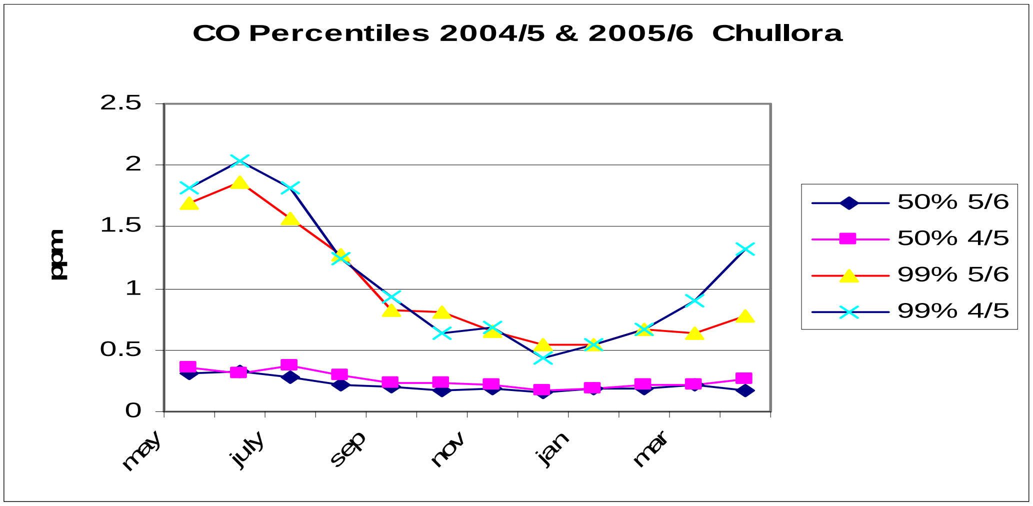


Figure 3. The 50 percentiles and 99 percentile for Chullora

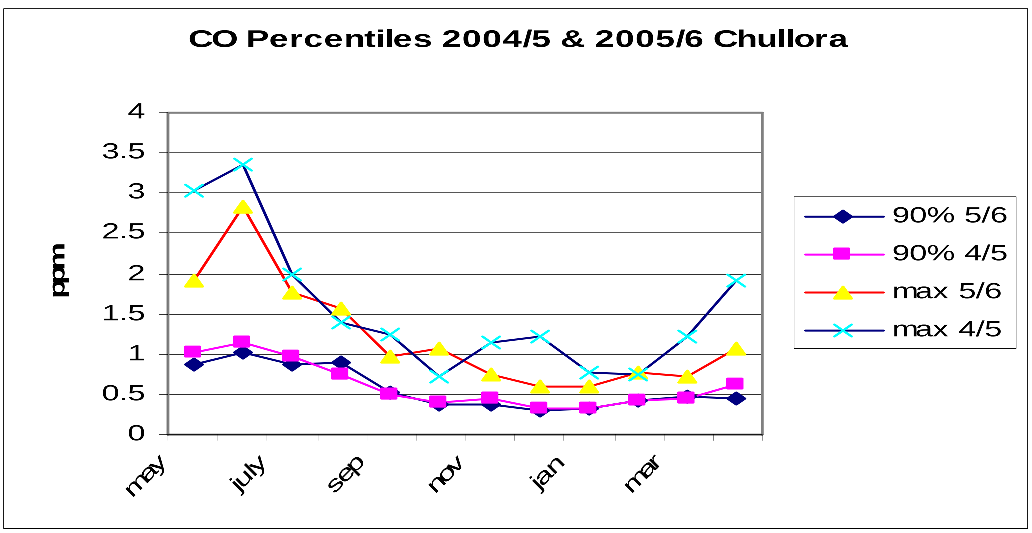


Figure 4. The 90 percentiles and maxima for Chullora

The annual percentiles, derived from the monthly percentiles, for both years are shown in Table 2 and Figure 5.

Table 2. Annual CO Percentiles over the two years 2005/6 & 2004/5 for Chullora

CO	ppm	2005/6	2004/5
	50%	0.215	0.256
	90%	0.573	0.613
	99%	0.990	1.087
	max	1.217	1.561

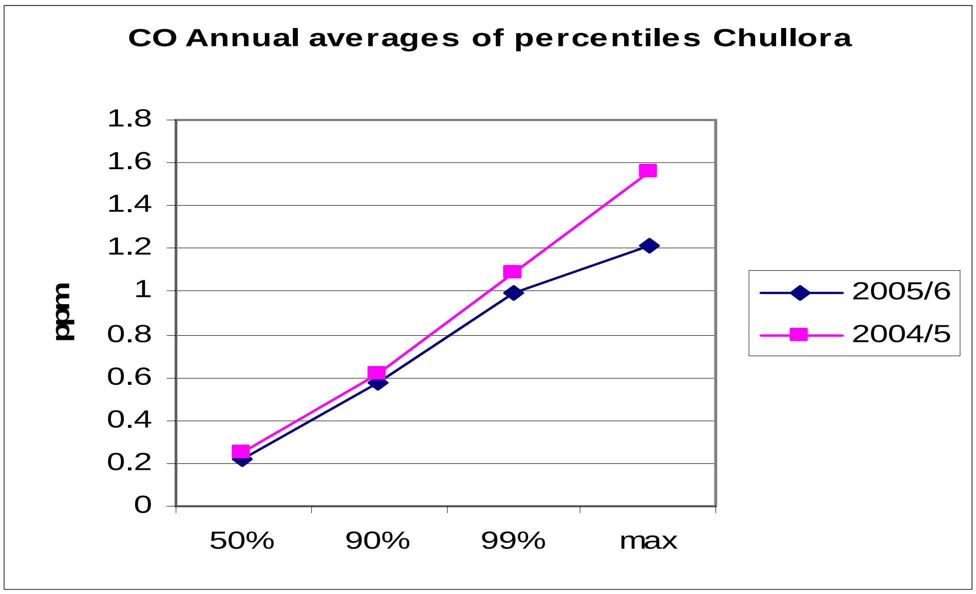


Figure 5. CO Percentiles over the two years 2005/6 & 2004/5 for Chullora

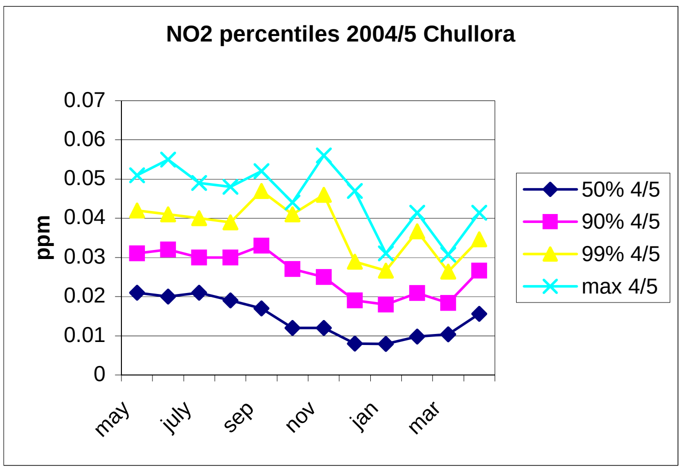
3.1.2. NO_2

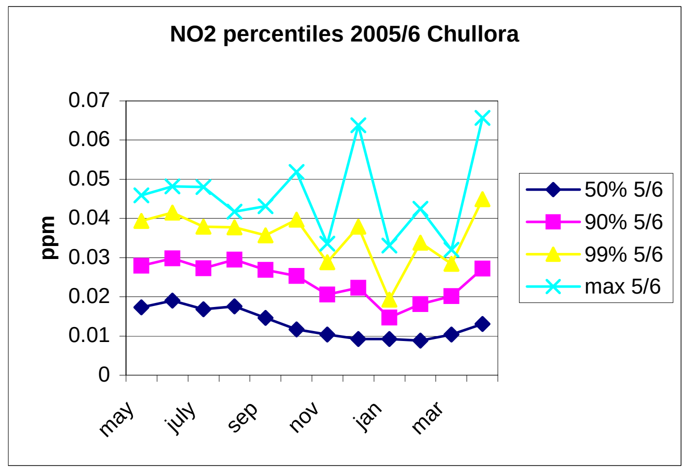
Table 3 shows the 50, 90, 99 percentiles and maximum values for the months May to April in each year. Figure 6 and Figure 7 below show the common trends of higher values in winter and lower in the warmer months for the 50 and 90 percentiles. The 99 percentile and the maximum values show occasional peaks in the warmer months inconsistent with the general trends.

Figure 8 plots the monthly 50 and 99 percentiles and Figure 9 plots the monthly 90 percentile and the maxima over the two years. The plots over the two years show remarkable agreement with only a slight variation at the 99 percentiles and maxima values. This is reinforced with Figure 10 showing excellent agreement between the two years over the whole range of all percentiles up to and including the maxima.

