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Air Quality Monitoring 2005

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Executive Summary

This report presents results of ambient air quality monitoring carried out by Environment Waikato during 2005. Monitoring sites were located in Hamilton, Tokoroa, Te Kuiti, Taupo and Matamata.

The main air contaminant of concern in the Waikato region is suspended particles (PM_{10}). In September 2004, the Ministry for the Environment introduced a National Environmental Standard (NES) for PM_{10} of 50µg m^{-3} (24-hour average) with one allowable exceedence each year. The NES became effective from September 2005. Concentrations of PM_{10} were measured at all locations, along with monitoring of benzene at three Hamilton sites.

Tokoroa experienced the highest PM_{10} concentrations and greatest frequency of exceedence. During 2005, the maximum measured PM_{10} concentration at Tokoroa was 89µg m^{-3} and 30 exceedences of 50µg m^{-3} were measured. This compares with a previous maximum of 97µg m^{-3} measured in 2004, the same year that the maximum of 41 exceedences was observed. Unusually elevated concentrations of PM_{10} appear to have been observed at Tokoroa between Dec 2003 – Sept 2005 and this may be related to variations of wind conditions or a baseline data anomaly caused by instrumentation error.

In Hamilton, measured PM_{10} concentrations did not exceed 50µg m^{-3}. However data were not collected between 15 May – 19 July 2005 and it is entirely possible that the highest PM_{10} concentration occurred, but was undetected, during this period. It is also possible that PM_{10} exceedances may have occurred during this time of instrument failure. Monitoring at Hamilton was carried out using a TEOM analyser with a sample temperature of 40°C. Additional daily sampling with a gravimetric instrument is recommended during winter 2006 to verify data from the TEOM.

Monitoring of benzene at Hamilton for 12 months in 2004–2005 showed concentrations at previously monitored sites were lower than results from 2003–2004. While it is possible that this is an early indication of a declining trend, the limited monitoring period is too small to be certain. Benzene concentrations are within the current MfE guidelines, but would exceed the guideline value that will become operative in 2010.

At Te Kuiti, concentrations twice exceeded 50µg m^{-3} (24-hour average) and the maximum measured 24-hour average was 54µg m^{-3}. In Taupo, monitoring was carried out every third day and one exceedance of 50µg m^{-3} was measured in 2005, when a 24-hour PM_{10} concentration of 52µg m^{-3} was recorded. Because the sampling regime at Taupo is limited to monitoring one-day-in-three, extrapolation would suggest around three exceedances for 2005.

In general, all areas show similar seasonal variations in PM_{10} concentrations, with higher values occurring during the winter months. Interannual trends of PM_{10} concentrations were not apparent at any of the monitoring sites.

A new PM_{10} monitoring site was established at Matamata in June 2005 and, while no exceedances have been observed since the monitoring commenced, the dataset is too short to allow for further analysis and interpretation of the data.

1 Introduction

During 2005, air quality monitoring was carried out by Environment Waikato at the four locations monitored in 2004. These were in Hamilton, Tokoroa, Te Kuiti and Taupo. A new air monitoring site was also established at Matamata in June 2005. Results from these sites are presented in this report.

The main contaminant of concern in the Waikato Region is suspended particulate, commonly referred to as PM_{10}, which comprises particles in the air less than 10 microns in diameter. In September 2004, the Ministry for the Environment (MfE) introduced a National Environmental Standard (NES) for PM_{10} of 50 µg m^{-3} (24-hour average) with one allowable exceedence each year (MfE 2004). Table 1-1 shows the NES values for PM_{10} and other air contaminants. The NES became effective in September 2005.

In addition to the NES, air quality can be benchmarked against air quality guidelines (MfE 2002) and air quality indicator categories. The air quality guidelines for PM_{10} include an annual average concentration of 20 µg m^{-3} as well as additional contaminants and averaging periods for contaminants including carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ozone and benzene (Table 1-2). In addition, it is common for air quality data to be presented relative to the MfE air quality indicator categories (Table 1-3).

Details of the recently commissioned site at Matamata are included in this report. Because the other air quality monitoring sites, equipment and quality assurance procedures are described in detail elsewhere, only basic descriptions of these are included here. A more comprehensive review of air quality monitoring in the Waikato Region, including historical data up until 2001 and air quality monitoring sites and equipment is available in *"Air Quality Monitoring Report - Waikato Region 2002*" (Wilton 2002a). Further information on quality assurance procedures for the monitoring is presented in the *"Quality Assurance Procedures Manual - for ambient air quality monitoring at Environment Waikato"* (Wilton 2003a). Further details of data processing and office procedures are described in "*Environment Waikato Environmental Processing and Reporting manual*" (Buchanan 2004).

Table 1-1: National Environmental Standards for ambient air quality (MfE, 2004)

Contaminant	NES values		
	Concentration	**Averaging Period**	**Allowable exceedences / year**
Carbon monoxide	10 mg m^{-3}	8-hour	1
Particles (PM_{10})	50 µg m^{-3}	24-hour	1
Nitrogen dioxide	200 µg m^{-3}	1-hour	9
Sulphur dioxide [a]	350 µg m^{-3}	1-hour	9
Sulphur dioxide [a]	570 µg m^{-3}	1-hour	0
Ozone	150 µg m^{-3}	1-hour	0

Notes:
[a] The sulphur dioxide values do not apply to sulphur acid mist.

Table 1-2: Ambient air quality guideline for New Zealand (MfE, 2002)

Contaminant	2002 guideline values[a]	
	Concentration	**Averaging Period**
Carbon monoxide	30 mg m^{-3} 10 mg m^{-3}	1-hour 8-hour
Particles (PM_{10})	50 µg m^{-3} 20 µg m^{-3}	24-hour Annual
Nitrogen dioxide	200 µg m^{-3} 100 µg m^{-3}	1-hour 24-hour
Sulphur dioxide [b]	350 µg m^{-3} 120 µg m^{-3}	1-hour 24-hour
Ozone	150 µg m^{-3} 100 µg m^{-3}	1-hour 8-hour
Hydrogen sulphide [c]	7 µg m^{-3}	1-hour
Lead [d]	0.2 µg m^{-3} (lead content of PM_{10})	3-month-moving, calculated monthly
Benzene (year 2002) Benzene (year 2010)	10 µgm^{-3} 3.6 µgm^{-3}	Annual Annual
1,3-Butadiene	2.4 µgm^{-3}	Annual
Formaldehyde	100 µgm^{-3}	30-minutes
Acetaldehyde	30 µgm^{-3}	Annual
Benzo(a)pyrene	0.0003 µgm^{-3}	Annual
Mercury (inorganic) [d] Mercury (organic)	0.33 µgm^{-3} 0.13 µgm^{-3}	Annual Annual
Chromium VI [d] Chromium metal and chromium III	0.0011 µgm^{-3} 0.11 µgm^{-3}	Annual Annual
Arsenic (organic) [d] Arsine	0.0055 µgm^{-3} 0.055 µgm^{-3}	Annual Annual

Notes:
[a] All values apply to the gas measured at standard conditions of temperature (0°C) and pressure (1 atmosphere).
[b] The sulphur dioxide guideline values do not apply to sulphur acid mist.
[c] The hydrogen sulphide value is based on odour nuisance and may be unsuitable for use in geothermal areas.
[d] The guideline values for metals are for inhalation exposure only; they do not include exposure from other routes such as ingestion. These other routes should be considered in assessments where appropriate.

Table 1-3: Ministry for the Environment's Environmental Performance Indicator categories for air quality:

Category	Value relative to guideline	Comment
Excellent	Less than 10% of the guideline	Of little concern: if maximum values are less than a tenth of the guideline, average values are likely to be much less
Good	Between 10% and 33% of the guideline	Peak measurements in this range are unlikely to affect air quality
Acceptable	Between 33% and 66% of the guideline	A broad category, where maximum values might be of concern in some sensitive locations but generally they are at a level which does not warrant urgent action
Alert	Between 66% and 100% of the guideline	This is a warning level, which can lead to exceedences if trends are not curbed
Action	More than 100% of the guideline	Exceedences of the guideline are a cause for concern and warrant action, particularly if they occur on a regular basis

2 Air quality monitoring in Hamilton

Air quality in Hamilton has been measured at a monitoring site in Peachgrove Road since November 1997. Additional "traffic peak" monitoring sites at Bridge Street and Claudelands Bridge have also been used in recent years to monitor concentrations of benzene. The Peachgrove Road site is located on the south-east side of Hamilton City (Figure 2-1). During 2005, PM_{10} and benzene were measured at Peachgrove Road and the site is consistent with the "Residential Peak" site classification as described in *Good Practice Guideline for Air Quality Monitoring and Data Management* (MfE 2000).

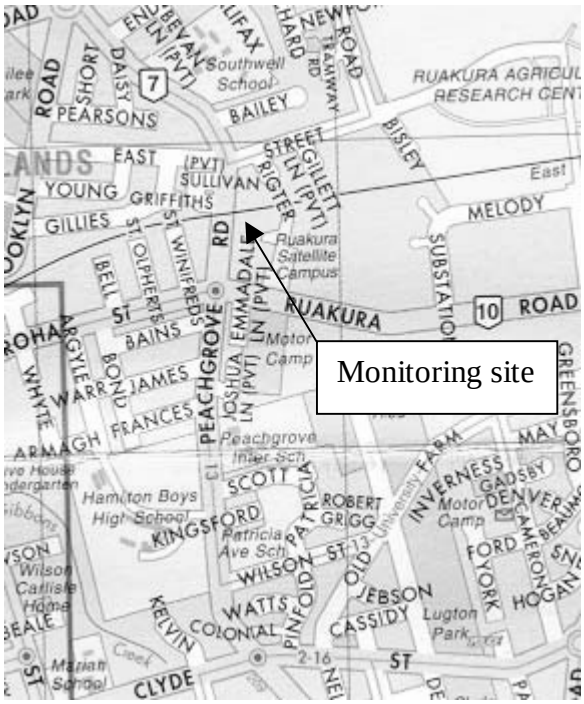


Figure 2-1: Location of Hamilton Peachgrove Road monitoring site

During 2005, PM_{10} monitoring at Peachgrove Road was carried out using a Tapered Elemental Oscillating Microbalance (TEOM) with a sample temperature setting of 40°C. With TEOMs, the Ministry for the Environment (MfE 2002) recommends that a co-located gravimetric reference method sampler is operated for one year to identify an

adjustment factor that calibrates TEOM data to HiVol PM_{10} concentrations. This process was effected during 2004, when a gravimetric high-volume (HiVol) sampler was operated on a one-day-in-three basis (Wilton 2005a). Unfortunately, because of the one-day-in-three operation, insufficient data may have been collected when PM_{10} concentrations were highest during 2004 (Wilton 2005a) and daily HiVol operation during the winter period is required to establish a more robust relationship. Daily operation was attempted during the winter of 2005. However, the HiVol failed after a few days of operation and it is regarded as uneconomic to repair the aged instrument.

It is anticipated that TEOM results will be compared with another gravimetric instrument during winter 2006. In the meantime, this report concurs with the conclusion of Wilton (2005a) that no adjustments for gravimetric equivalency are considered warranted.

The PM_{10} data were collected at the Peachgrove Road site as 10-minute averages and subsequent calculations of hourly averages were made from these data. These averages were only calculated if 85% of the 10-minute data for the given averaging period were available. This is higher than the 75% data requirement used to calculate 24-hour averages, which is the recommendation in the *Good Practice Guideline for Air Quality Monitoring and Data Management* (MfE 2000). However, the former criteria has been used because it is the value specified in the software used to store 10-minute data. Neither cut-point has been used for the reporting of monthly concentrations. However, the monthly summary for June is not reported because no data were available for that month (Figure 2-7).

PM_{10} data were available for only 77% of 2005. The main periods of missing data were between 1 – 16 March 2005 (Figure 2-5) when the TEOM was removed for annual servicing and 17 April – 20 July 2005 when the instrument was shipped to Australia for diagnosis and replacement of a major component.

Passive sampling for the volatile organic compound (VOC) benzene was carried out using BTEX canisters for the 12 month period 21 July 2004 – 20 July 2005. The method used is as described in Stevenson and Narsey (1999) with filters being deployed for periods of three months. The analysis was carried out by Hills Laboratory in Hamilton. While this type of passive sampling is recommended as a screening method only, it is the most common approach to benzene monitoring in New Zealand and is significantly more cost effective than the method recommended by the Ministry for the Environment's ambient air quality guidelines (MfE 2002).

The passive samplers used to evaluate three-monthly average levels of benzene also allow for measurement of toluene and total xylenes. While benzene is the main VOC of concern in Hamilton, toluene and xylenes concentrations are also reported here.

The consistency of “good” or “excellent” CO results since 1998 (Wilton 2005a) demonstrates that concentrations are not a serious concern at the Hamilton monitoring site. Carbon monoxide monitoring was therefore discontinued during 2005 and is not reported here. This will be reviewed and monitoring of CO possibly resumed again on a 5-yearly basis. Ozone monitoring was also attempted at the site during the summer of 2004/05, however equipment failure rendered most of the data spurious for the period, so results are not reported. Monitoring in the past has shown little evidence of a problem with ambient ozone concentrations in Hamilton and higher priority has been given to PM_{10} monitoring in the Waikato. Ozone monitoring may be reviewed and perhaps recommenced at another Waikato location in the future.

2.1 Meteorology

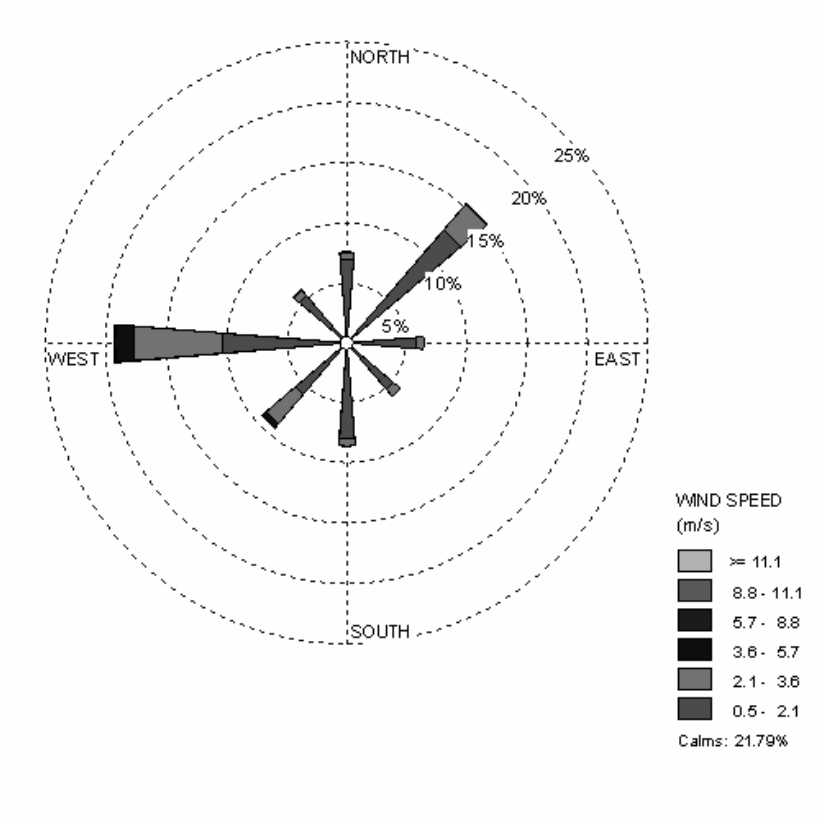
The windrose plots in Figure 2-2 are very similar and demonstrate that wind conditions during the full year 2005 (Figure 2-2a) were typical of those observed at Peachgrove Road since monitoring began in 1998. Figure 2-3 shows that during the winter months (June-August), the wind characteristics were similar to winter wind conditions

experienced since 1998. The windrose plots confirm that the Peachgrove Road site often experiences calm conditions, with windspeeds less than 0.5m s^{-1} observed around 25% of the time during winter. Meteorological conditions most conducive to elevated air pollution are during these calm or light winds, when dispersion of contaminants is retarded. While the prevailing winds from the westerly quarter are reasonably strong, relatively light winds from the northeast are also common. During winter there are also higher frequencies of southerly and south-westerly winds (Figure 2-3).

Another indicator of interannual climate variability is mean annual air temperature. The mean air temperature at Peachgrove Road during 2005 was 15.16°C and this is congruent with the mean air temperature of 15.23°C for the years 1998-2004. The seasonal variation of air temperature during 2005 was also typical of that observed since monitoring began in 1998 (Figure 2-4), especially during the winter months of June, July and August when air pollution events are most likely to occur. This information indicates that the magnitude and variation of air temperatures were not unusual during 2005 when compared to previous years.

The wind and temperature data demonstrate that meteorological conditions at Peachgrove Road during 2005 were typical of those observed since 1998.

(a)



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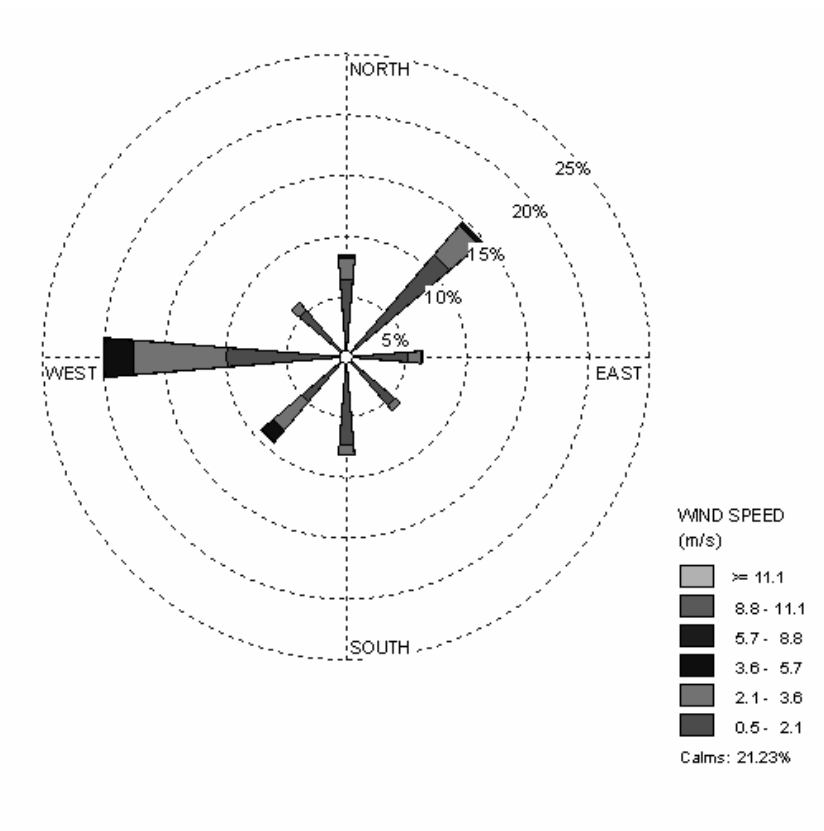
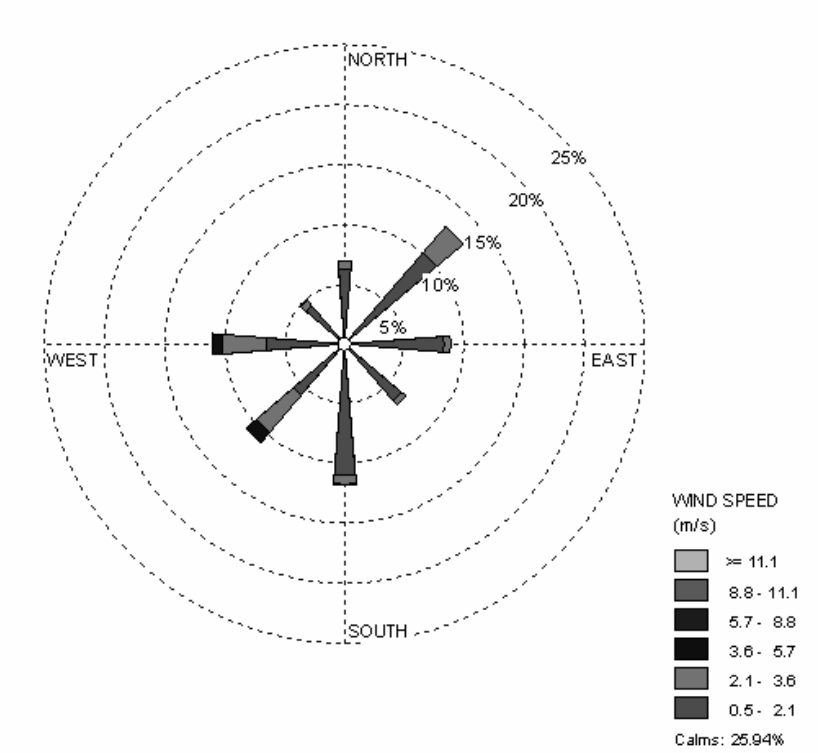


Figure 2-2: Windrose plots for Hamilton Peachgrove Road site during (a) 2005 and (b) 1998 – 2004

(a)



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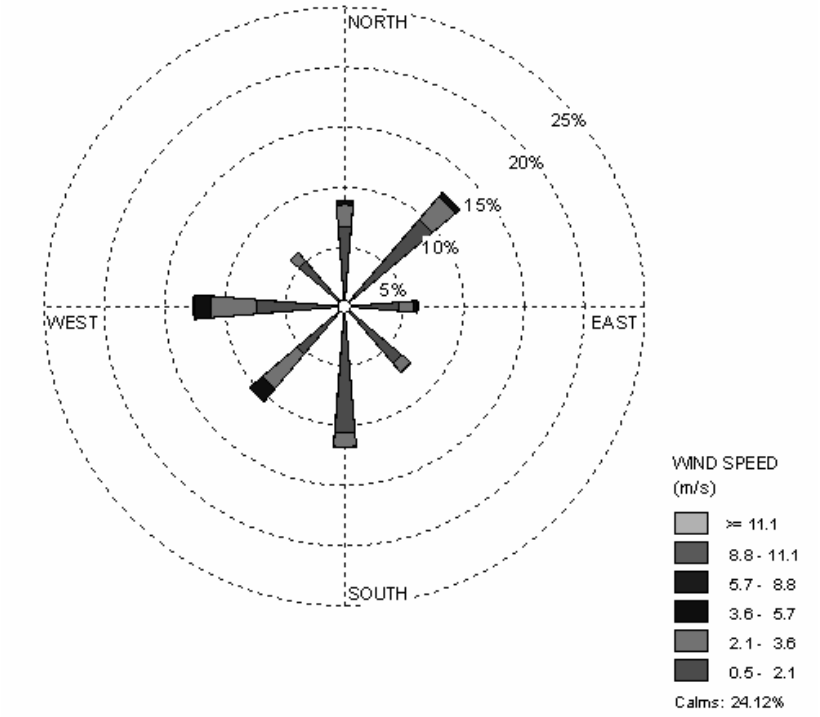


Figure 2-3: Windrose plots for winter months (June, July, August) at Hamilton Peachgrove Road site during (a) winter 2005 and (b) winter periods 1998 – 2004

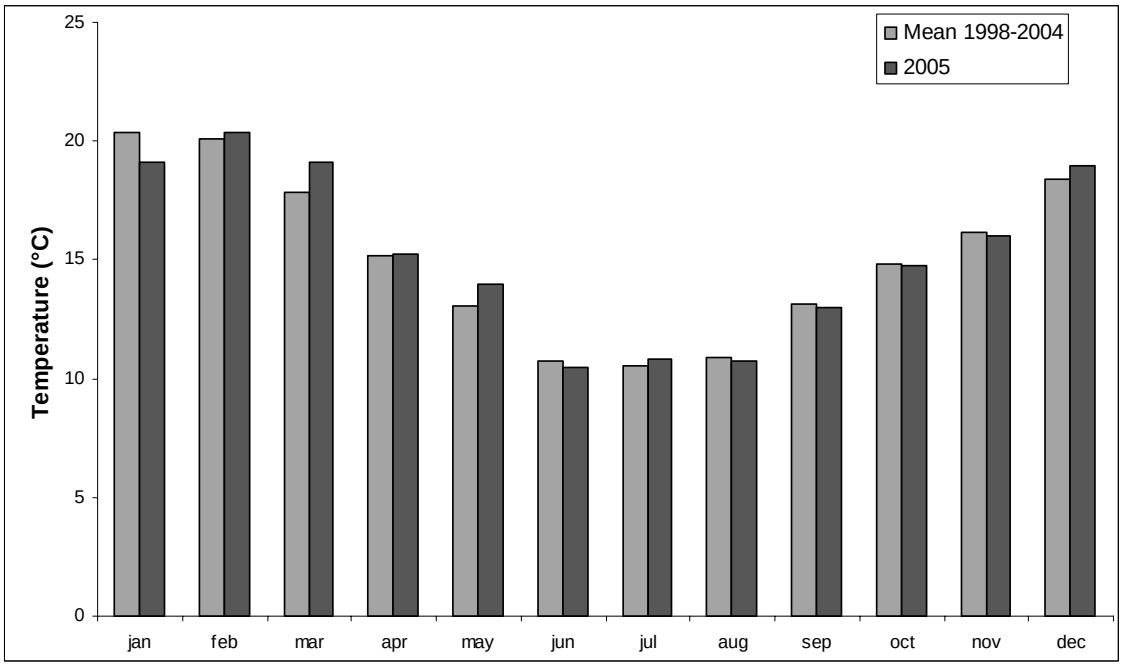


Figure 2-4: Monthly mean air temperatures for 2005 and ensemble monthly mean temperatures for the years 1998 – 2004 at Peachgrove Road, Hamilton.

2.2 Concentrations of PM_{10}

Concentrations of PM_{10} measured at the Hamilton monitoring site during 2005 are shown in Figure 2-5. While there were no recorded exceedances of the guideline and NES threshold of 50 µg m^{-3} PM_{10} concentration during 2005, some caution is required with interpretation. PM_{10} concentrations may have exceeded the 50 µg m^{-3} threshold during the first half of winter. However, these events would have been unnoticed due to the loss of data over this period.

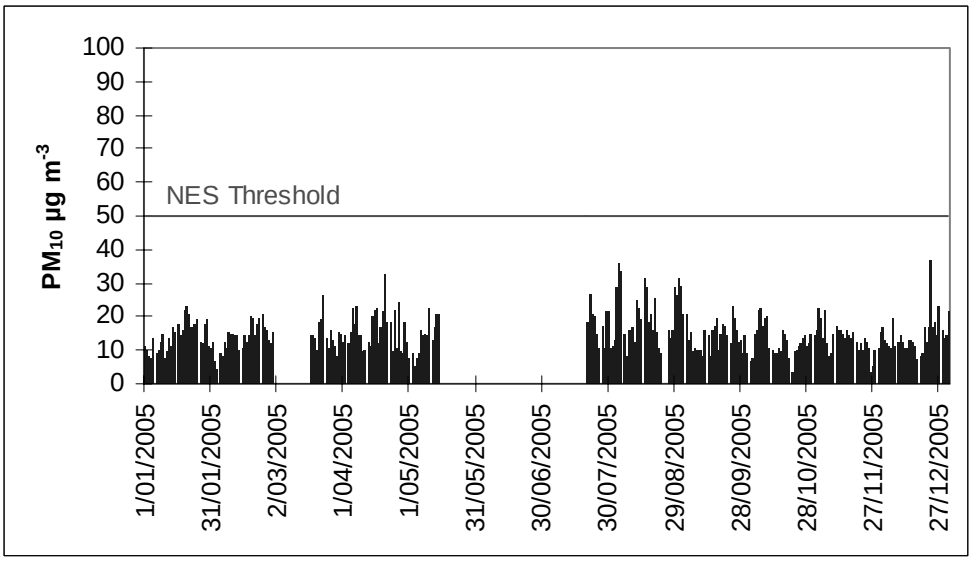


Figure 2-5: Daily PM_{10} concentrations measured in Hamilton during 2005

The maximum measured PM_{10} concentration in Hamilton during 2005 was 37µg m^{-3} (24-hour average) which was recorded on 23 December. The maximum PM_{10} concentration observed during winter 2005 was 35µg m^{-3} and was measured on 4 August. Since monitoring began at Peachgrove Road, PM_{10} maxima have invariably

occurred in winter and it is unusual for the maximum concentration to be observed during the summer period. Two reasons may be responsible for the anomaly in 2005: 1) atypical conditions or an extraordinary source of PM_{10} may have occurred on 23 December 2005 to produce a higher than usual summertime concentration; or 2) the highest concentration may actually have occurred during the early 2005 winter period, but this would have been unobserved while the TEOM was out of service.

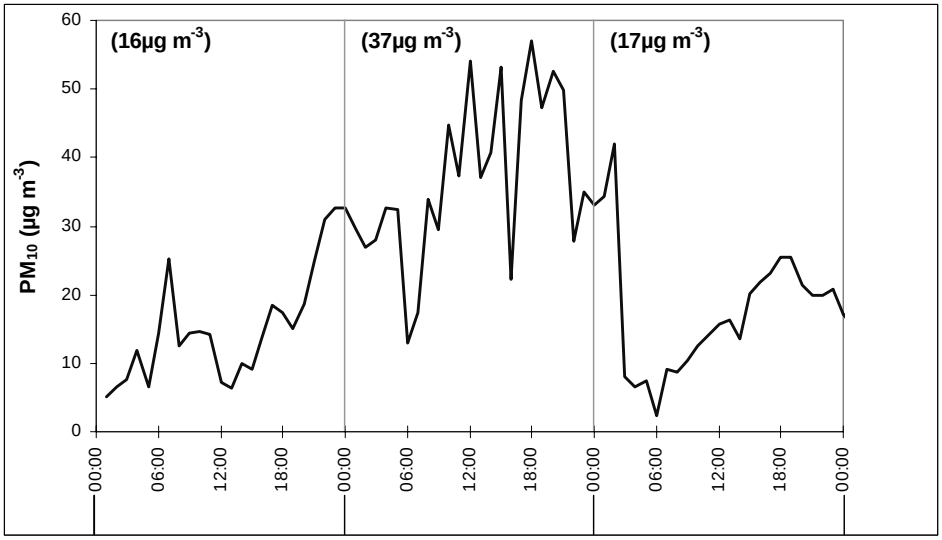
Figure 2-6 shows that compared with adjacent days, meteorological conditions on 23 December were not atypical and are unlikely to explain the relatively high 24-hour PM_{10} concentration on this day. Wind was from the west for almost the entire 3 day period in Figure 2-6 and the diurnal variation of windspeed was also similar for each day, albeit with a slightly higher peak on 23 December. Despite this, the 24hr average PM_{10} concentration on 23 December was twice that observed on the previous and subsequent days. There is also little variation in air temperature and relative humidity between the days that might otherwise have explained the relatively high concentrations of PM_{10} that occurred on 23 December.