Table 3. Monthly Percentiles for NO_2 in 2005/6 and 2004/5 (ppm) for Chullora

2005/6	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	avg
50% 5/6	0.017	0.019	0.017	0.018	0.015	0.012	0.010	0.009	0.010	0.009	0.010	0.013	0.0132
90% 5/6	0.028	0.030	0.027	0.030	0.027	0.025	0.021	0.022	0.010	0.018	0.020	0.027	0.0241
99% 5/6	0.039	0.042	0.038	0.038	0.036	0.040	0.029	0.038	0.020	0.034	0.030	0.045	0.0354
max 5/6	0.046	0.048	0.048	0.042	0.043	0.052	0.034	0.064	0.030	0.043	0.030	0.066	0.0458
2004/5													
	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	avg
50% 4/5	0.021	0.020	0.021	0.019	0.017	0.012	0.012	0.008	0.010	0.010	0.010	0.016	0.0145
90% 4/5	0.031	0.032	0.030	0.030	0.033	0.027	0.025	0.019	0.020	0.021	0.020	0.027	0.0259
99% 4/5	0.042	0.041	0.040	0.039	0.047	0.041	0.046	0.029	0.030	0.037	0.030	0.035	0.0374
max 4/5	0.051	0.055	0.049	0.048	0.052	0.044	0.056	0.047	0.030	0.041	0.030	0.041	0.0455





Figures 6 & 7. Monthly Percentiles for NO_2 in 2005/6 and 2004/5 for Chullora

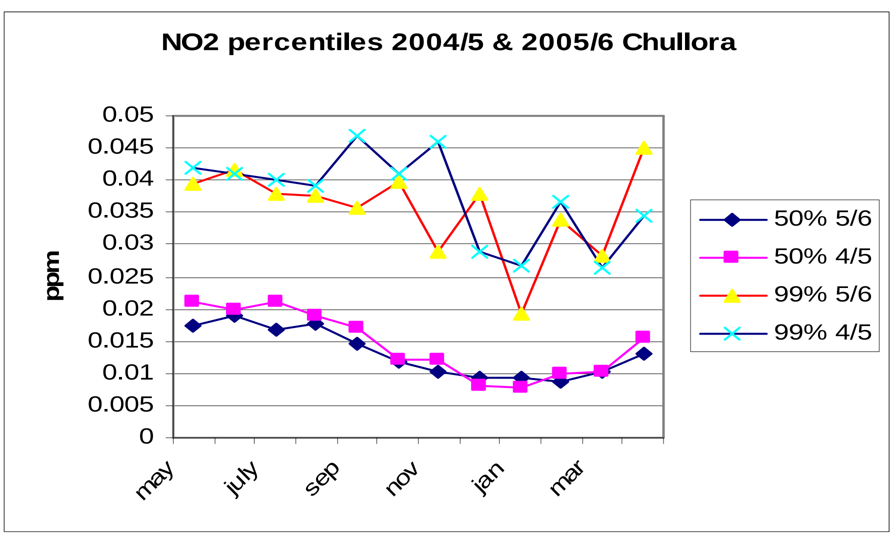


Figure 8. The 50 percentiles and 99 percentiles for Chullora

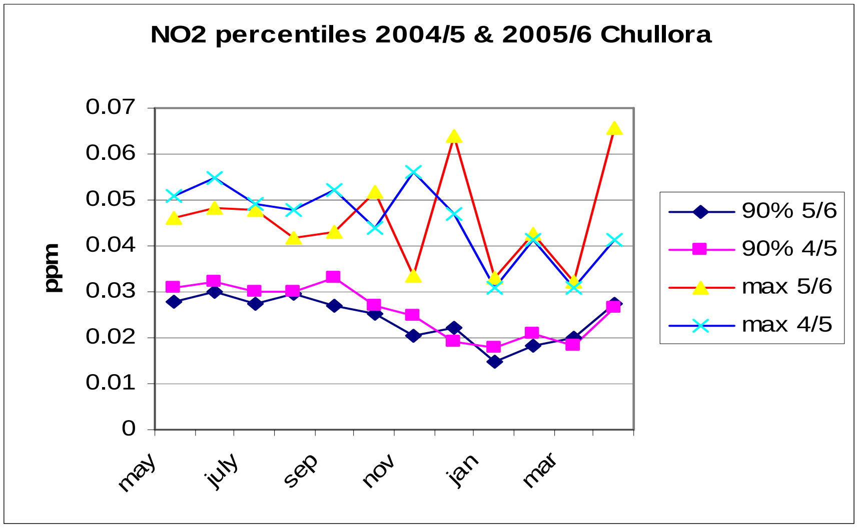


Figure 9. The 90 percentiles and maxima for Chullora

The annual percentiles for both years are shown in Table 4 and Figure 10.

Table 4. Annual NO_2 Percentiles over the two years 2005/6 & 2004/5 for Chullora

NO_2	ppm	2005/6	2004/5
	50%	0.0132	0.0145
	90%	0.0241	0.0259
	99%	0.0354	0.0374
	max	0.0458	0.0455

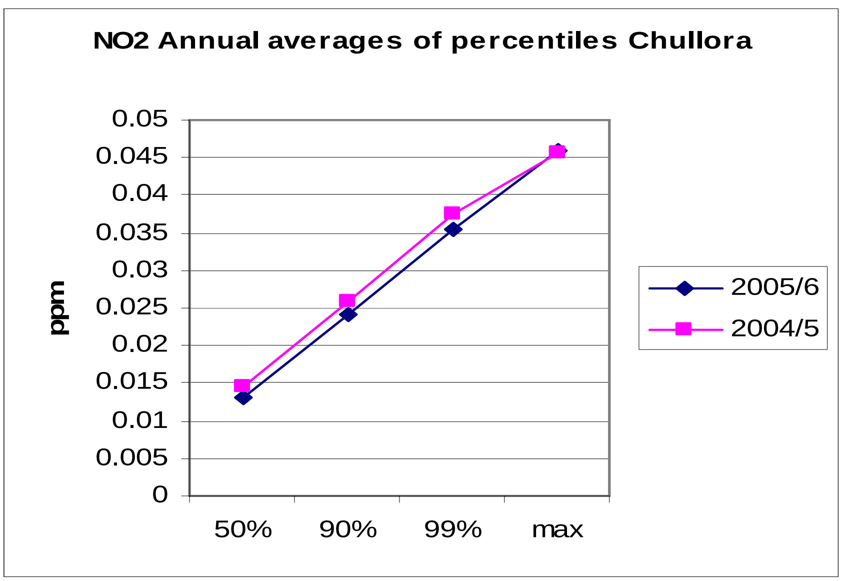


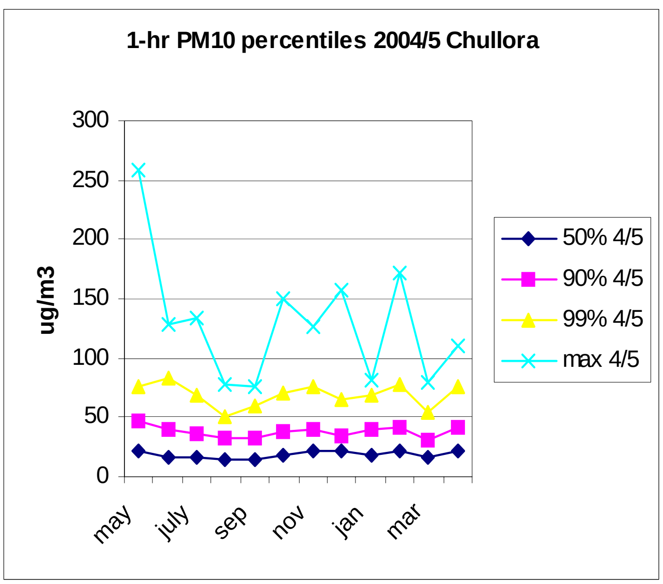
Figure 10. NO_2 Percentiles over the two years 2005/6 & 2004/5 for Chullora

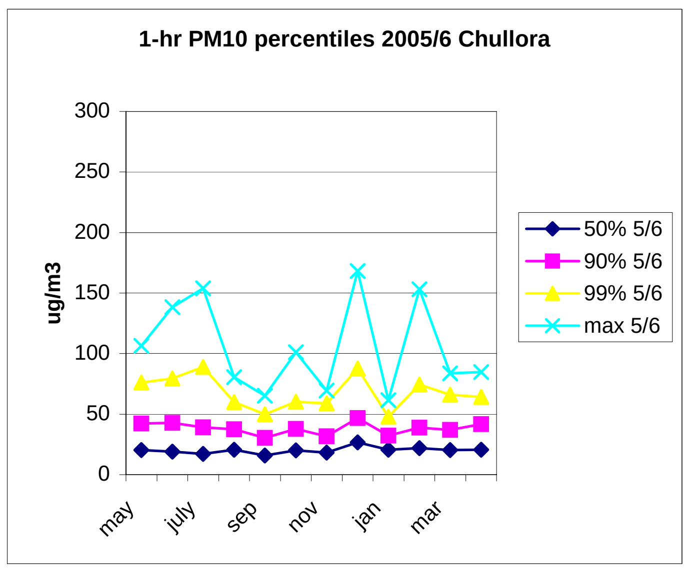
3.1.3. PM_{10}

Table 5 shows the 1-hour 50, 90, 99 percentiles and maxima values for the months May to April in each year. The trends for 50, 90 and 99 percentile are generally flat with the maxima values (and to some extent the 99 percentiles in 2005/6) being quite variable. These highly variable trends for the maxima values are sometimes a feature of 1-hour PM_{10} values. This variability in 1-hour values is often due to specific climatic occurrences, eg. rain or very high humidity, and thus make the results of the assessment conservative. The LCT goals and LCT reports are 24-hour values which would show much less fluctuations (at the time of analysis the DEC 24-hour values were not available). The trends are displayed in the Figure 11 and Figure 12 below.