The air temperature throughout 23 December was consistently warm (15–21°C), so the use of home heating appliances is very unlikely and may be discounted as a source of PM_{10} on this day. Instead, it is possible that the elevated PM_{10} concentrations on 23 December may be due to increased motor vehicle emissions as a consequence of greater road congestion during the last weekday before Christmas in 2005. It may also be possible that neighbouring householders were tidying their sections and burning greenwaste before Christmas, which may have contributed to elevated PM_{10} concentrations. These alternative explanations are supported by an emissions inventory that estimated nearly 80% of PM_{10} emissions in Hamilton during December are from motor vehicles and outdoor burning of domestic waste (Wilton 2005b). These sources contribute an estimated 41% and 38% of December PM_{10} emissions respectively (Wilton 2005b).

While these explanations will persist as untested hypotheses, it is unlikely that the unusually high PM_{10} measurements are a consequence of technical issues related to the monitoring equipment. There is no record of any work or activity at the monitoring site on 23 December and there is no reason to suspect a problem with monitoring equipment.

Notwithstanding the unusually high PM_{10} concentrations measured on this summer day, it remains a reasonable hypothesis that the highest 24-hour concentration actually occurred during the winter when the TEOM was removed for servicing. Since monitoring began in Hamilton, PM_{10} guideline exceedances have been recorded in 2001, 2003 and 2004, and for each of these years the exceedances were observed during the first fortnight in July. However, data were not collected between 15 May – 19 July 2005 and it is entirely possible that the highest PM_{10} concentration occurred, but was undetected, during this period.

(a)



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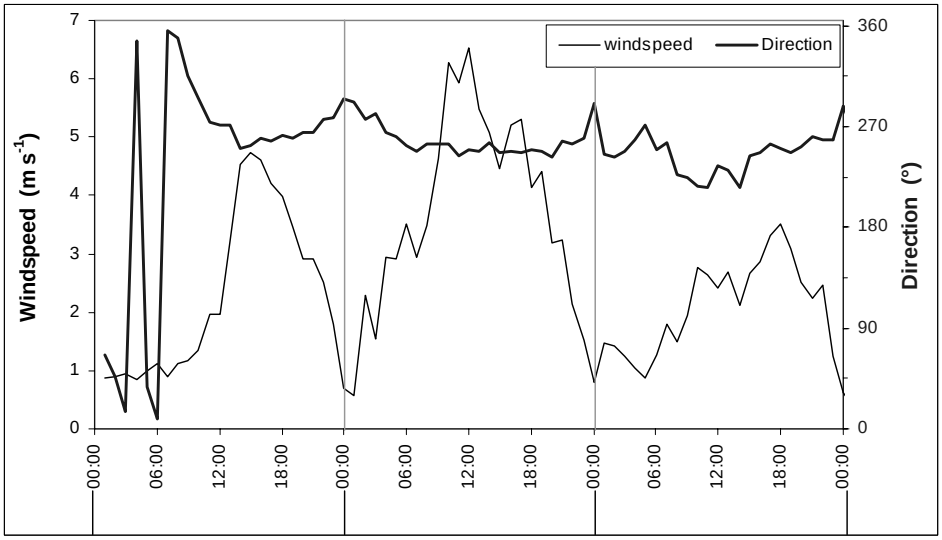

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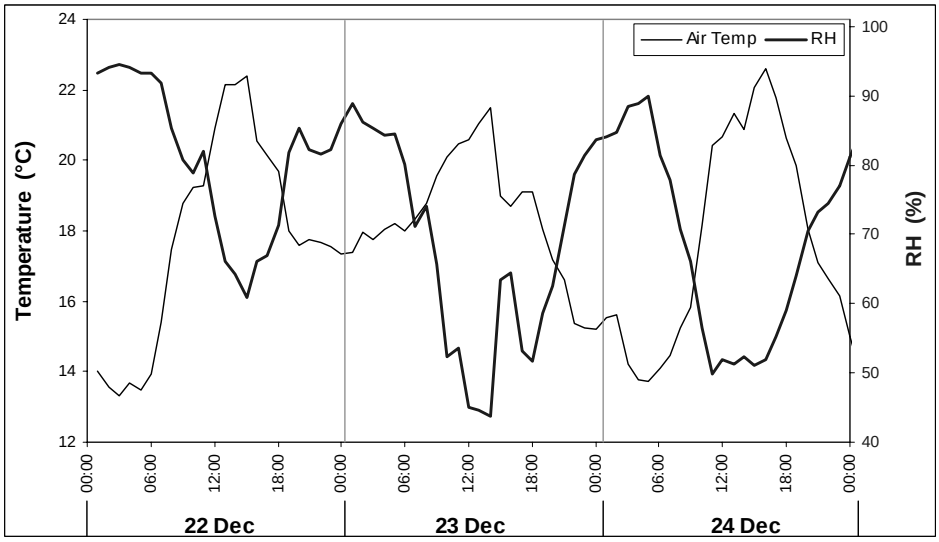


Figure 2-6: Diurnal variation of: (a) hourly average PM_{10} concentrations (numbers in parentheses are 24hr averages); (b) hourly average windspeed and direction; and (c) hourly average air temperature and relative humidity (RH) measured at Peachgrove Road, Hamilton for the period 22-25 December 2005.

The annual average PM_{10} concentration for Hamilton for 2005 was 15 µg m^{-3} based on TEOM data. This is less than the MfE annual guideline for PM_{10} of 20 µg m^{-3} and is of similar magnitude to annual average concentrations for Hamilton of 16 µg m^{-3} for 1999, 15 µg m^{-3} from 2000 to 2003, and 17 µg m^{-3} for 2004.

A comparison of the PM_{10} concentrations to the MfE air quality indicator categories is shown in Figure 2-7. This suggests that for most of the year, concentrations of PM_{10} measured in Hamilton were within the MfE "good" or "acceptable" air quality categories. Again, caution is required with this interpretation due to the absence of data in June and only around 45% data capture for March, May and July.

Figure 2-8 and Table 2-1 compare the distribution of PM_{10} concentrations in Hamilton during 2005 and summary statistics to results from previous years. No trends in PM_{10} concentrations are evident from these data.

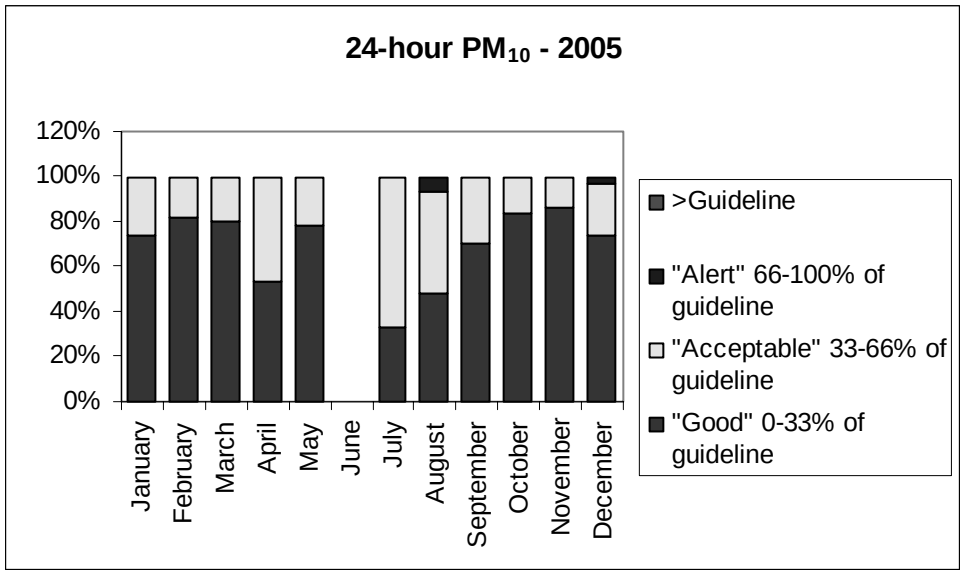


Figure 2-7: Comparison of PM_{10} concentrations measured in Hamilton during 2005 to MfE air quality indicator categories

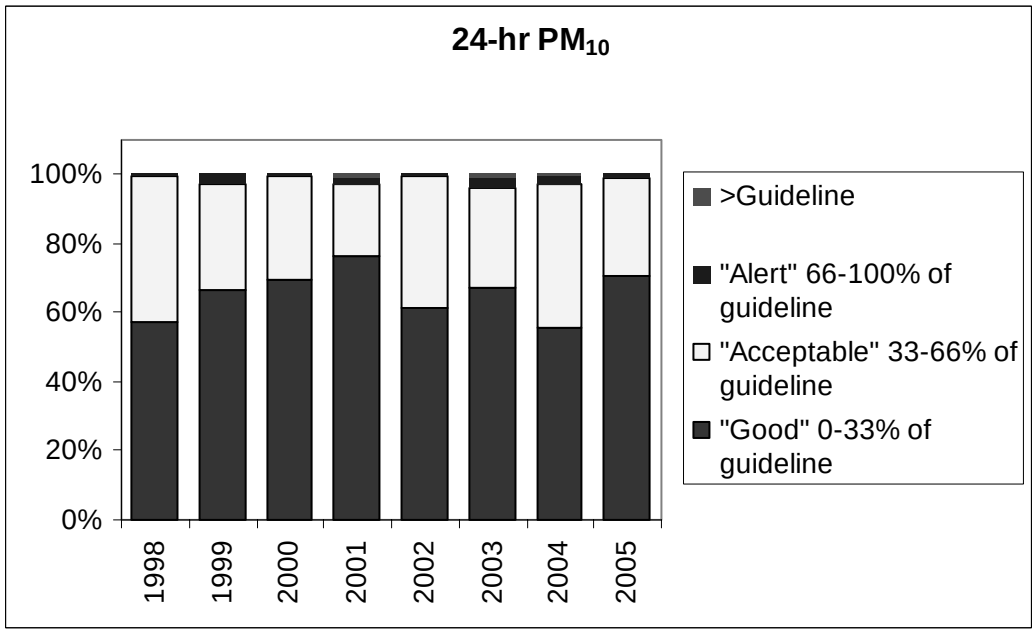


Figure 2-8: Comparison of PM_{10} concentrations measured at Hamilton from 1998 to 2005 to MfE air quality indicator categories

Table 2-1: Summary statistics for PM_{10} data for Hamilton from 1998 to 2005

	PM_{10} 1998	PM_{10} 1999	PM_{10} 2000	PM_{10} 2001	PM_{10} 2002	PM_{10} 2003	PM_{10} 2004	PM_{10} 2005
"Good" 0-33% of guideline	57%	67%	70%	77%	61%	67%	56%	71%
"Acceptable" 33-66% of guideline	42%	31%	30%	21%	38%	29%	41%	28%
"Alert" 66-100% of guideline	1%	3%	1%	2%	1%	3%	3%	1%
"Action" >Guideline	0%	0%	0%	1%	0%	1%	0%	0%
Percentage of valid data	47%	99%	91%	70%	93%	91%	94%	77%
Annual average (µg m^{-3})	15	16	15	15	15	15	17	15
Guideline exceedences (extrapolated)	0	0	0	3	0	4	1	0
99.7 %ile concentration (µg m^{-3})	33	43	33	57	34	54	43	36
Annual maximum (µg m^{-3})	35	44	43	67	36	62	55	37

2.3 Concentrations of Benzene, Toluene and Xylenes

Benzene monitoring in Hamilton commenced in 2003 at Peachgrove Road air monitoring site and at a site in the high-density traffic area around Bridge Street. In July 2004 an additional high-density site was added at the intersection of Claudelands Road and Victoria St (Claudelands Bridge).

Figure 2-9 shows that benzene concentrations in Hamilton are within the Ministry for the Environment's current guideline for benzene of 10µg m^{-3} per year (Table 1-2). However, the benzene levels measured at Hamilton's Bridge Street and Claudelands Bridge high-density traffic sites would exceed the 2010 guideline, which has been set at 3.6µg m^{-3} per year. The results of monitoring at Tokoroa during 2003 are shown here for comparison and indicate that benzene concentrations at Tokoroa during 2003 were below the current and 2010 guidelines (Figure 2-9).

Benzene concentrations at Peachgrove Road and Bridge Street were lower in 2004/05 than during the preceding 12 month monitoring period and it is possible that this is an early indication of a declining trend. The main source of benzene in Waikato urban areas is likely to be motor vehicle emissions and domestic home heating. The Hamilton benzene monitoring sites are located near to busy roads to capture the worst-case motor vehicle impacts. Improved vehicle technology, along with higher quality fuel, may be causing a reduction in benzene concentrations. However, the limited monitoring period is too small to be certain of any trends.

It is hoped that a declining trend of benzene concentrations will result in compliance with the 2010 guideline before this becomes operative. To comply with the New Zealand Petroleum Products Specifications Regulations 2002, benzene in petrol reduced from three percent volume to one percent volume by 1 January 2006. It is hoped that the reduction of benzene in petrol, along with the increasing use of catalytic converters on petrol cars, will reduce emissions of benzene sufficiently to ensure compliance with the 2010 ambient guideline. Passive sampling of benzene is continuing at the three Hamilton sites to monitor trends in concentrations as 2010 approaches.

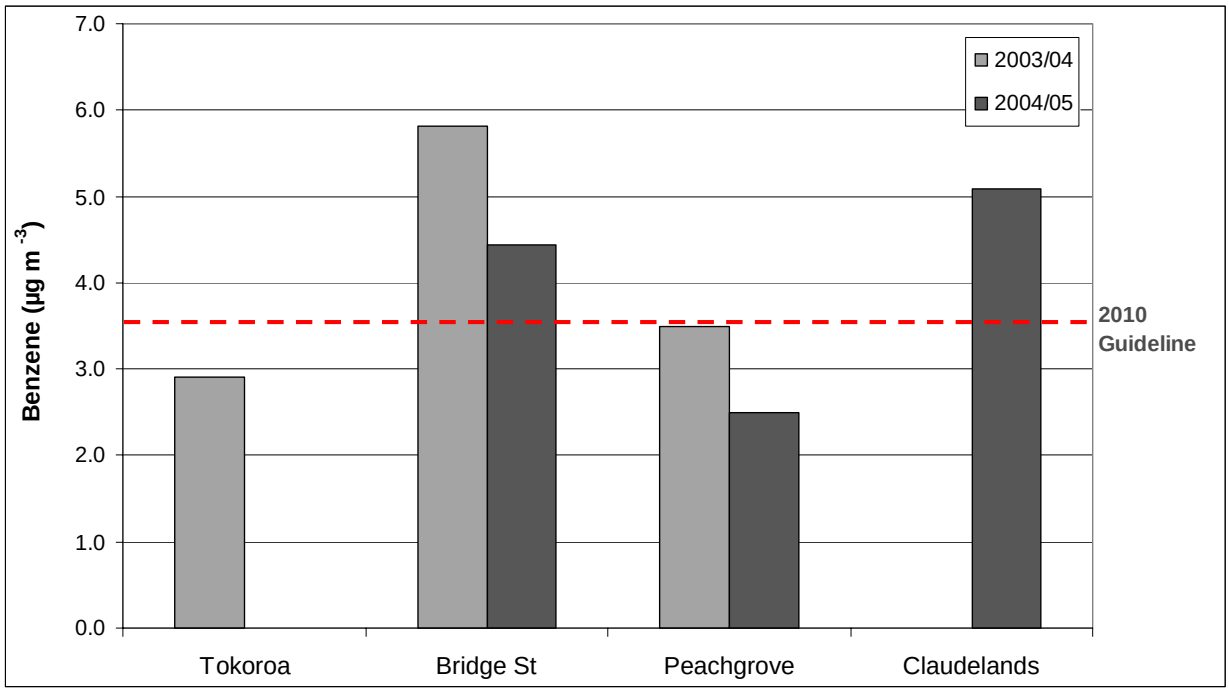


Figure 2-9: Annual average concentrations of Benzene measured at Tokoroa and three Hamilton sites for periods 3 February 2003 – 3 February 2004 and 19 July 2004 – 19 July 2005.