Table 5. Monthly Percentiles for PM_{10} in 2005/6 and 2004/5 (ug/m^3) for Chullora

2005/6	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	avg
50% 5/6	20.36	18.97	17.12	20.53	15.85	20.17	18.27	26.57	20.6	21.87	20.40	20.55	20.10
90% 5/6	42.35	42.91	39.14	37.58	30.24	37.76	31.64	46.65	32.3	38.82	36.90	41.60	38.16
99% 5/6	76.04	79.57	88.98	59.95	49.90	60.32	58.92	87.80	47.9	74.55	66.10	64.18	67.85
max 5/6	106.30	138.50	153.9	80.63	65.11	101.10	69.40	168.1	61.5	153.1	83.70	84.71	105.53
2004/5													
	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	
50% 4/5	21.99	16.87	17.06	13.84	15.28	18.08	20.98	20.89	18.90	21.78	15.90	20.82	18.53
90% 4/5	46.49	39.99	36.92	32.15	32.54	37.88	39.71	33.96	39.70	41.11	31.50	41.34	37.78
99% 4/5	75.96	83.92	69.30	51.40	59.80	71.24	75.78	65.38	69.60	77.12	55.10	75.33	69.15
max 4/5	259.00	127.70	134.00	76.88	75.03	149.30	126.30	157.60	81.40	171.20	79.00	110.90	129.02





Figures 11 & 12. Monthly Percentiles for PM_{10} in 2005/6 and 2004/5 for Chullora

Figure 13 plots the monthly 50 and 99 percentiles and Figure 14 plots the monthly 90 percentile and the maxima over the two years. The plots over the two years show very good agreement with only a slight variation at the 99 percentiles and maxima values. This is reinforced with Figure 15 showing excellent agreement between the two years over the whole range of all percentiles up to the 99 percentile.

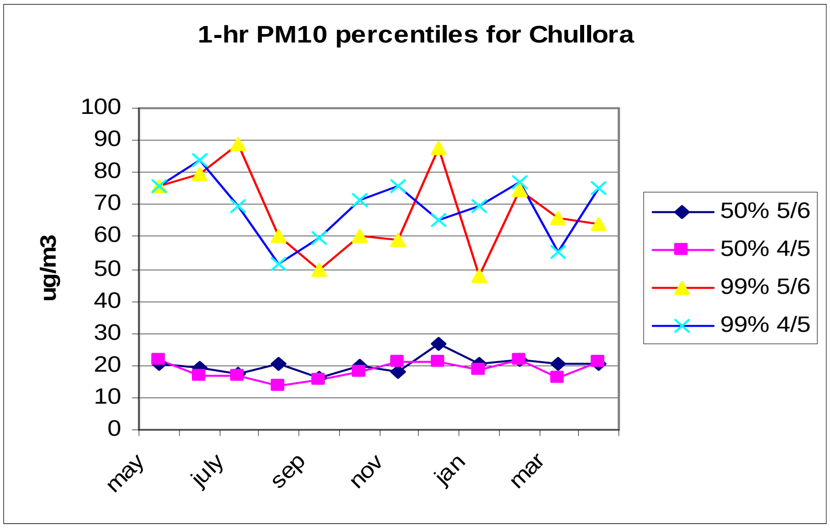


Figure 13. The 50 percentiles and 99 percentiles for Chullora

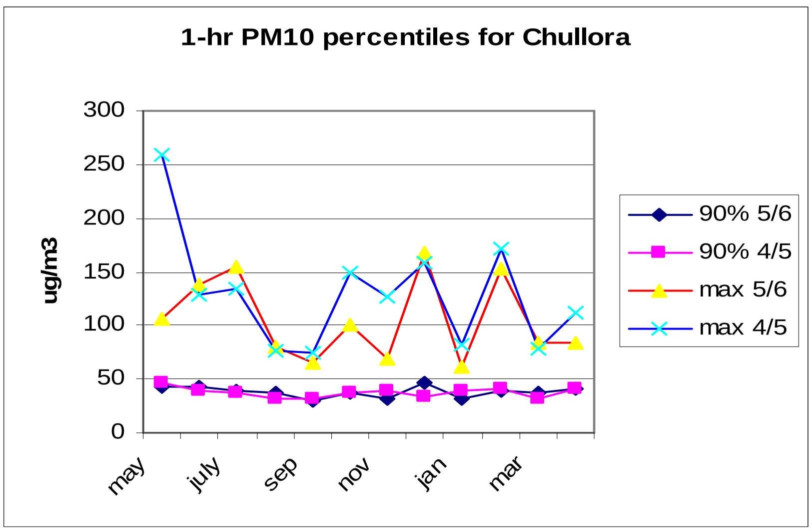


Figure 14. The 90 percentiles and maxima for Chullora

The annual percentiles for both years are shown in Table 6.

Table 6. Annual PM_{10} percentiles over the two years 2005/6 & 2004/5 for Chullora

PM10	ug/m^3	2005/6	2004/5
	50%	20.10	18.53
	90%	38.16	37.78
	99%	67.85	69.16
	max	105.50	129.00

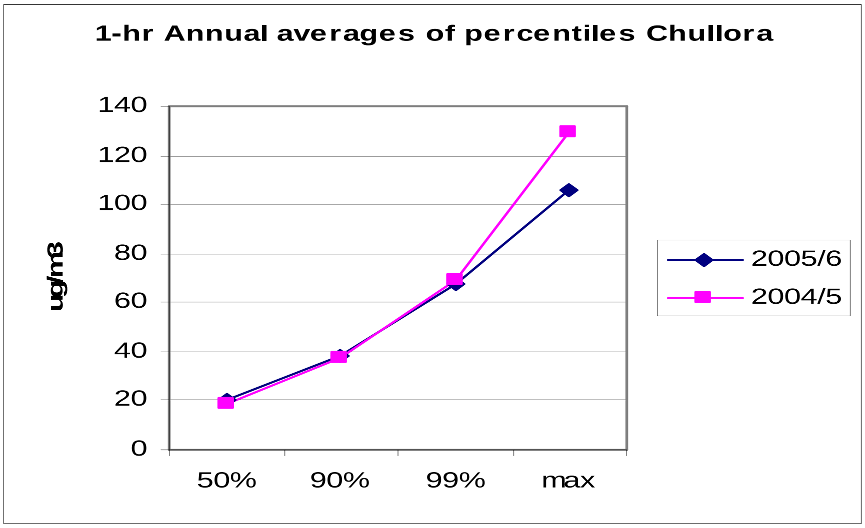


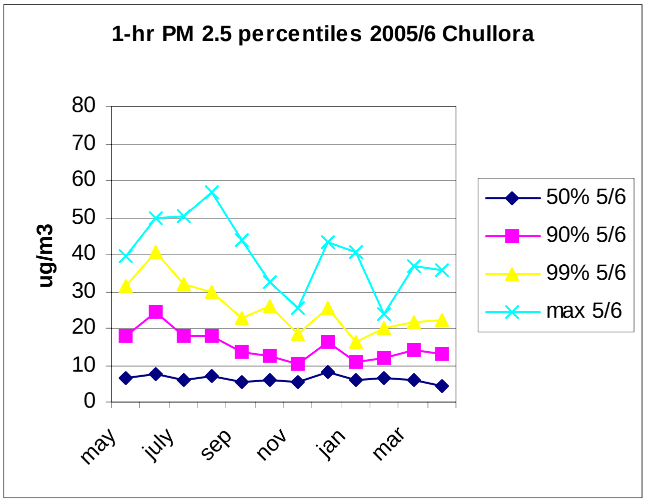
Figure 15. PM_{10} Percentiles over the two years 2005/6 & 2004/5 for Chullora

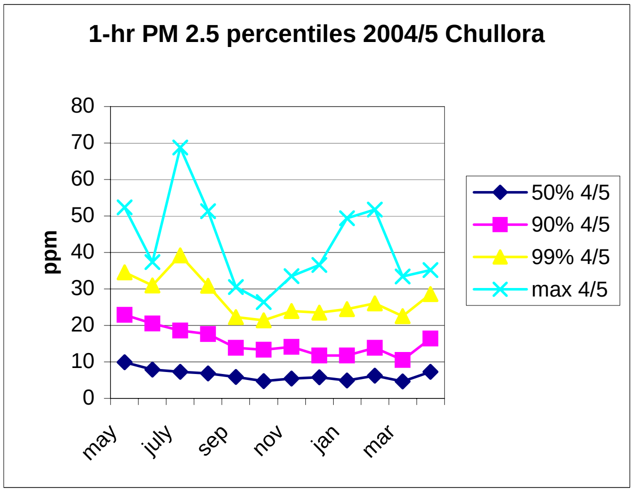
3.1.4. $PM_{2.5}$

Table 7 shows the 1-hour 50, 90, 99 percentiles and maxima values for the months May to April in each year. The trends for 50, 90 and 99 percentile are generally flat with the maxima values (and to some extent the 99 percentiles in 2005/6) being quite variable. These highly variable levels for the maxima values is sometimes a feature of 1-hour $PM_{2.5}$ values which can be subject to influences of moisture which are usually evened out on 24-hour averages. There are no LCT goals for $PM_{2.5}$ and the LCT reports are 24-hour values which would show much less fluctuations (at the time of analysis the DEC 24-hour values were not available). The trends are evident in the Figure 16 and Figure 17 below.

Table 7. Monthly Percentiles for $PM_{2.5}$ in 2005/6 and 2004/5 (ug/m^3) for Chullora

2005/6	PM2.5												
	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	avg
50% 5/6	6.42	7.72	5.86	6.91	5.58	5.90	5.21	8.04	5.93	6.39	6.08	4.23	6.19
90% 5/6	18.09	24.31	17.86	17.93	13.61	12.41	10.25	16.10	10.60	12.06	13.90	12.71	14.99
99% 5/6	31.24	40.38	32.02	29.88	22.44	26.17	18.60	25.63	16.20	19.97	21.80	22.08	25.54
max 5/6	39.61	49.86	50.13	56.75	43.98	32.35	25.60	43.02	40.80	23.97	36.70	35.74	39.87
2004/5													
	PM2.5												
50% 4/5	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	6.41
90% 4/5	22.91	20.56	18.63	17.66	13.82	13.33	14.08	11.79	11.80	13.89	10.50	16.40	15.45
99% 4/5	34.59	30.99	39.21	30.91	22.27	21.39	23.94	23.49	24.50	26.08	22.60	28.61	27.38
max 4/5	52.39	37.37	68.75	51.32	30.54	26.42	33.49	36.56	49.40	51.73	33.40	35.19	42.21





Figures 16 & 17. Monthly Percentiles for $PM_{2.5}$ in 2005/6 and 2004/5 for Chullora

Figure 18 plots the monthly 50 and 99 percentiles and Figure 19 plots the monthly 90 percentile and the maxima over the two years. The plots over the two years show very good agreement with only a slight variation at the 99 percentiles and maxima values. This is reinforced with Figure 20 showing excellent agreement between the two years over the whole range of all percentiles up to the 99 percentile.