Along with benzene, the passive samplers also facilitate the measurement of toluene and xylenes. While there are no current MfE guidelines for ambient concentrations of toluene and xylenes, a MfE discussion document outlining proposals for amendments to the 1994 ambient air quality guidelines included annual thresholds of 190µg m^{-3} and 950µg m^{-3} for toluene and total xylenes respectively (MfE 2000). The annual average concentrations of these volatile organic compounds (VOCs) measured at the Hamilton sites were very much less than the proposed guideline values (Table 2-2). Of the VOCs monitored with the BTEX passive samplers, benzene is the only contaminant of concern in Hamilton.

Table 2-2: Annual average concentrations of volatile organic compounds (VOCs) at Hamilton sites between July 2004 – July 2005. All units are µg m^{-3}.

	Peachgrove Road	Bridge St	Claudelands Bridge	Guideline value[a]
Benzene	2.5	4.4	5.1	3.6 (10[a])
Toluene	7.3	13.1	15.6	190[b]
total Xylenes	5.4	9.5	11.4	950[b]

[a] The current guideline for benzene is 10µg m^{-3}, but this threshold will reduce to 3.6µg m^{-3} in 2010.
[b] There are currently no guideline values for toluene and xylenes, but the thresholds used here are from proposed amendments to the 1994 ambient air quality guidelines.

3 Air quality monitoring in Tokoroa

Air quality monitoring for PM_{10} has been carried out in Tokoroa since 2001 at the Billah Street Reserve air quality monitoring site (Figure 3-1). This site is located in central Tokoroa to the west and was established in 2001. Prior to this, in 1999 monitoring was carried out in Tokoroa at the South Waikato Council Offices, on the east side of the town. Results of the 1999 monitoring are not included because of uncertainties surrounding the monitoring method. The Billah Street site is consistent with the "Residential Neighbourhood" site classification as described in *Good Practice Guideline for Air Quality Monitoring and Data Management* (MfE 2000).

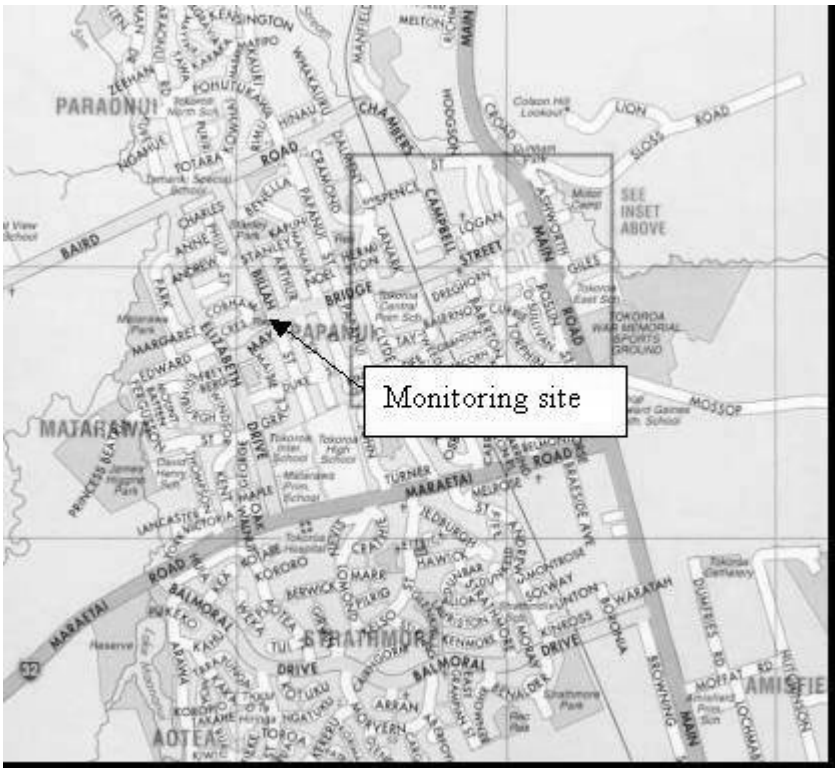


Figure 3-1: Location of PM_{10} monitoring site at Billah Street, Tokoroa

From 2001 to September 2005, the monitoring method used to measure PM_{10} concentrations at Billah Street was a MET ONE series 1020 Beta Attenuation Monitor (BAM). From September 2005 the monitoring method was a ThermoAndersen FH62C14 BAM. The MET ONE instrument was replaced because of unacceptable data loss caused by frequent tape failure. Until August 2005, the site was operated and maintained by NIWA for Environment Waikato. Operation of the Waikato air quality network is now managed by Environment Waikato staff.

PM_{10} data were collected by the FH62 BAM at ten minute intervals. Data gaps of a week or more occurred in January, March, June and September due to BAM tape failure, calibration or during the changeover to the new FH62 instrument.

3.1 Concentrations of PM_{10}

Concentrations of PM_{10} during 2005 breached the ambient air quality guideline of 50 µg m^{-3} (24-hour average) on 30 occasions. This would equate to 29 breaches of the NES, had it been in effect for the entire year. The annual maximum number of exceedences was previously 41, during 2004. Figure 3-2 shows the majority of the breaches occurred between May and August 2005. The maximum PM_{10} concentration measured in Tokoroa during 2005 was 89µg m^{-3} and was recorded on 3 July. This was not an isolated peak, as concentrations of 81µg m^{-3} and 83µg m^{-3} were also recorded in July

2005. These peaks compare with a previous maximum concentration of 97µg m^{-3}, measured in 2004.

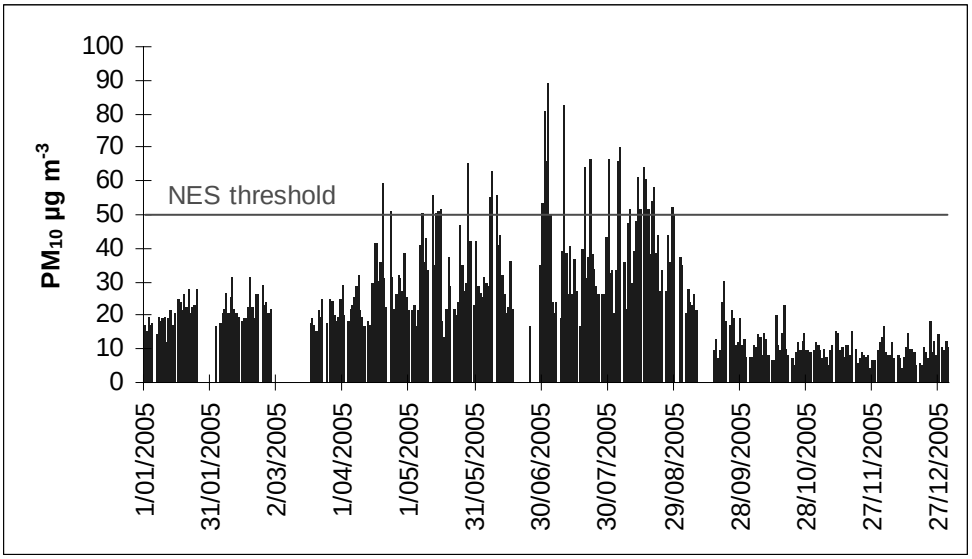


Figure 3-2: 24-hour average concentrations of PM_{10} in Tokoroa during 2005

Figure 3-2 also suggests that an attenuation of baseline data has occurred following the installation of the FH62 BAM in September 2005. This phenomenon might indicate a return to accurate measurement by the new instrument as Wilton (2005a) noted an increase in baseline data after December 2003 and suspected this may have been caused by an instrumentation anomaly. It is possible that data collected between December 2003 and September 2005 were falsely amplified by an illegitimate offset or slope associated with the MET ONE instrument. Variation of PM_{10} sources and meteorology were discounted as reasons for the baseline augmentation by Wilton (2005a). The reduction in baseline PM_{10} concentrations after installation of the FH62 BAM supports Wilton's (2005a) argument.

However, metadata supplied by NIWA instruments disclose that full annual servicing of the older MET ONE instrument was completed in March 2004 and March 2005, and the specification of this servicing included instrument calibration. There is no record of any changes to the instrument or datalogger settings in the metadata supplied by NIWA, so there is no explicit evidence of a problem with this instrument that may have caused variations in recorded concentrations. During installation, the FH62 BAM was calibrated by Environment Waikato staff under the supervision of experienced contractors (Watercare Services) and there is no doubt of the validity of data measured by the FH62 instrument since September 2005. Because both instruments have been calibrated, validated adjustments to the data are not possible, even though the apparent shift in baseline data after installation of the FH62 BAM suggests that the data from December 2003 – September 2005 are anomalously high.

Figure 3-3 compares PM_{10} concentrations measured in Tokoroa during 2005 to MfE air quality indicator categories for each month of the year. This shows a considerable proportion of exceedences as early as April, with PM_{10} concentrations in excess of 50µg m^{-3} on approximately 20% of days during May–July and over a third of days during August. While the highest concentrations were recorded during July, the most frequent PM_{10} events occurred in the month of August 2005.

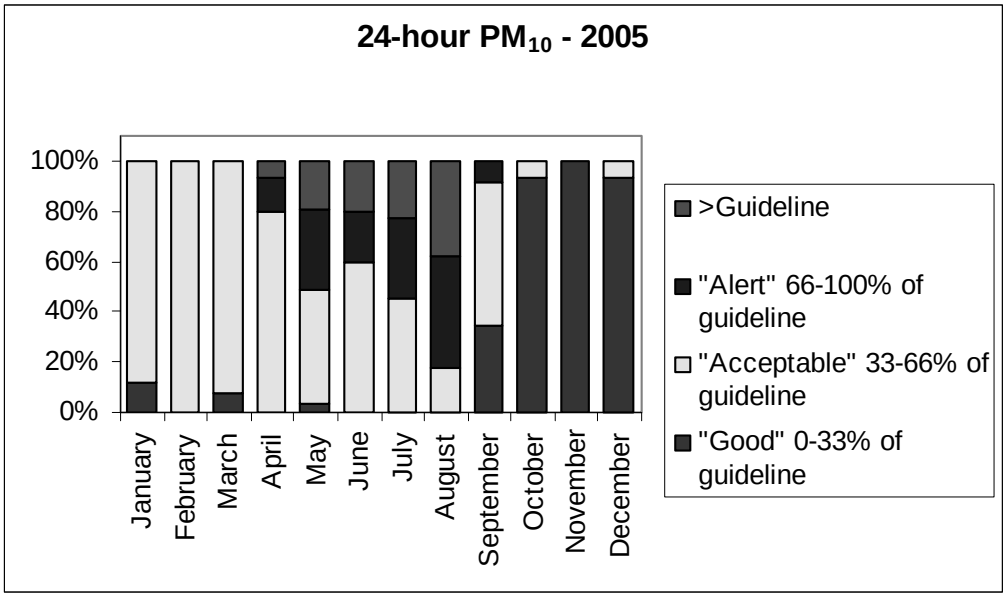


Figure 3-3: Comparison of PM_{10} concentrations measured in Tokoroa to MfE air quality indicator categories

Table 3-1 and Figure 3-4 compare PM_{10} concentrations measured in Tokoroa during 2005 to historic data. Prior to December, much of the data for 2003 are either absent or may be suspect[1], so comparison with data for 2003 is not warranted. For other years, PM_{10} concentrations at Tokoroa have exceeded the annual average guideline for PM_{10} of 20µg m^{-3} (MfE 2002) since monitoring commenced in 2001.

Based on the data in Table 3-1 and Figure 3-4, it is likely that the NES for 24-hour average PM_{10} concentrations will also be breached in Tokoroa in winter 2006 and management methods to reduce PM_{10} emissions will be required to achieve NES compliance in future years.

Table 3-1: Summary statistics for PM_{10} data for Tokoroa from 2001 to 2005. Note that 2003 data are unavailable (see EWdoc#991860).

	PM_{10} 2001	PM_{10} 2002	PM_{10} 2003	PM_{10} 2004	PM_{10} 2005
"Good" 0-33% of guideline	12%	15%	n/a	12%	32%
"Acceptable" 33-66% of guideline	64%	71%	n/a	54%	46%
"Alert" 66-100% of guideline	17%	10%	n/a	23%	13%
“Action” >Guideline	8%	4%	n/a	12%	9%
Percentage of valid data	47%	98%	n/a	96%	88%
Annual average (µg m^{-3})	27	24	n/a	31	25
Guideline exceedences (extrapolated)	24	15	n/a	41	33
99.7 %ile concentration (µg m^{-3})	67	65	n/a	92	83
Annual maximum (µg m^{-3})	75	70	n/a	97	89

[1] see EWdoc#991860

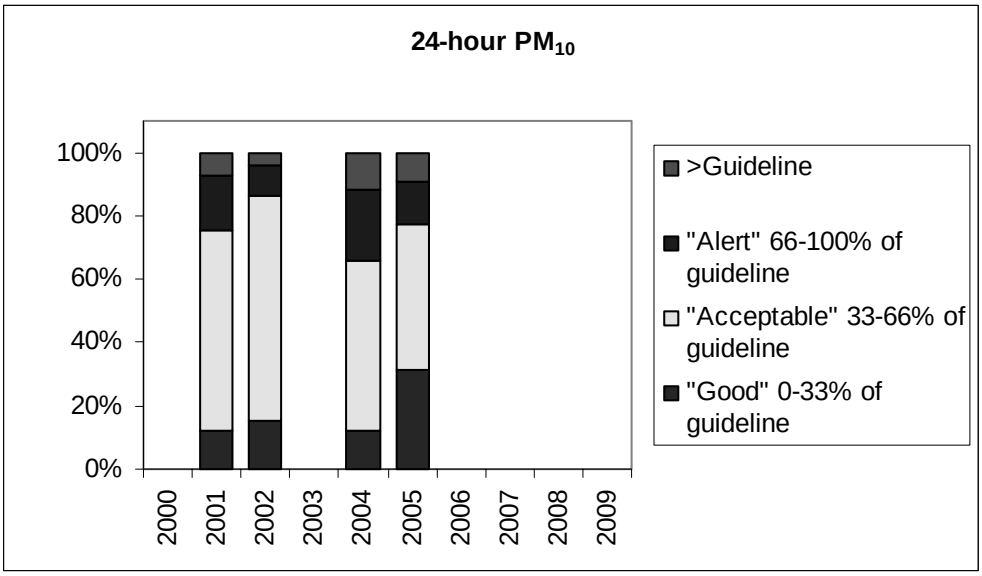


Figure 3-4: Comparison of PM_{10} concentrations measured in Tokoroa from 2001 to 2005 to MfE air quality indicator categories.

Because 2003 data are not reportable and only 47% of data for 2001 are valid (Table 3-1), it is only possible to compare data for 2004 and 2005 with records from 2002. Concentrations of PM_{10} in Tokoroa during 2004 and 2005 were higher than in 2002, both in terms of magnitude and frequency of exceedences. Possible reasons for the increased concentrations in 2004 and 2005 include variations in meteorological conditions, increased emissions or instrumentation error. These possibilities are considered below.

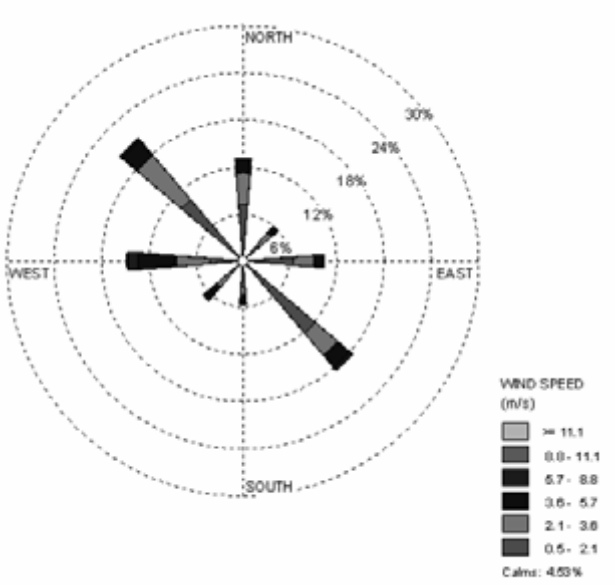
3.2 Meteorology

Meteorological data including air temperature, wind speed and direction were collected at the air quality monitoring site in Tokoroa.

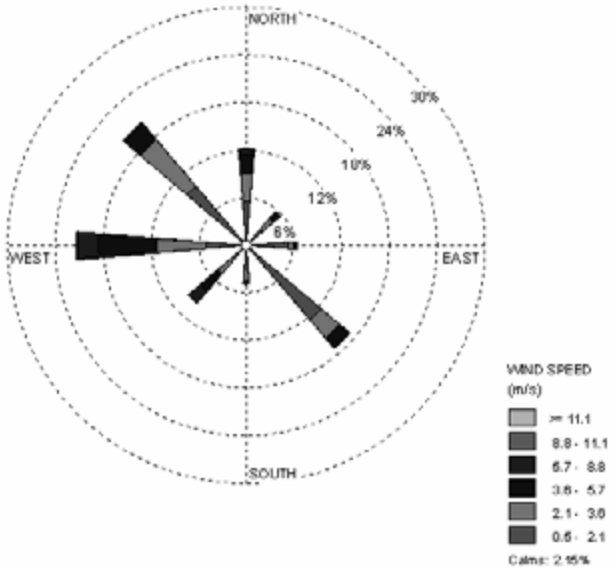
Figure 3-5 shows that wind conditions during 2004 and 2005 (Figure 3-5b and Figure 3-5a respectively) were not entirely similar to those during 2002 (Figure 3-5c). While westerly winds were more common in 2004 (Figure 3-5), this was not so during the winter months of June – August (Figure 3-6) when elevated PM_{10} events occurred. During winter there was generally a higher frequency of light winds from the southeast in both 2004 and 2005 than during 2002 (Figure 3-6). During winter, the light southeast winds are usually associated with clear skies, cooler air temperatures and stable atmospheric conditions: circumstances which are conducive to elevated air pollution. There was also a higher frequency of stronger northwest winds during winter 2002 which would have generated more dispersion of PM_{10} than in winter of the other two years. It is possible, therefore, that wind conditions during winter of 2004 and 2005 may have been more conducive to PM_{10} exceedances and this remains a possible explanation for the elevated PM_{10} concentrations recorded in 2004 and 2005.

While the monthly mean air temperature during August 2004 was lower than for the same month in 2002 and 2005, the monthly mean air temperature for July and August was higher in 2005 than 2002 (Figure 3-7). Therefore cooler temperatures do not provide an explanation for the elevated PM_{10} concentrations and frequency of events during 2005 compared with 2002. It is unlikely that variation of air temperature explains the elevated PM_{10} concentrations recorded in 2004 and 2005.

(a)



(b)



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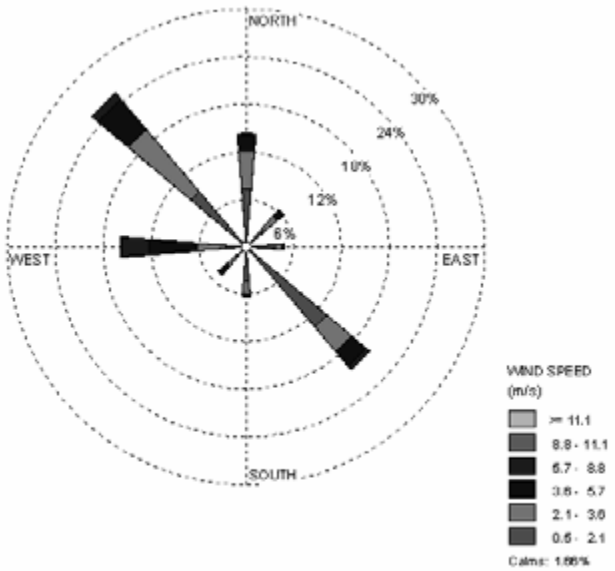
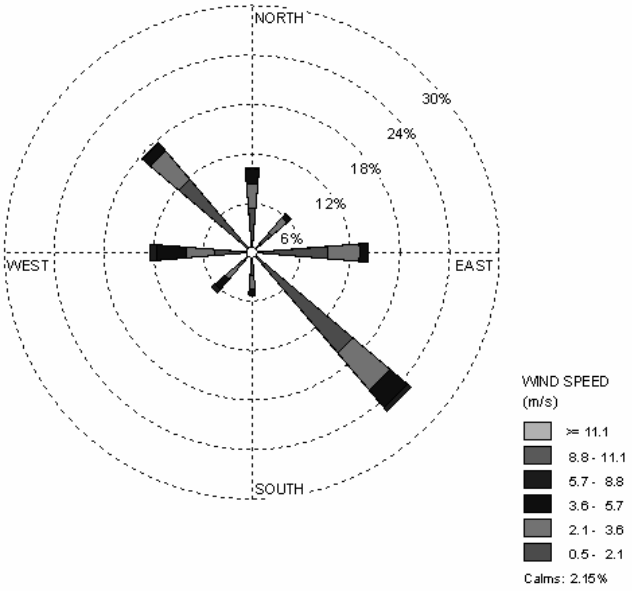
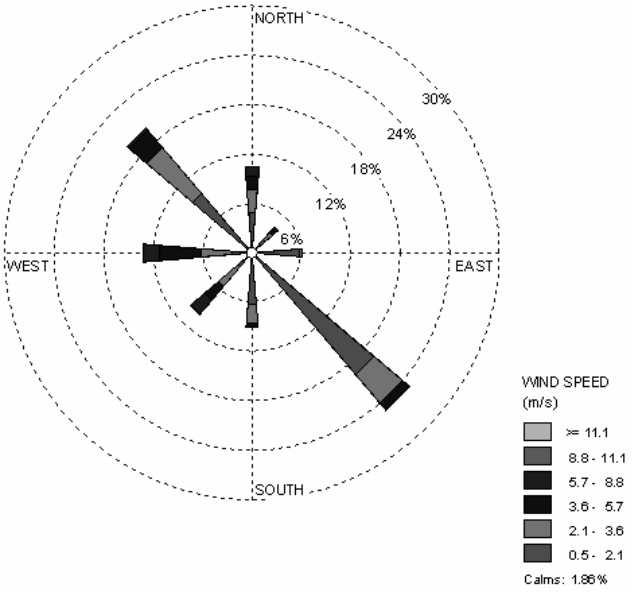


Figure 3-5: Windrose plots for Tokoroa during: (a) 2005; (b) 2004; and (c) 2002

(a)



(b)



(c)

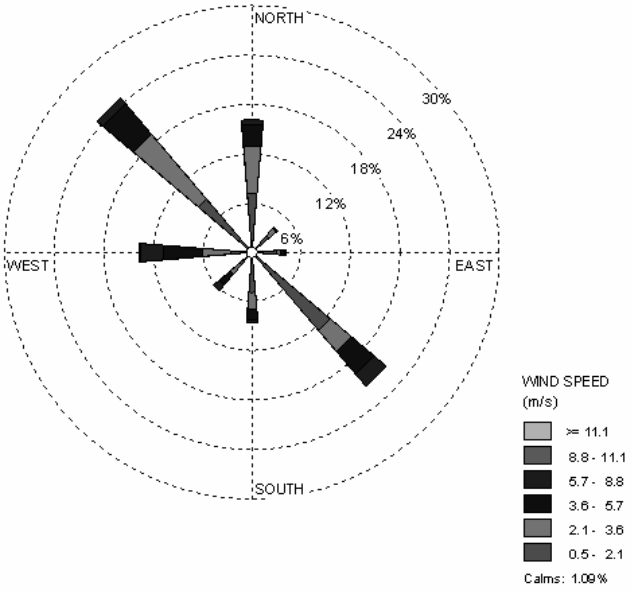


Figure 3-6: Windrose plots for winter months (June-August) at Tokoroa during: (a) 2005; (b) 2004; and (c) 2002

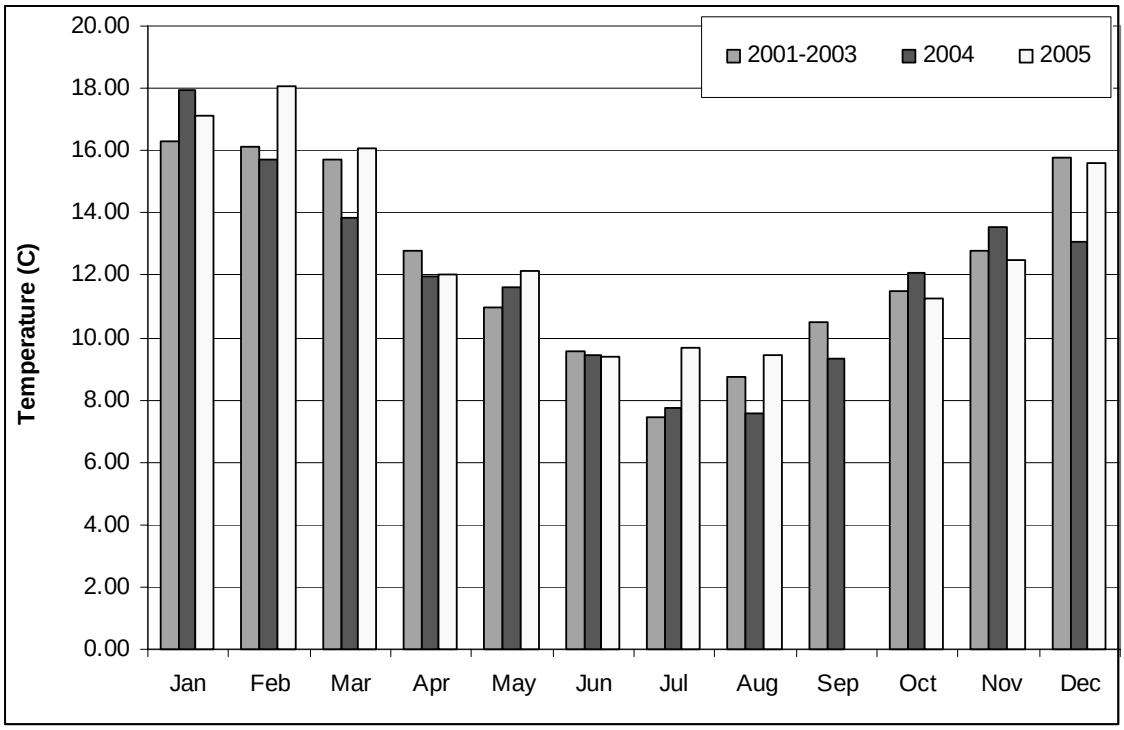


Figure 3-7: Monthly mean air temperatures for 2004, 2005 and monthly mean temperatures for the years 2001–2003 at Tokoroa.

3.3 Emissions and Instrumentation Issues

Research conducted for a recent Tokoroa emissions inventory has indicated that the magnitude of emissions at Tokoroa is unlikely to have varied significantly between 2002 and 2005 and no new sources of PM_{10} have been identified over this period (Wilton 2004a, Wilton 2005c). Also, as noted by Wilton (2005a), it would be unusual for a single emission source to have such a persistent effect on PM_{10} concentrations across all seasons and variations of meteorological conditions.

Therefore the remaining possible explanations for the increased PM_{10} concentrations in 2004 and 2005 are: variations in wind conditions; and instrumentation error. Instrumentation error is indicated by the apparent baseline shift in PM_{10} following the upgrade of the Met One instrument that operated during 2004 and 2005. Also, the windrose analysis above shows that wind conditions may have been more conducive to elevated PM_{10} concentrations during 2004 and 2005. Neither of these explanations can be discounted.

4 Air quality monitoring in Taupo

The air quality monitoring site in Taupo for 2005 was at the Gillies Street Reserve. The site is located in central Taupo and was established in November 2000. The site is consistent with the "Residential Neighbourhood" site classification as described in *Good Practice Guideline for Air Quality Monitoring and Data Management* (MfE 2000).

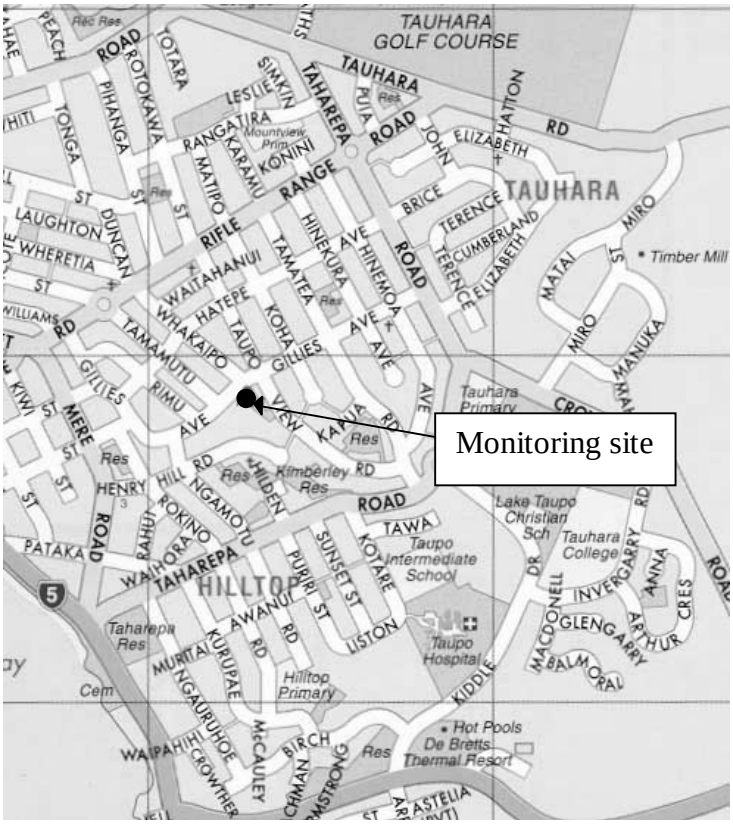


Figure 4-1: Location of Taupo PM_{10} monitoring site during 2005

The monitoring method for measuring PM_{10} concentrations in Taupo was gravimetric sampling using a Rupprecht and Patashnick Partisol Model 2000 PM_{10} sampler. The sampling regime during 2005 was approximately one-day-in-three, with a midnight to midnight filter exposure period. The sampling was carried out by the Institute of Geological & Nuclear Sciences (GNS) on behalf of Environment Waikato.