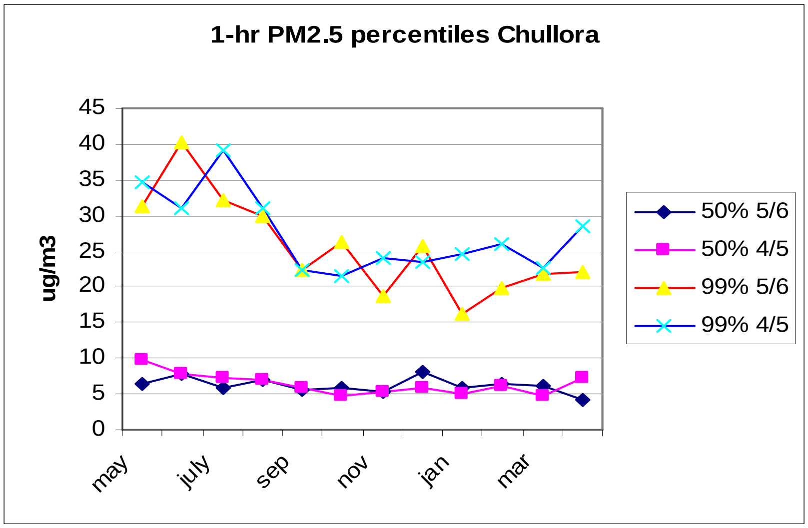


Figure 18. The 50 percentiles and 99 percentiles for Chullora

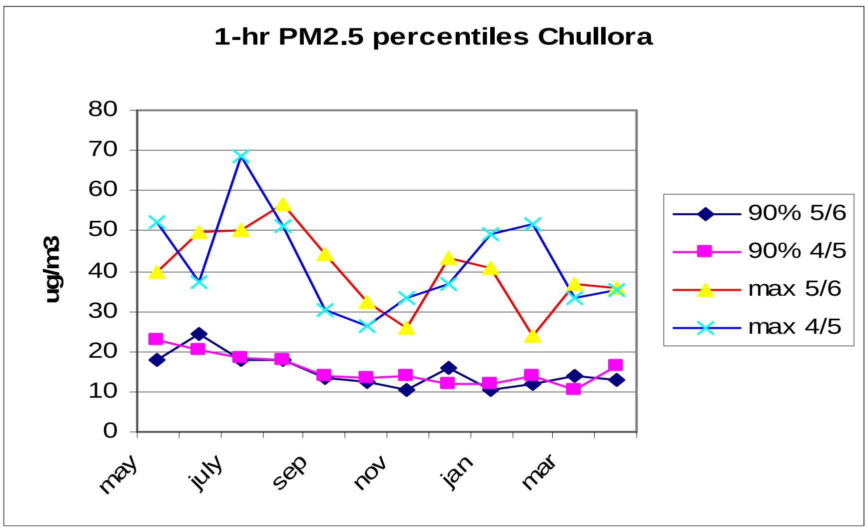


Figure 19. The 50 percentiles and 99 percentiles for Chullora

The annual percentiles for both years are shown in Table 8.

Table 8. Annual $PM_{2.5}$ percentiles over the two years 2005/6 & 2004/5 for Chullora

$PM_{2.5}$	ug/m3	2005/6	2004/5
	50%	6.19	6.41
	90%	14.99	15.45
	99%	25.54	27.38
	max	39.87	42.21

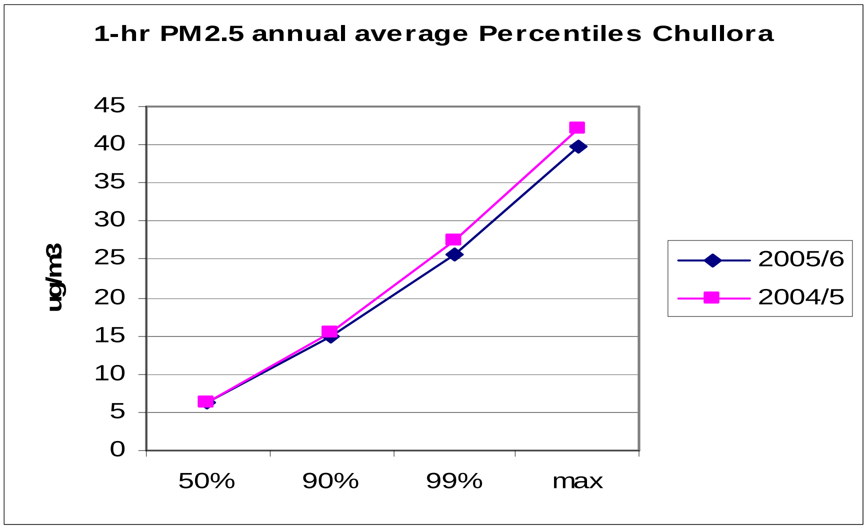


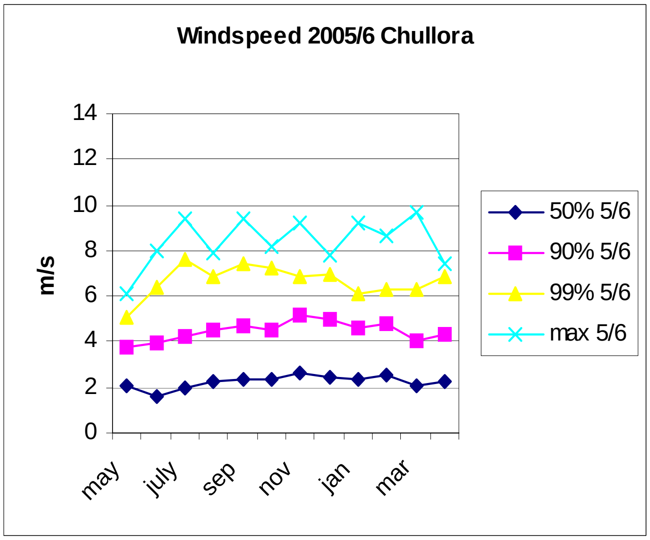
Figure 20. $PM_{2.5}$ Percentiles over the two years 2005/6 & 2004/5 for Chullora

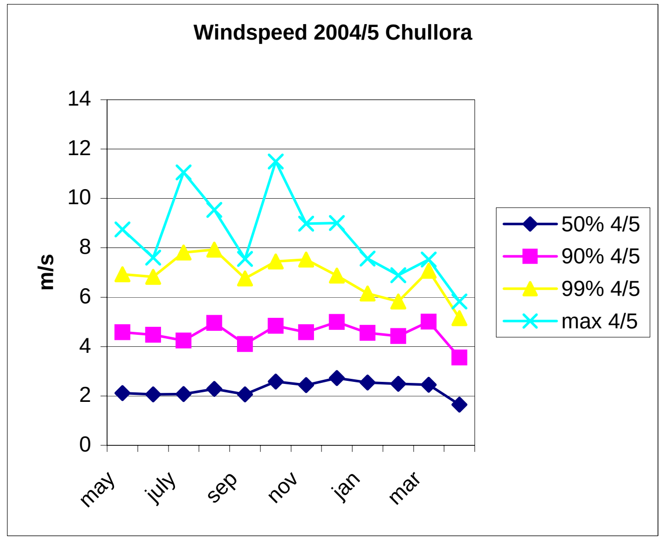
3.1.5. Wind Speed

Table 9 shows the 1-hour 50, 90, 99 percentiles and maxima values for the months May to April in each year. The trends are evident in the Figure 21 and Figure 22 below.

Table 9. Monthly Percentiles for Wind Speed in 2005/6 and 2004/5 (m/s) for Chullora

2005/6													
	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	avg
50% 5/6	2.08	1.59	1.95	2.26	2.33	2.33	2.65	2.45	2.31	2.56	2.11	2.25	2.24
90% 5/6	3.79	3.92	4.20	4.53	4.66	4.53	5.16	4.96	4.60	4.78	4.00	4.33	4.45
99% 5/6	5.06	6.43	7.57	6.87	7.41	7.25	6.90	6.94	6.14	6.33	6.25	6.88	6.67
max 5/6	6.13	8.02	9.37	7.85	9.36	8.22	9.17	7.76	9.23	8.63	9.65	7.39	8.40
2004/5													
	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	avg
50% 4/5	2.12	2.06	2.08	2.28	2.06	2.58	2.44	2.72	2.54	2.49	2.45	1.65	2.29
90% 4/5	4.58	4.47	4.24	4.95	4.10	4.84	4.58	5.00	4.56	4.42	5.01	3.55	4.52
99% 4/5	6.93	6.82	7.81	7.93	6.76	7.45	7.52	6.88	6.15	5.83	7.07	5.15	6.86
max 4/5	8.74	7.60	11.05	9.54	7.55	11.49	8.98	9.01	7.57	6.89	7.52	5.82	8.48





Figures 21 & 22. Monthly Percentiles for wind speed in 2005/6 and 2004/5 for Chullora

Figure 23 plots the monthly 50 and 99 percentiles and Figure 24 plots the monthly 90 percentile and the maxima over the two years. The plots over the two years show very good agreement with only a slight variation at the maxima values. This is reinforced with Figure 25 showing excellent agreement between the two years over the whole range of all percentiles up to and including the maxima.