A total of 109 samples were collected during 2005. Meteorological instrumentation is not installed at this site, so data are not available for 2005.

4.1 Concentrations of PM_{10}

One exceedence of the 50µg m^{-3} guideline for PM_{10} was measured during 2005 (Figure 4-2). Extrapolating the data statistically for days when monitoring wasn't conducted suggests that around three exceedances may have occurred during 2005. This is less than the 12 estimated for 2003 and the six exceedances estimated for both 2002 and 2004. Concentrations of PM_{10} in Taupo would have exceeded the NES for PM_{10} in each of these years.

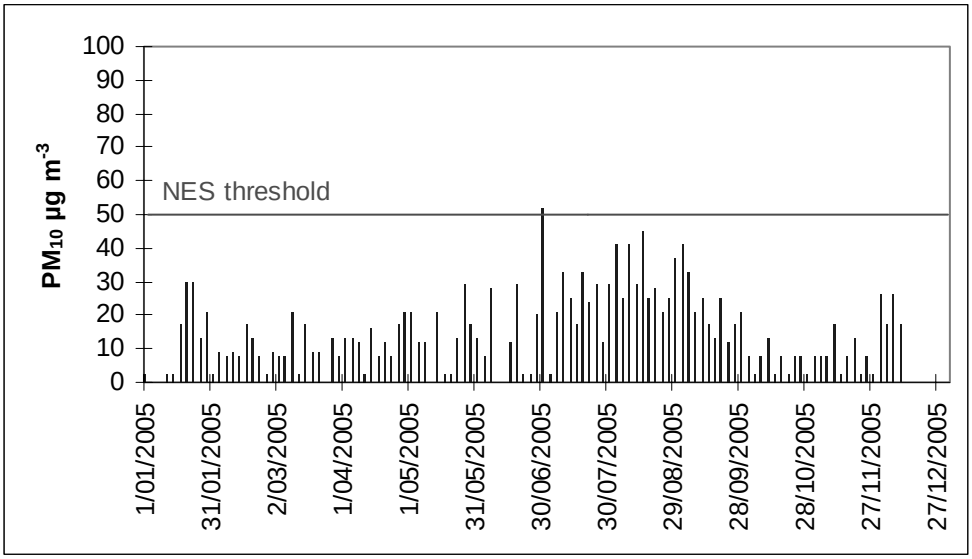


Figure 4-2: 24-hour average concentrations of PM_{10} in Taupo during 2005

The maximum measured PM_{10} concentration at Taupo during 2005 was 52µg m^{-3}. This is less than maximum values measured from 2001 to 2004 (53µg m^{-3} – 65µg m^{-3}). One day in three sampling suggests that the annual average PM_{10} concentration for Taupo for 2004 was around 17µg m^{-3}. This compares to an annual average guideline for PM_{10} of 20 µg m^{-3} (MfE 2002).

Monthly summaries of daily PM_{10} concentrations relative to the MfE air quality indicator categories are shown in Figure 4-3. Because of the one-day-in-three sampling frequency, there is a small sample size of daily data for each month and it would be prudent to avoid further interpretation of seasonal trends. For example, while June appears to be a relatively average month in terms of the air quality indicators, only eight daily measurements were made during this period. Being spread across four categories, there is much potential for unrepresentative calculation of percentages from the eight data values. There are typically 10 or 11 daily records for other months in 2005.

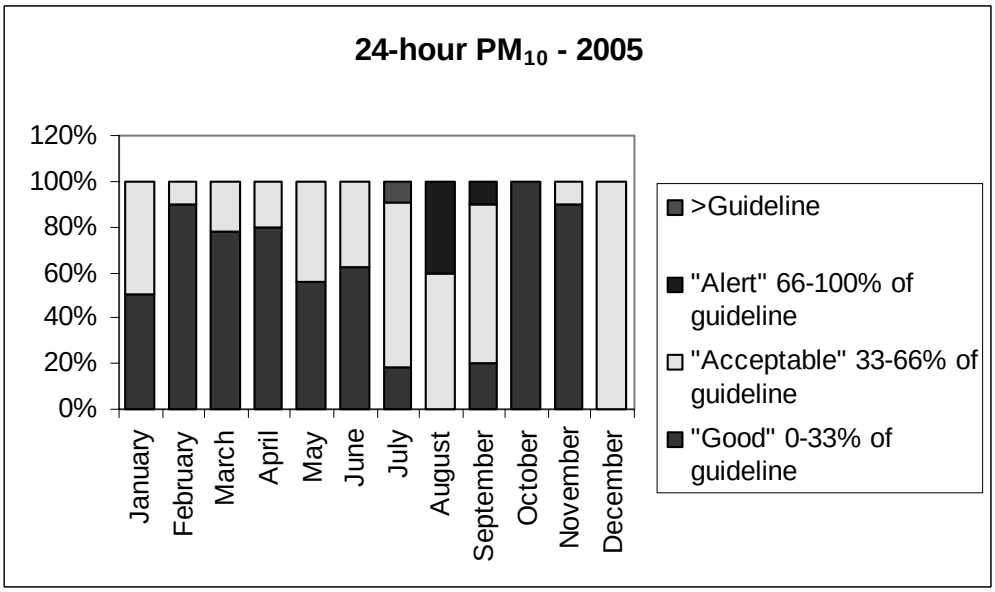


Figure 4-3: Comparison of PM_{10} concentrations measured in Taupo to MfE air quality indicator categories

A comparison of PM_{10} data for Taupo from 2001 to 2005 is shown in Table 4-1 and Figure 4-4. No trends in PM_{10} concentrations are evident from these data.

Table 4-1: Summary statistics for PM_{10} data for Taupo from 2001 to 2005

	PM_{10} 2001	PM_{10} 2002	PM_{10} 2003	PM_{10} 2004	PM_{10} 2005
"Good" 0-33% of guideline	43%	59%	52%	55%	56%
"Acceptable" 33-66% of guideline	36%	33%	32%	33%	38%
"Alert" 66-100% of guideline	18%	7%	12%	10%	5%
"Action" >Guideline	2%	1%	4%	2%	1%
Percentage of valid data	12%	21%	29%	29%	30%
Annual average (µg m^{-3})	20	16	18	17	16
Guideline exceedences (extrapolated)	7	6	12	6	3
99.7 %ile concentration (µg m^{-3})	54	49	61	62	50
Annual maximum (µg m^{-3})	57	54	62	65	52

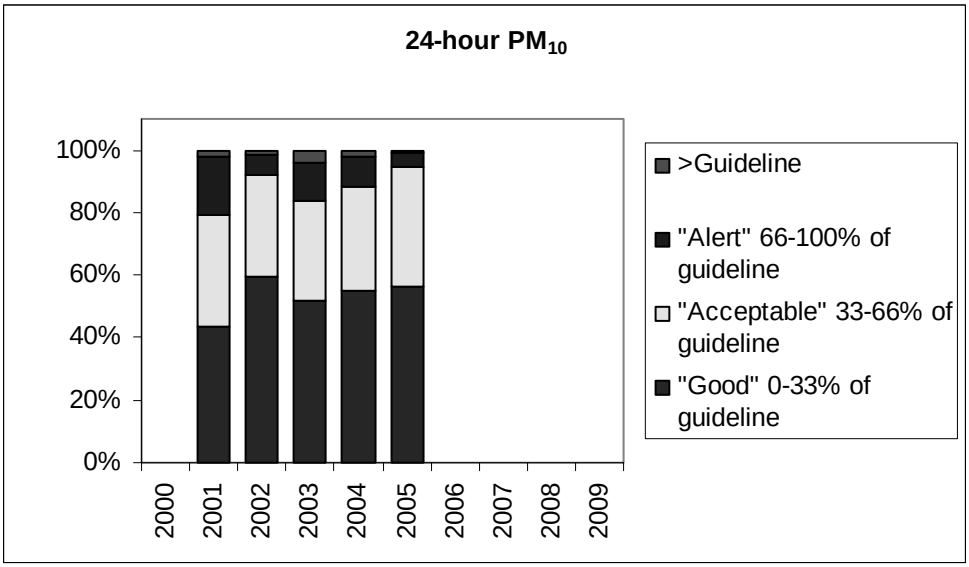


Figure 4-4: Comparison of PM_{10} concentrations measured in Taupo from 2001 to 2005 to MfE air quality indicator categories

An emission inventory study carried out in Taupo for 2004 indicates that the main source of PM_{10} emissions is solid fuel burning for domestic home heating (Wilton 2004c).

5 Air quality monitoring in Te Kuiti

Air quality monitoring in Te Kuiti during 2005 was carried out at the Te Kuiti City Council Offices off Queen Street (Figure 5-1). This is the same site as used since 2003 and for the 1998 PM_{10} monitoring in Te Kuiti. Further descriptions of the air quality monitoring site, including a map and site layout are given in the *"Air Quality Monitoring Report – Waikato Region*" (Wilton 2002a). The site is consistent with the "Residential Neighbourhood" site classification as described in *Good Practice Guideline for Air Quality Monitoring and Data Management* (MfE 2000).

Concentrations of PM_{10} were measured at the site using an ESM (Anderson) FH62C14 Beta Attenuation Monitor (BAM). The site was operated and maintained by NIWA for Environment Waikato until August 2005 when the Waikato air quality network was subsequently managed by Environment Waikato staff.

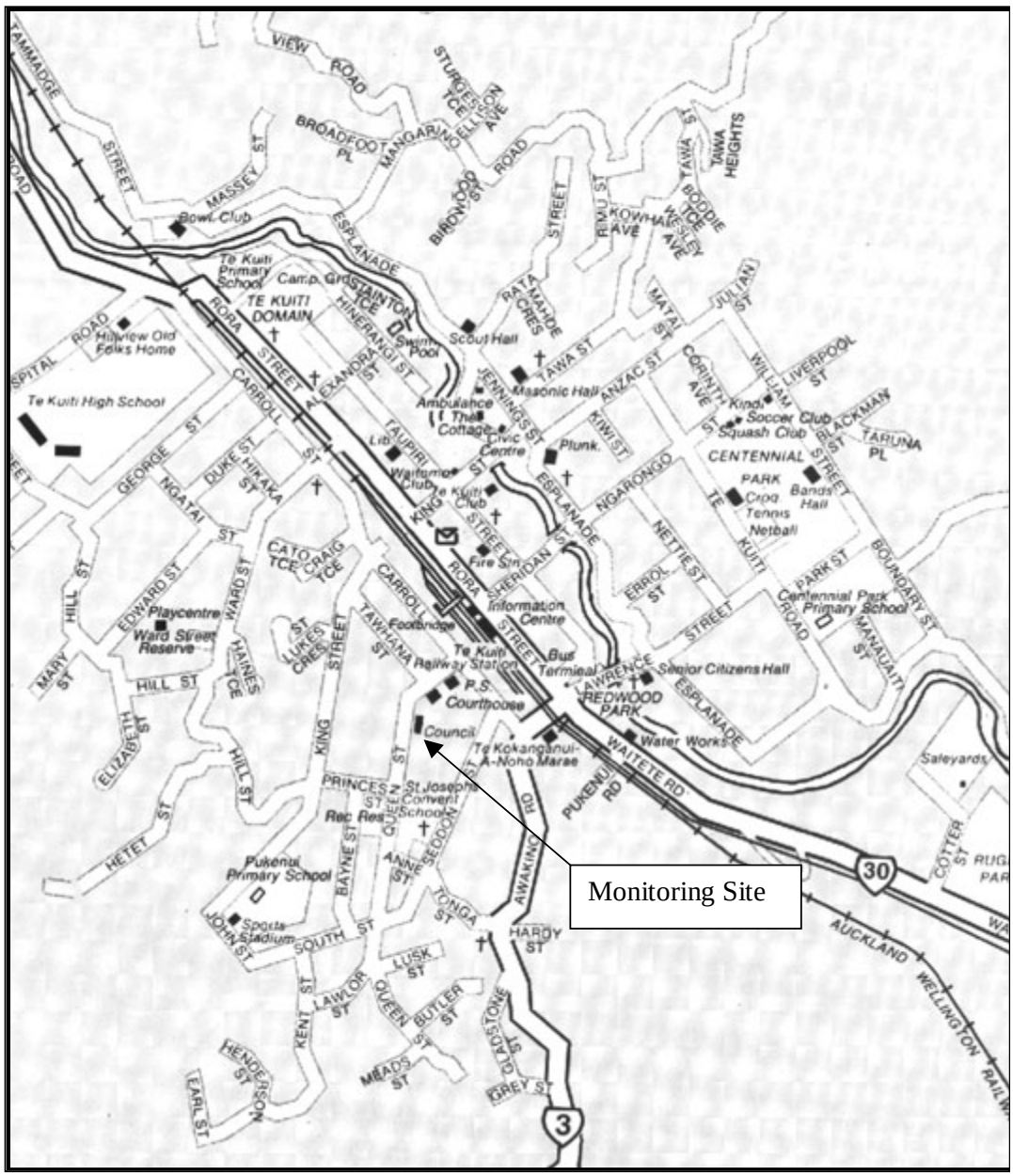


Figure 5-1: Location of the PM_{10} monitoring site at Te Kuiti

5.1 Concentrations of PM_{10}

Figure 5-2 shows that PM_{10} concentrations in excess of 50µg m^{-3} occurred on two days during 2005. The maximum measured PM_{10} concentration was 54µg m^{-3} (24-hour average) and occurred on 4 July 2005.