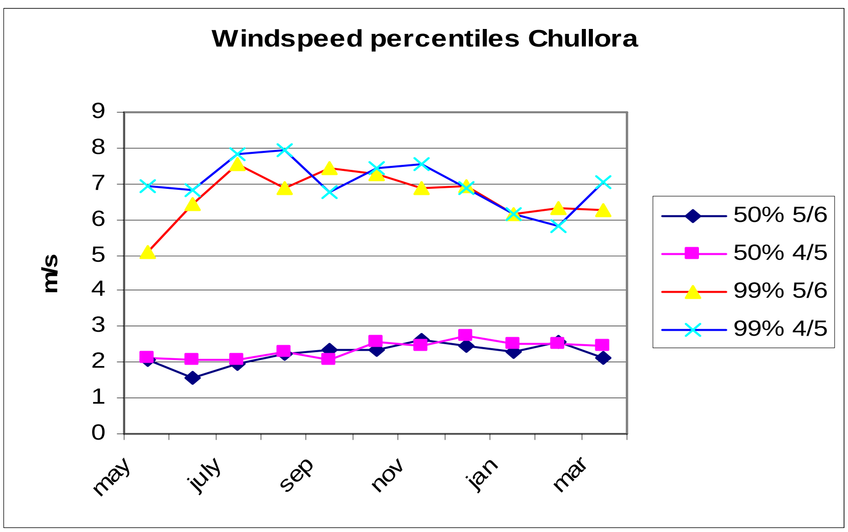


Figure 23. The 50 percentiles and 99 percentiles for Chullora

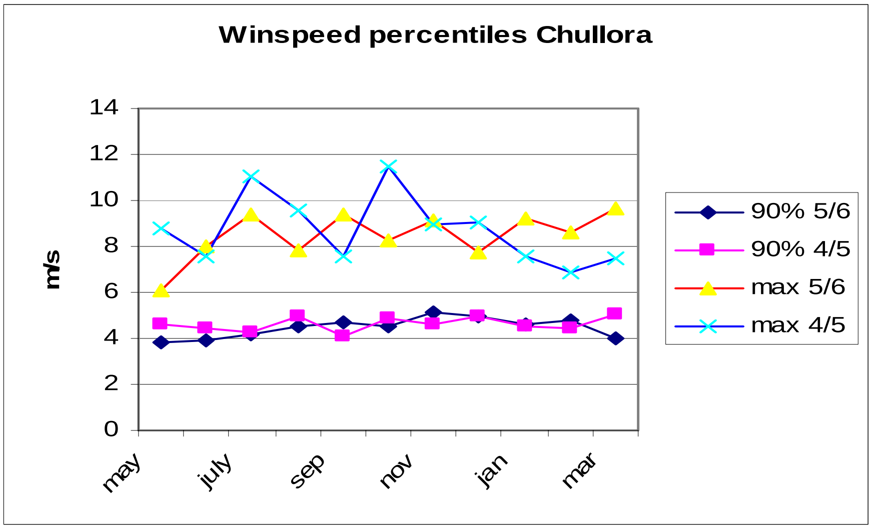


Figure 24. The 90 percentiles and maxima for Chullora

The annual percentiles for both years are shown in Table 10.

Table 10. Annual Wind Speed percentiles over the two years 2005/6 & 2004/5 for Chullora

WS m/s	2005/6	2004/5
50%	2.24	2.29
90%	4.45	4.52
99%	6.67	6.86
max	8.40	8.48

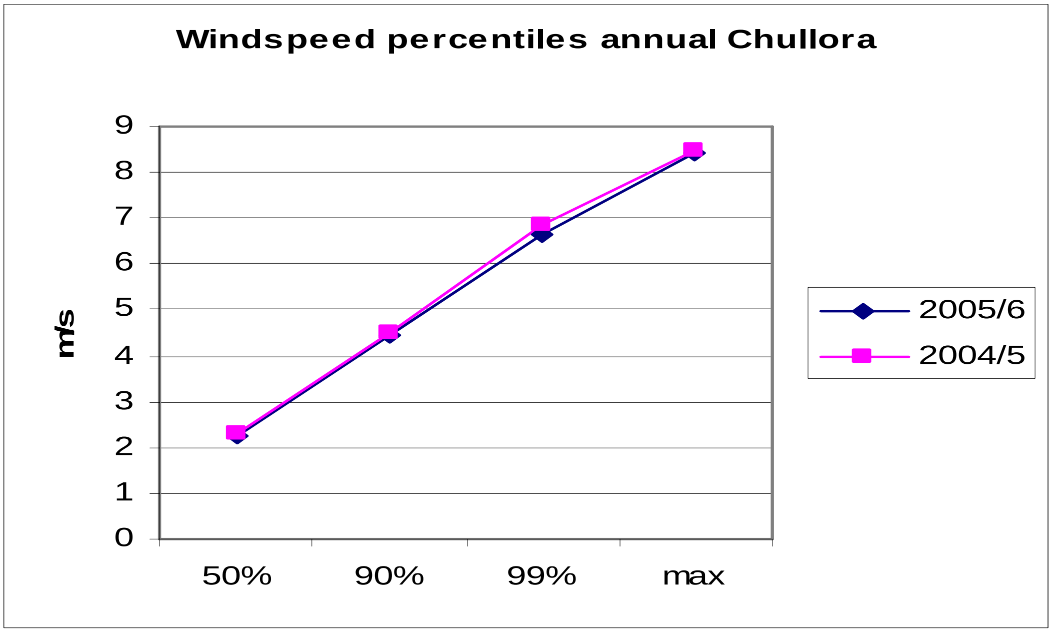


Figure 25. Wind Speed Percentiles over the two years 2005/6 & 2004/5 for Chullora

3.2. Rozelle

Statistical analysis for upper percentiles on the Rozelle data was conducted (see Appendix) and the outcomes are presented below.

3.2.1. CO

Figure 26 plots the monthly 50 and 99 percentiles and Figure 27 plots the monthly 90 percentile and the maxima over the two years. The plots over the two years show good agreement with only a slight variation at the maxima values. This is reinforced with Figure 28 showing very good agreement between the two years at the 50 and 90 percentiles.

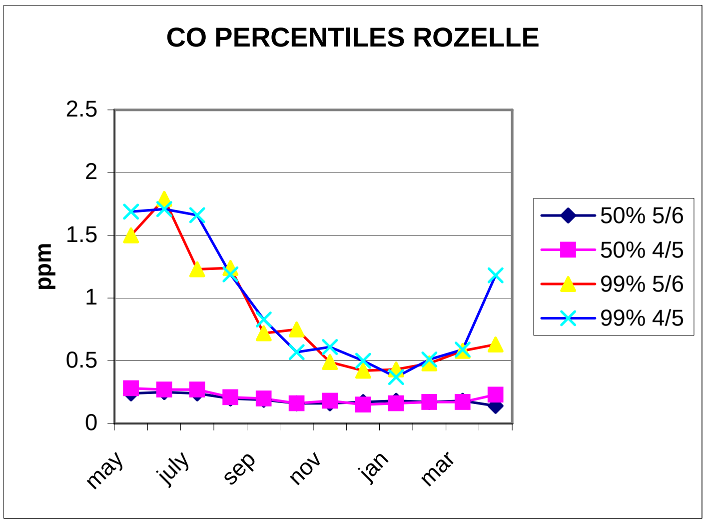


Figure 26. The 50 percentiles and 99 percentiles for Rozelle

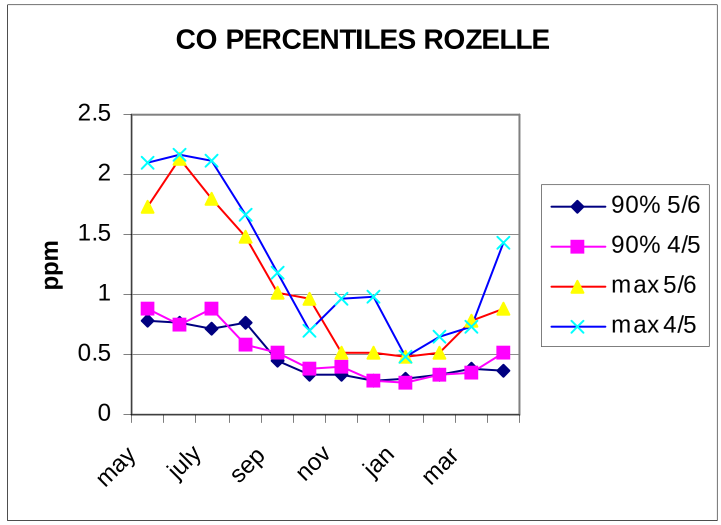


Figure 27. The 90 percentiles and maxima for Rozelle

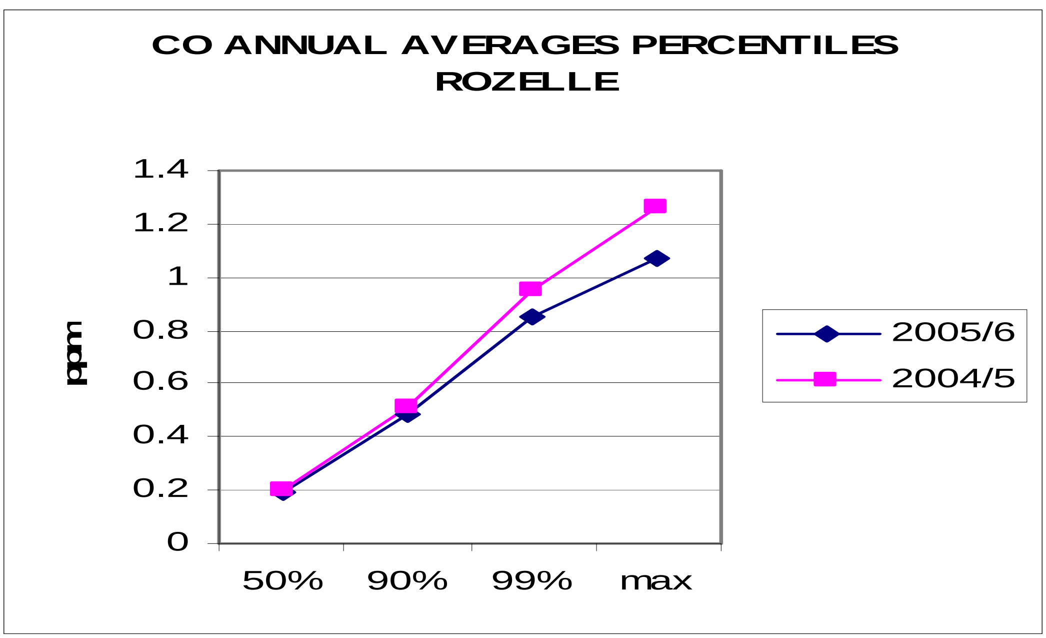


Figure 28. CO Percentiles over the two years 2005/6 & 2004/5 for Rozelle

3.2.2. NO_2

Figure 29 plots the monthly 50 and 99 percentiles and Figure 30 plots the monthly 90 percentile and the maxima over the two years. The plots over the two years show good agreement with only a slight variation at the maxima values. This is reinforced with Figure 31 showing very good agreement between the two years over the whole range of all percentiles up to and including the maxima.

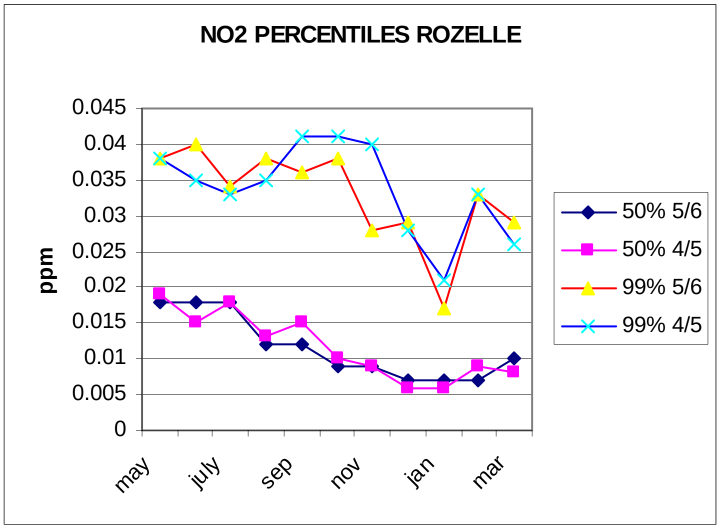


Figure 29. The 50 percentiles and 99 percentiles for Rozelle

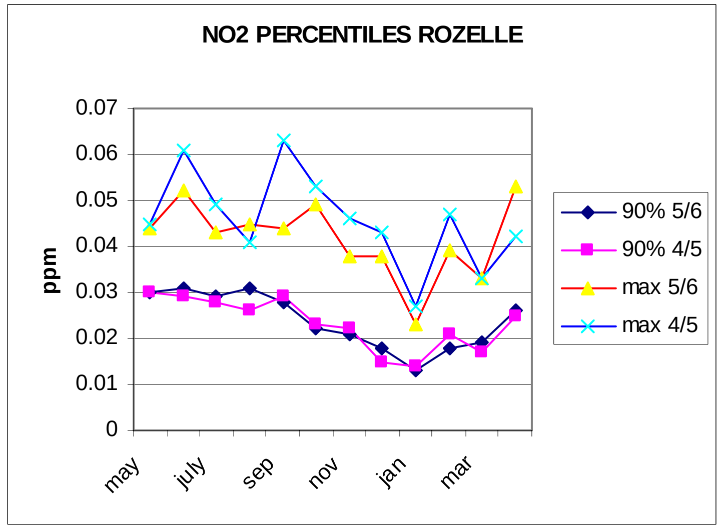


Figure 30. The 90 percentiles and maxima for for Rozelle

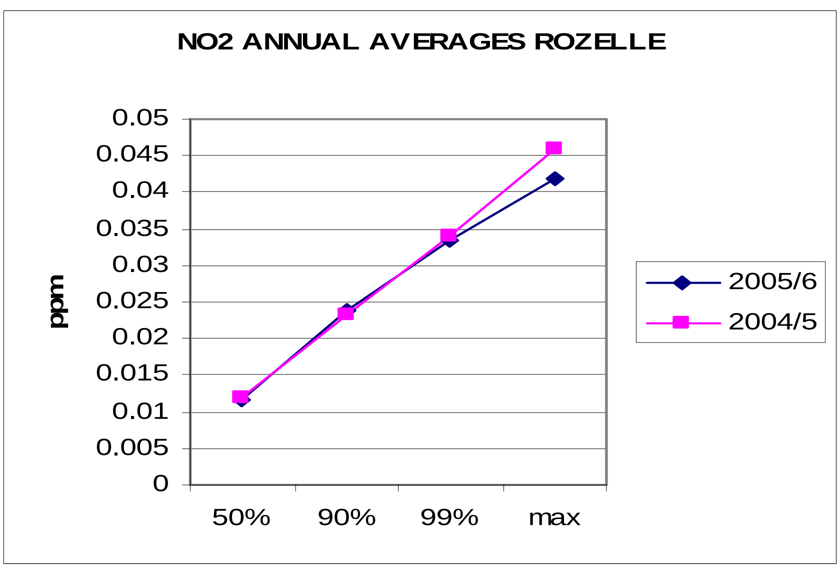


Figure 31. NO_2 Percentiles over the two years 2005/6 & 2004/5 for Rozelle

3.2.3. PM_{10}

Figure 32 plots the monthly 50 and 99 percentiles and Figure 33 plots the monthly 90 percentile and the maxima over the two years. The plots over the two years show very good agreement with only a slight variation at the maxima values. This is reinforced with Figure 34 showing excellent agreement between the two years over the whole range of all percentiles up to and including the maxima.

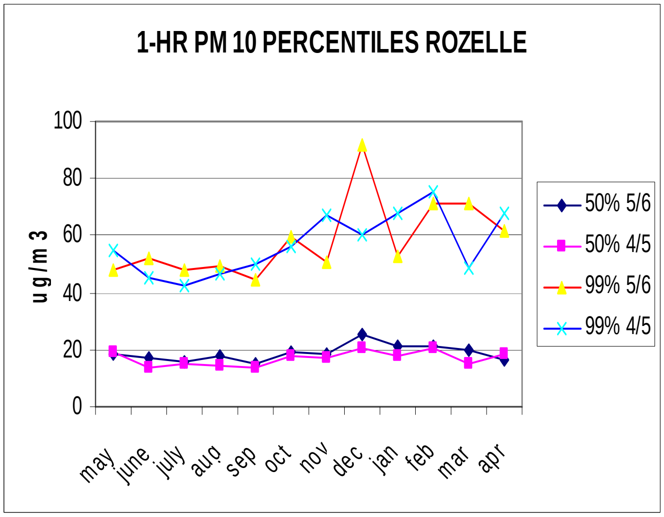


Figure 32. The 50 percentiles and 99 percentiles for Rozelle

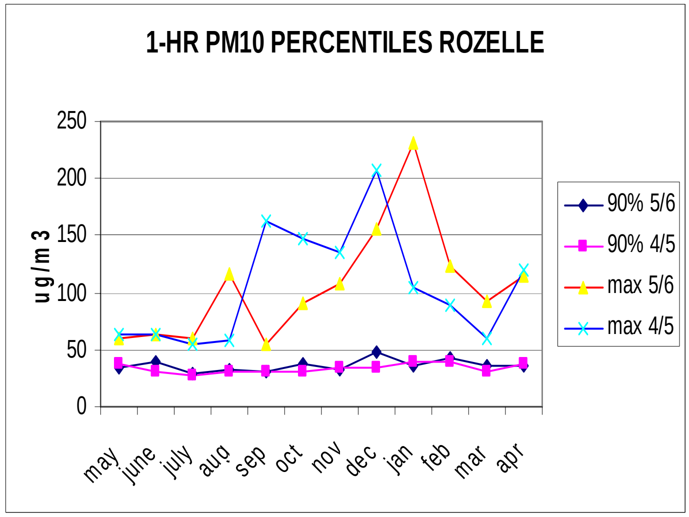


Figure 33. The 90 percentiles and maxima for Rozelle

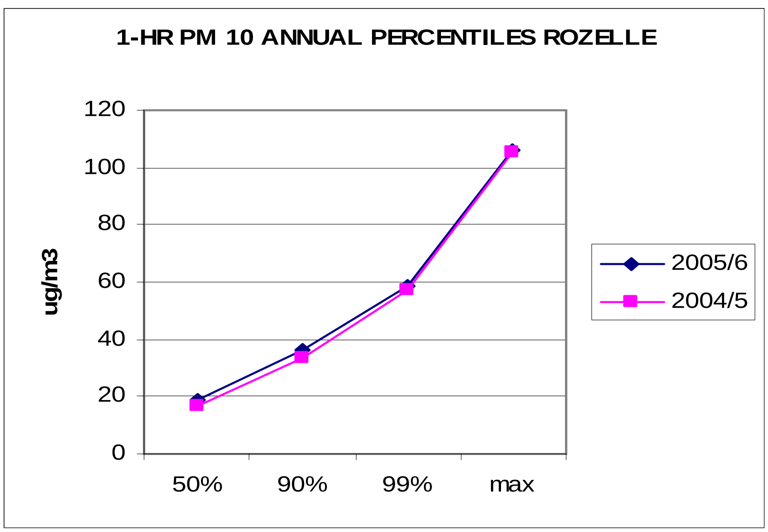


Figure 34. PM_{10} Percentiles over the two years 2005/6 & 2004/5 for Rozelle

3.2.4. Wind Speed

Figure 35 plots the monthly 50 and 99 percentile and Figure 36 plots the monthly 90 percentile and the maxima over the two years. The plots over the two years show very good agreement with only a slight variation at the maxima values. This is reinforced with Figure 37 showing very good agreement between the two years over the whole range of all percentiles up to and including the maxima.