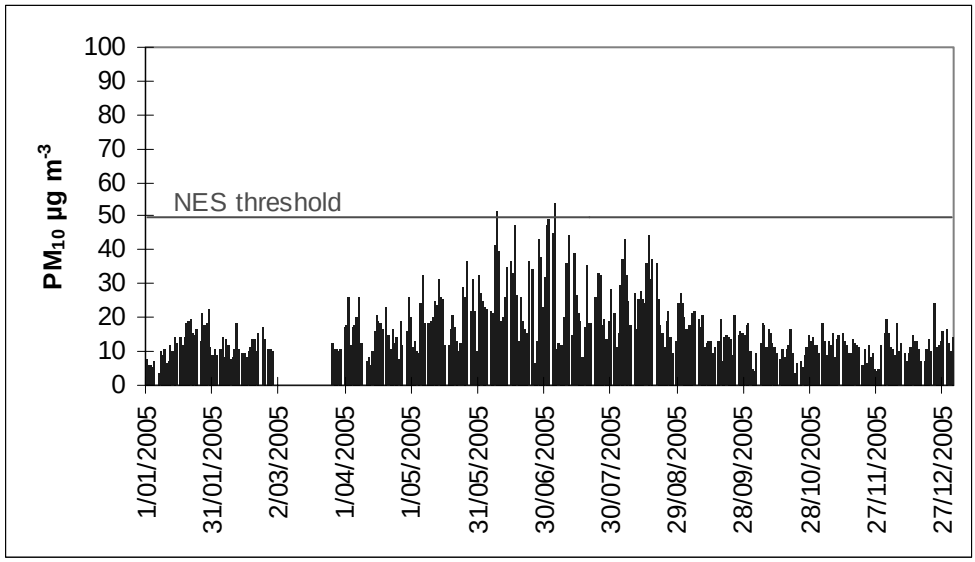


Figure 5-2: 24-hour average concentrations of PM_{10} in Te Kuiti during 2005

The annual average PM_{10} concentration for Te Kuiti for 2005 was 17µg m^{-3}. This is less than annual average concentrations of 18µg m^{-3} recorded during both 2003 and 2004 and less than the MfE annual average guideline of 20µg m^{-3} (MfE 2002). Seasonal variation of PM_{10} concentrations in Te Kuiti relative to the MfE air quality indicator categories are shown in Figure 5-3. As with other locations within the region, the poorest air quality occurs during the months May to August.

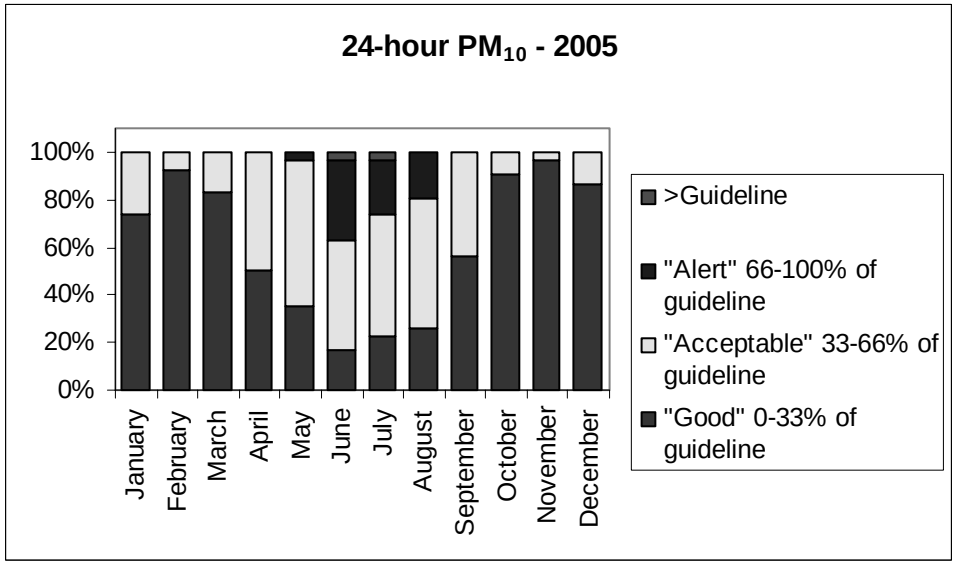


Figure 5-3: Comparison of PM_{10} concentrations measured in Te Kuiti to MfE air quality indicator categories

Figure 5-4 compares PM_{10} concentrations measured from 2003–2005. Previous monitoring of PM_{10} in Te Kuiti during 1998 is not shown because of differences in the monitoring method. However, summary statistics from 1998 as well as 2003–2005 are shown in Table 5-1. Note that the 1998 values are likely to under-represent PM_{10} concentrations relative to 2003–2005 because of the differences in the monitoring methods.

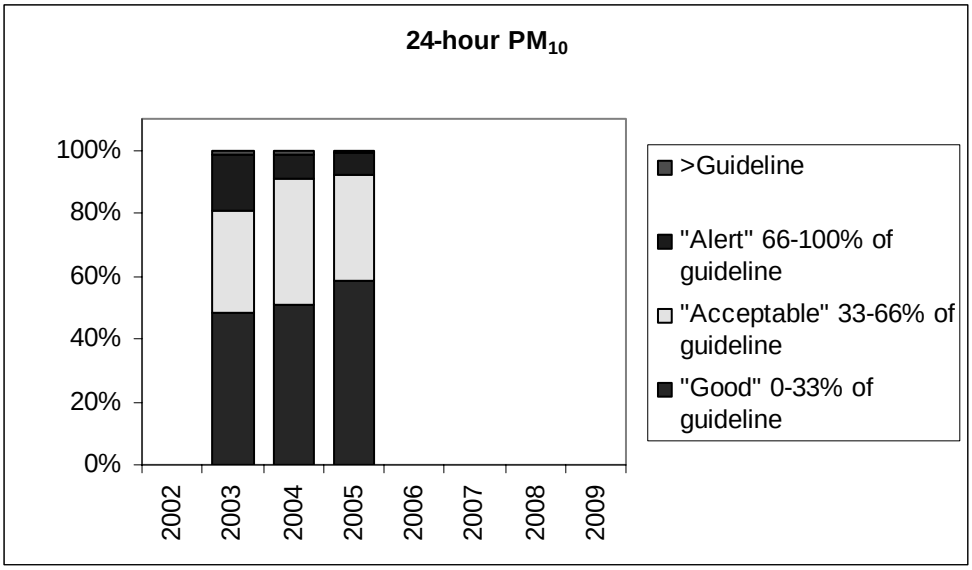


Figure 5-4: Comparison of PM_{10} concentrations measured from 2003–2005 in Te Kuiti to MfE air quality indicator categories

Table 5-1: Summary statistics for PM_{10} data for Te Kuiti for 1998 and 2003–2005

	PM_{10} 1998	PM_{10} 2003	PM_{10} 2004	PM_{10} 2005
"Good" 0-33% of guideline	61%	48%	51%	59%
"Acceptable" 33-66% of guideline	35%	32%	40%	34%
"Alert" 66-100% of guideline	4%	17%	8%	7%
"Action" >Guideline	0%	2%	1%	1%
Percentage of valid data	53%	63%	95%	92%
Annual average (µg m^{-3})	16	18	18	17
Guideline exceedences (extrapolated)	0	5	5	2
99.7 %ile concentration (µg m^{-3})	42	56	56	52
Annual maximum (µg m^{-3})	42	59	61	54

5.2 Meteorology

Diurnal variation

During 2005, two exceedances of PM_{10} were recorded at Te Kuiti: on 8 June and 4 July (hereafter referred to as *PM_{10} events*). Diurnal courses of hourly average PM_{10} are shown for these events, along with data from adjacent days, in Figure 5-5a. Diurnal plots of ambient air temperature and windspeed are shown in Figure 5-5b and Figure 5-5c respectively.

Emission inventory studies suggest that domestic home heating is the main source of PM_{10} in Te Kuiti (Noonan 1997a and 1997b). Acknowledging this, when meteorological conditions remain consistently cool and calm, the diurnal variation of PM_{10} concentration appears to be driven by human behaviour and the pattern of domestic heating appliance operation.

To demonstrate, Figure 5-5a shows that concentrations of PM_{10} soared in the evening at around 6pm on both days preceding the PM_{10} events (7 June and 3 July 2005: hereafter referred to as *antecedent days*). The PM_{10} increase occurred as temperature (Figure 5-5b) and windspeed (Figure 5-5c) decreased and was likely to be a consequence of home fires being started during the evening. This hypothesis is supported by a 2001 domestic heating emission inventory that reported 54% of PM_{10} emissions occur during the 4pm to 10pm period at Te Kuiti (Wilton 2002d).

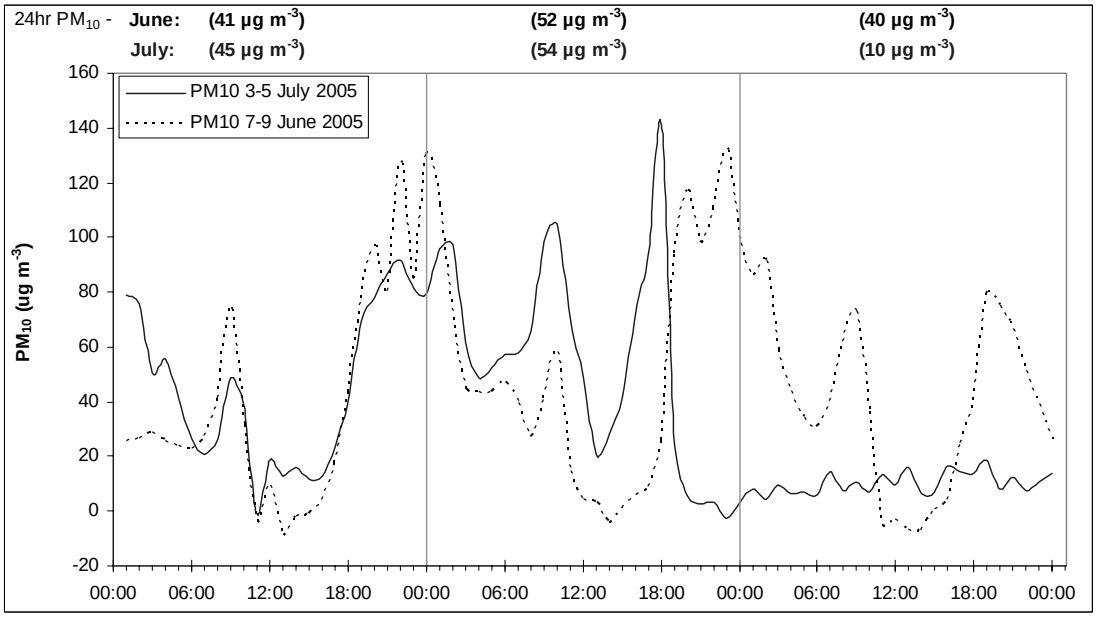
PM_{10} concentrations continued to rise during the evening on antecedent days and this is probably exclusively a consequence of home heating operation because temperature and windspeed remained constant throughout both nights. Immediately following the antecedent days, despite consistent windspeed and temperature, PM_{10} concentrations peaked after midnight and decreased during the early morning hours. This is almost certainly because householders would have ceased fuelling their appliances and retired to bed during this period.

The general diurnal pattern in Figure 5-5a is that while conditions remain cool and calm, PM_{10} concentrations continue to decrease until fires are re-started in the morning and a second peak develops between 6am and 11am. Brief midday reductions of PM_{10} concentrations are recorded but, provided that cool and calm conditions prevail, the nocturnal peak quickly develops again in the evening period.

Two possible explanations for the midday reduction in PM_{10} concentrations are: 1) augmented dispersion due to higher windspeed; and 2) less fuel being burnt at this time due to the warmer temperatures. An important difference in meteorology associated with the two PM_{10} events offers a clue to the relative importance of these two explanations. While both windspeed and temperature increased at midday on 8 June, only temperature increased on 4 July. Whereas midday windspeed remained below 1m s^{-1} on 4 July, the midday reduction of PM_{10} occurred during both PM_{10} events. The midday fall of PM_{10} on 4 July is therefore unlikely to be a consequence of turbulent dispersion and is more likely to be related entirely to people not using home heating appliances while at work or during the warmer period of the day.

An alternative explanation could be that the midday reduction of PM_{10} is caused by the onset of unstable atmospheric conditions, driven by convective activity associated with warmer temperatures as the morning progresses. Temperature inversions may have developed during the nocturnal hours of the PM_{10} events. The temperature inversions would trap PM_{10}, which would be released following the onset of unstable conditions and breakdown of the inversion during the morning periods. Unfortunately the instrumentation currently in use at Te Kuiti does not allow for calculation of stability parameters so this hypothesis remains to be tested. In future, a 3-dimensional sonic anemometer may be installed, which may facilitate the calculation of a stability parameter to test this hypothesis.

a)



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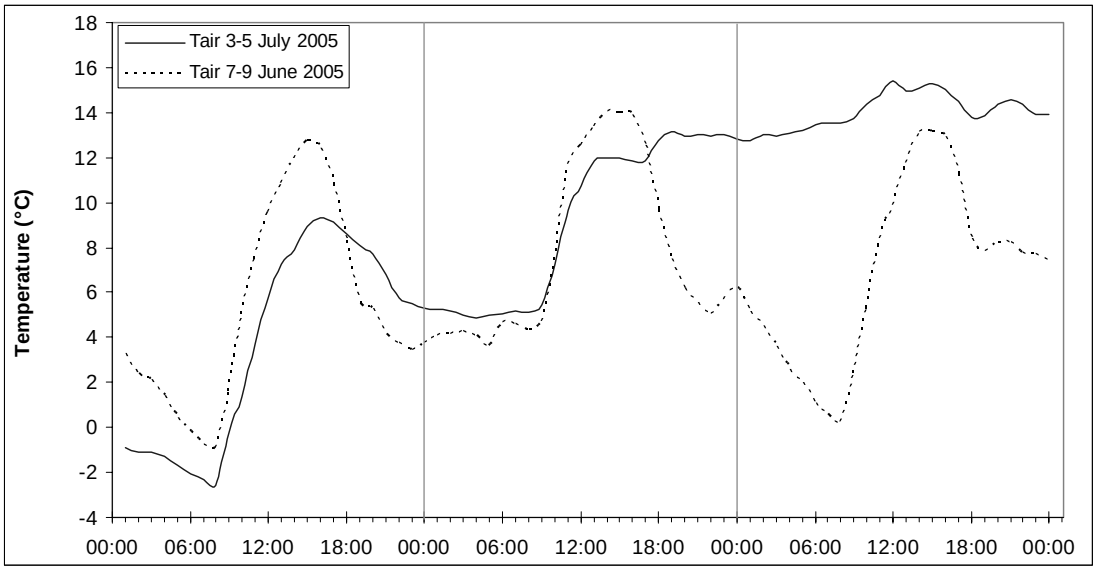

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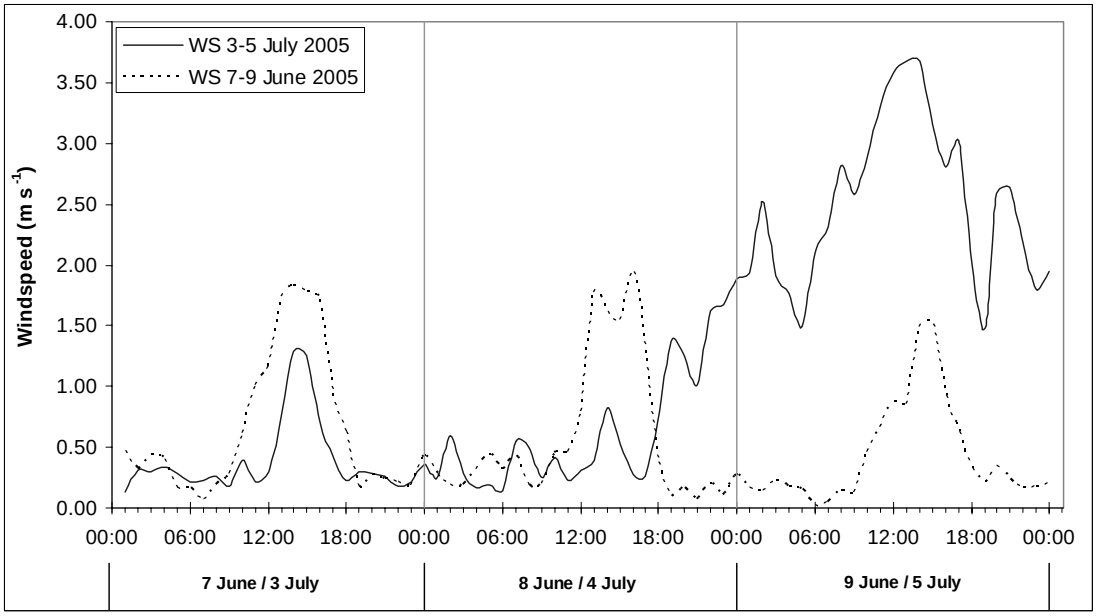


Figure 5-5: Diurnal variation of: a) PM_{10} concentrations (numbers in parentheses are 24hr averages); b) windspeed and; and c) air temperature measured at Te Kuiti for the periods 7-9 June and 3-5 July 2005.