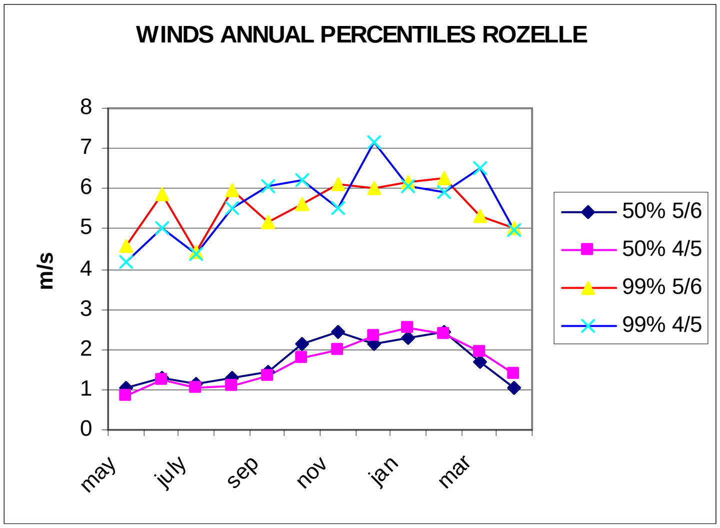


Figure 35. The 50 percentiles and 99 percentiles for Rozelle

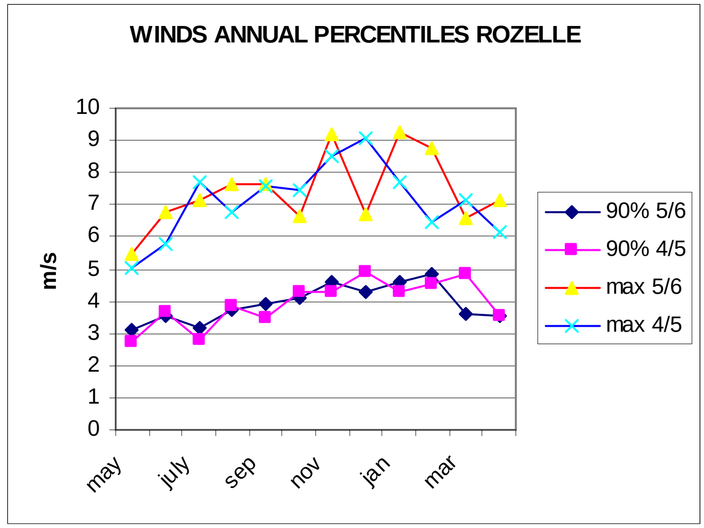


Figure 36. The 90 percentiles and maxima for for Rozelle

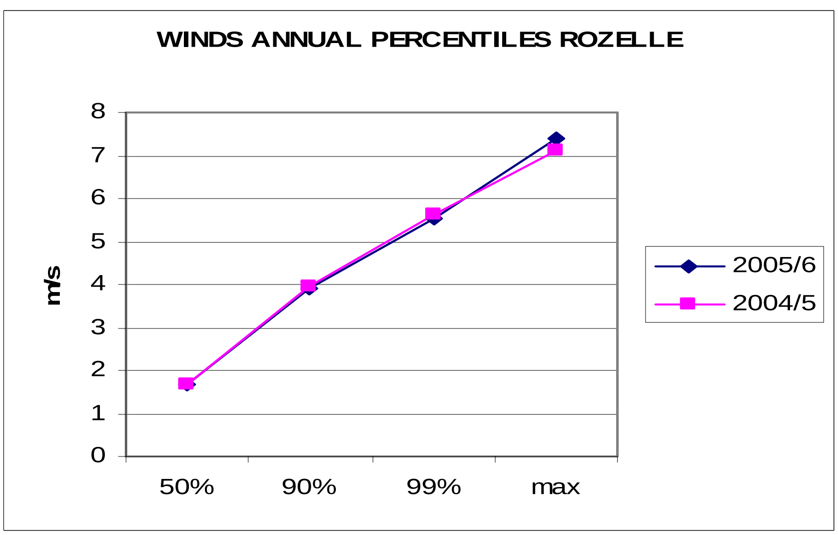


Figure 37. Wind Speed Percentiles over the two years 2005/6 & 2004/5 for Rozelle

3.3. LCT CBW and CBE

Statistical analysis for upper percentiles on the LCT data was conducted and the outcomes are presented below. The graphs for CBW and CBE are presented below as a record of the statistical percentile analysis of the levels measured during the period May 2005 to April 2006. These statistical records will be useful for making comparisons in the years following the tunnel opening. The levels measured at these two stations are different (as would be expected) but the value in the analysis will lie in making comparisons of the data at each station as time progresses.

3.3.1. CO

The percentiles of CO are shown in Figure 38 for CBW and Figure 39 for CBE. The slightly higher levels at CBW are possibly related to proximity to the motor vehicle traffic.

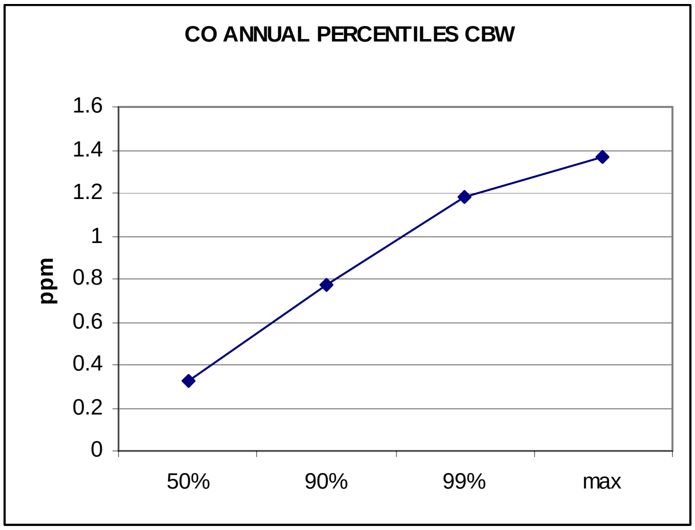


Figure 38. CO Annual Percentiles at CBW

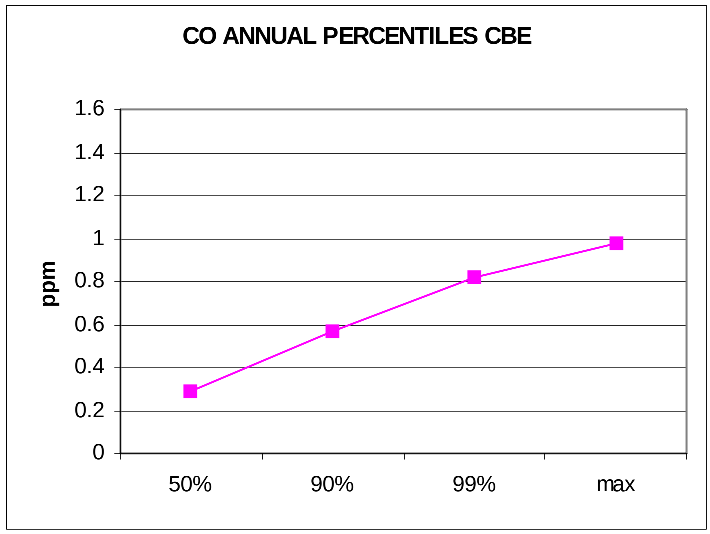


Figure 39 CO Annual Percentiles at CBE

3.3.2. NO_2

The percentiles of NO_2 for CBW are shown in Figure 40 and for CBE in Figure 41.

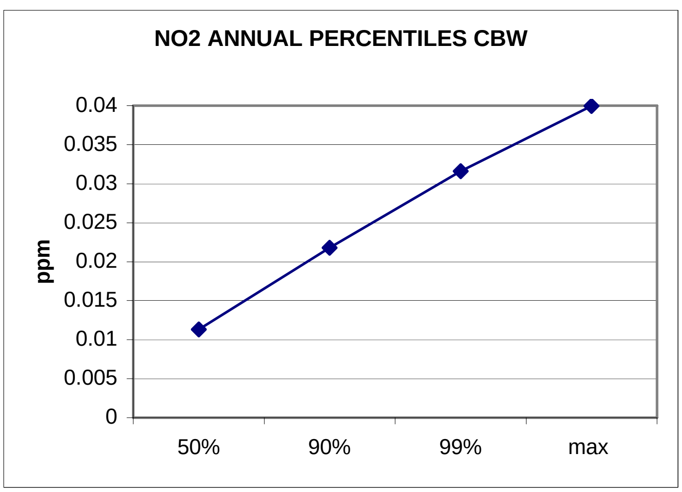


Figure 40. NO_2 Annual Percentiles at CBW

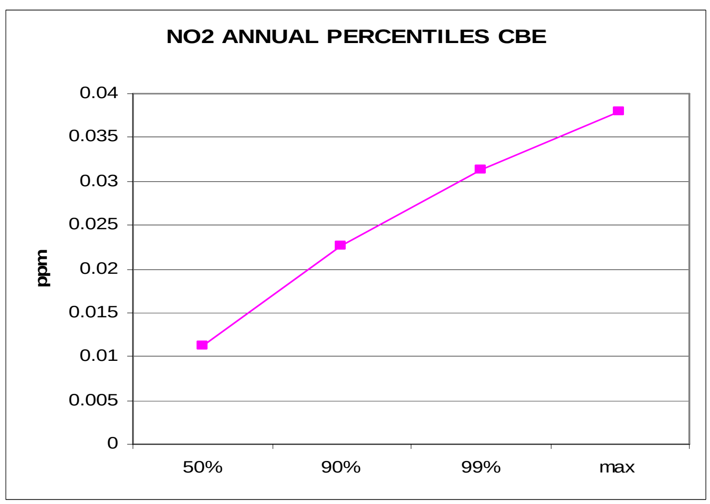


Figure 41 NO_2 Annual Percentiles at CBE

3.3.3. PM_{10}

The percentiles of PM_{10} for CBW are shown in Figure 42 and for CBE in Figure 43.

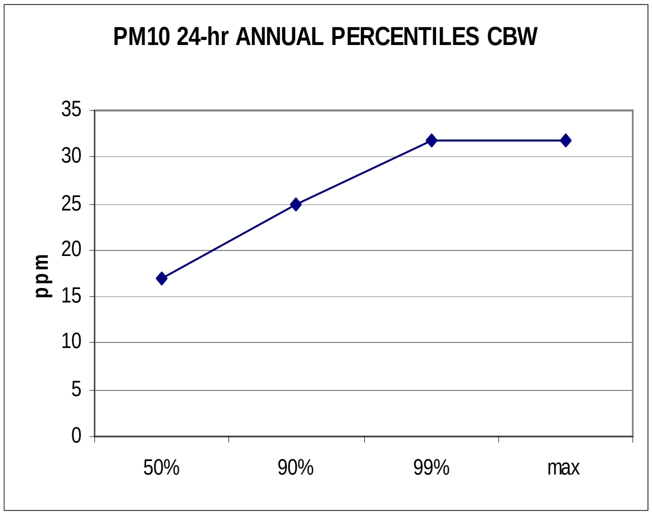


Figure 42. PM_{10} Annual Percentiles at CBW

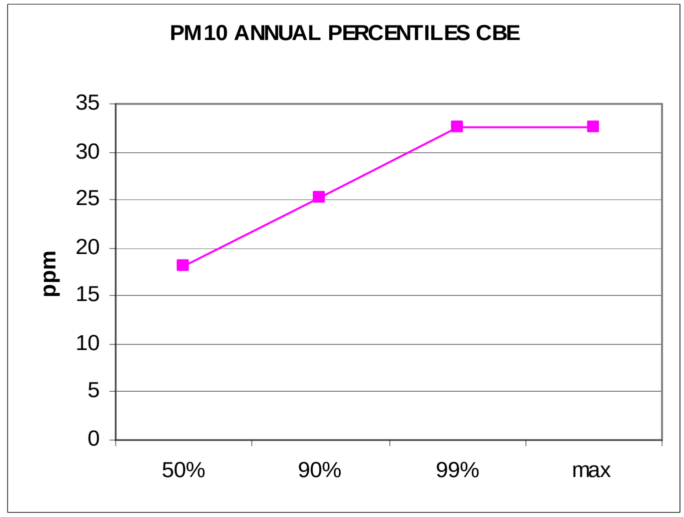


Figure 43. PM_{10} Annual Percentiles at CBE

3.3.4. $PM_{2.5}$

The percentiles of $PM_{2.5}$ for CBW are shown in Figure 44 and for CBE in Figure 45. Levels at CBW were somewhat higher than those at CBE. The slightly higher levels at CBW are possibly related to proximity to the motor vehicle traffic.

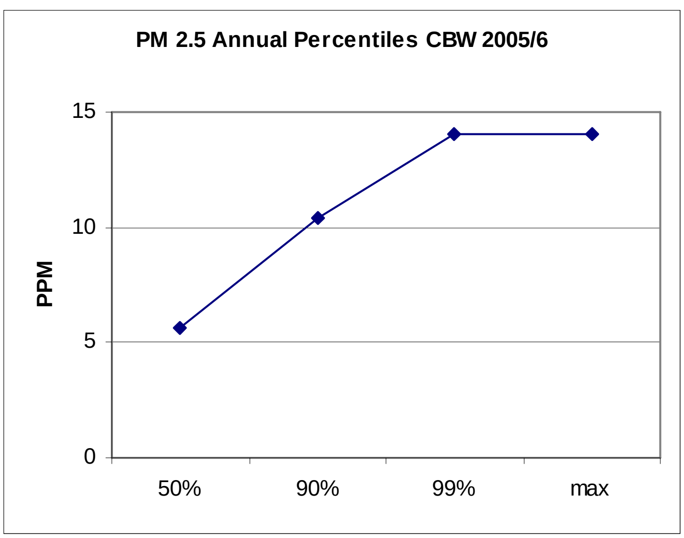


Figure 44. $PM_{2.5}$ Annual Percentiles at CBW

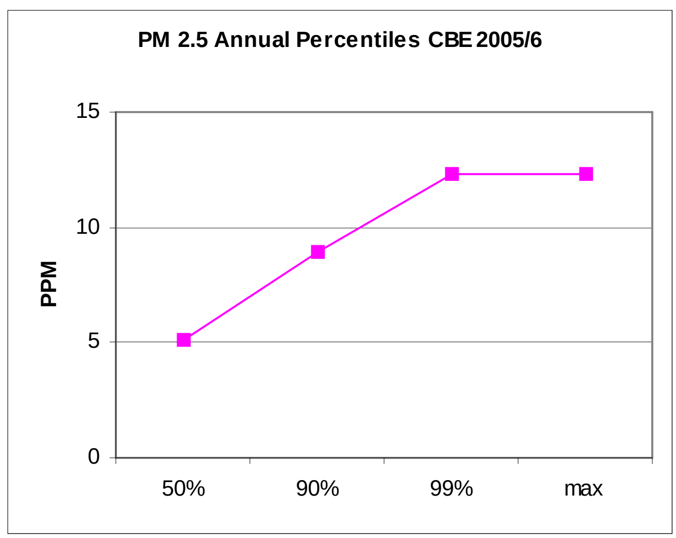
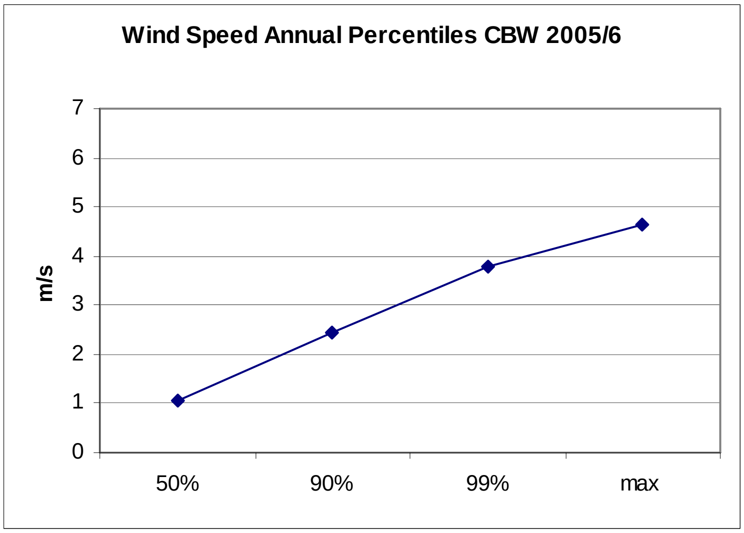


Figure 45 $PM_{2.5}$ Annual Percentiles at CBE

3.3.5. Wind Speed

The percentiles of wind speed are shown in Figure 46 and 47. Levels at CBW were somewhat higher than those at CBE possibly due to degree of exposure of the site.



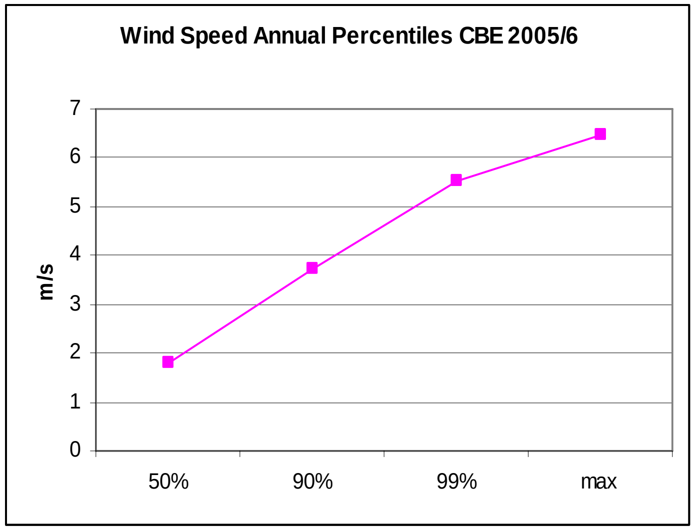


Figure 46. Wind Speed Annual Percentiles at CBW **Figure 47. Wind Speed Annual Percentiles at CBE**