The phenomenon of two PM_{10} peaks occurs during all PM_{10} events and antecedent days in Figure 5-5 when meteorological conditions were generally cool and calm. The June PM_{10} event was also followed by a subsequent day with the twin peak phenomenon. However, sudden onset of warm and windy conditions occurred at around 6pm during the July PM_{10} event and this was accompanied by a rapid and considerable decline in PM_{10} concentrations. Warm winds prevailed throughout the subsequent day, 5 July, and PM_{10} concentrations remained well below the NES threshold of 50µg m^{-3} throughout the entire day. The decrease of PM_{10} concentrations on 5 July 2005 may be a consequence of: 1) less fuel being burnt because of the warmer weather; 2) turbulent dispersion of emissions due to higher windspeed; or 3) a combination of these two phenomena.

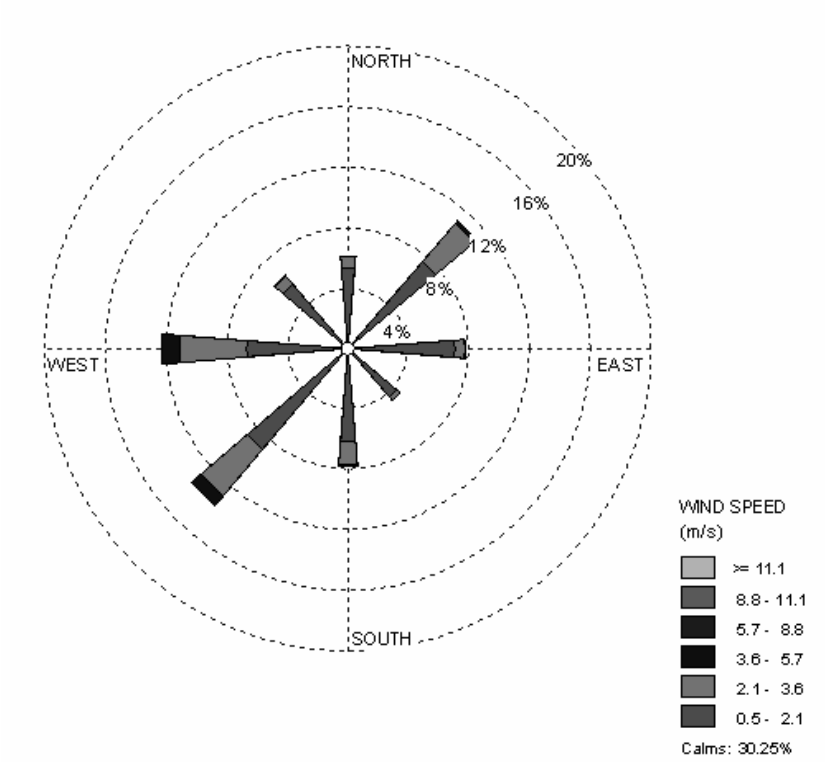
Interannual variation

Five exceedances of the 24 hour guideline for PM_{10} were reported for Te Kuiti during both 2003 and 2004, yet only two exceedances were recorded during 2005 (Table 5-1). Meteorological phenomena are considered here as a possible explanation for the interannual variation of PM_{10} exceedances.

Figure 5-6 summarises wind speed and wind direction for the years 2005 (Figure 5-6a) and 2003–2004 (Figure 5-6b) at Te Kuiti. There are very subtle variations in wind characteristics in 2005 compared to previous years (Figure 5-6), including a slightly higher frequency of winds from the westerly quarter and slightly lower windspeeds in 2005. However, in general the annual (Figure 5-6) and winter (Figure 5-7) summaries of wind characteristics are similar in 2005 to previous years. The percentage of annual and winter calms is similar for 2005 and 2003-04, with 30% and 40% calms during both periods for annual (Figure 5-6) and winter (Figure 5-7) wind roses respectively.

The mean annual air temperature during 2005 was 14.1°C, which is warmer than 13.4°C annual average for the years 2003–2004. The lowest monthly mean air temperatures were recorded in July 2003 and 2004 (Figure 5-8), which corresponds to the months with highest number of exceedances since monitoring began: four exceedances were observed in July 2003 and two in July 2004. In July 2005 only one exceedance was recorded and this may be explained by a 2°C higher mean July air temperature in 2005 compared with the previous two years (Figure 5-8).

(a)



(b)

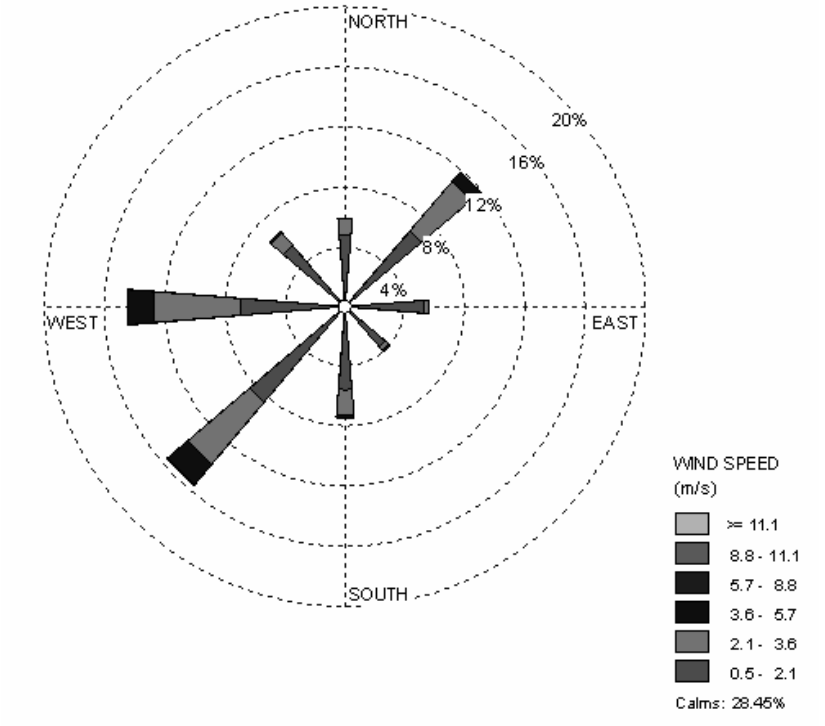
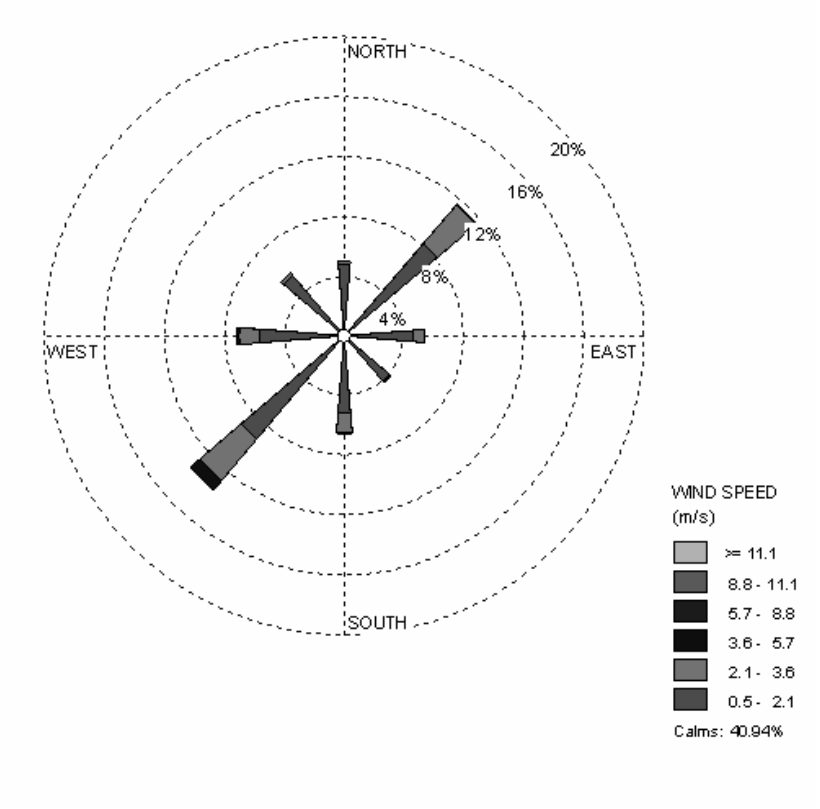


Figure 5-6: Windrose plots for Te Kuiti during: (a) 2005 and (b) 2003– 2004.

(a)



(b)

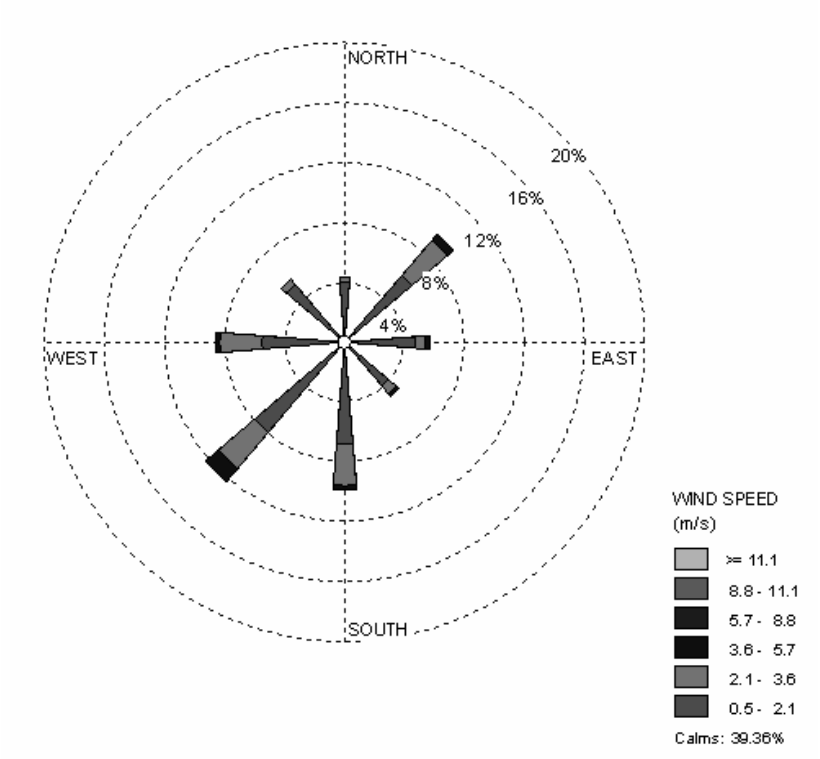


Figure 5-7: Windrose plots for winter months (June–August) at Te Kuiti during: (a) 2005 and (b) 2003– 2004.

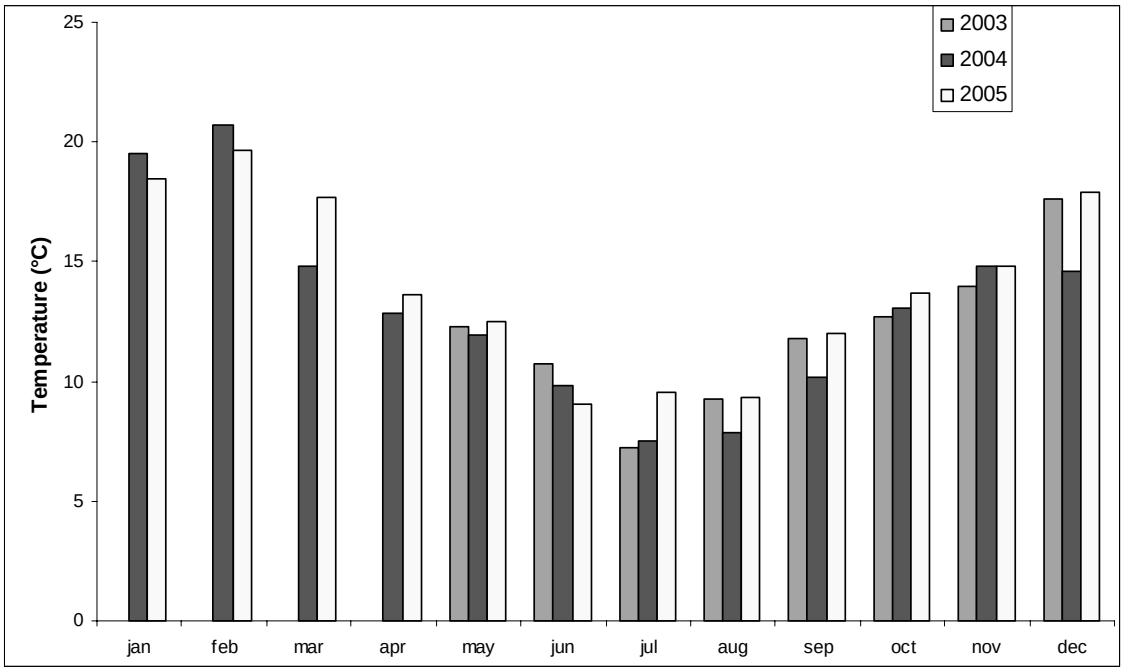


Figure 5-8: Monthly mean air temperatures for 2003, 2004 and 2005 at Te Kuiti.

To further explore the variable number of PM_{10} events observed between years, monthly ensemble averages were constructed for hourly PM_{10} and meteorological data collected during July 2003, 2004 and 2005 (Figure 5-9). Night time PM_{10} concentrations were higher during July 2003 and 2004 than in July 2005 (Figure 5-9c). While the diurnal courses of July ensemble average windspeed are similar for each year (Figure 5-9a), the ensemble average air temperature was very much lower during nocturnal hours for July 2003 and 2004 than during July 2005.

This suggests that the greater number of exceedances observed during July 2003 and 2004, compared with 2005, is unlikely to be related to **turbulent** dispersion phenomena because there is no evidence of greater incidences of nocturnal calm winds during July of the former years. Instead, a more likely explanation is that the cooler night time temperatures during July 2003 and 2004 resulted in increased particulate emissions as a consequence of more fuel being burnt during the colder conditions.

An alternative explanation, as with the diurnal variation, is that the increase in PM_{10} during cooler temperatures may possibly be an artefact. It is possible that fuel use and woodburner operation may not be modified during cooler temperatures and an alternative explanation may be that PM_{10} increase is instead a consequence of retarded **convective** dispersion caused by temperature inversions that can occur during cool, stable conditions. It is not possible to test this hypothesis with the meteorological data currently recorded at Te Kuiti, although this phenomenon may be examined in future investigations.

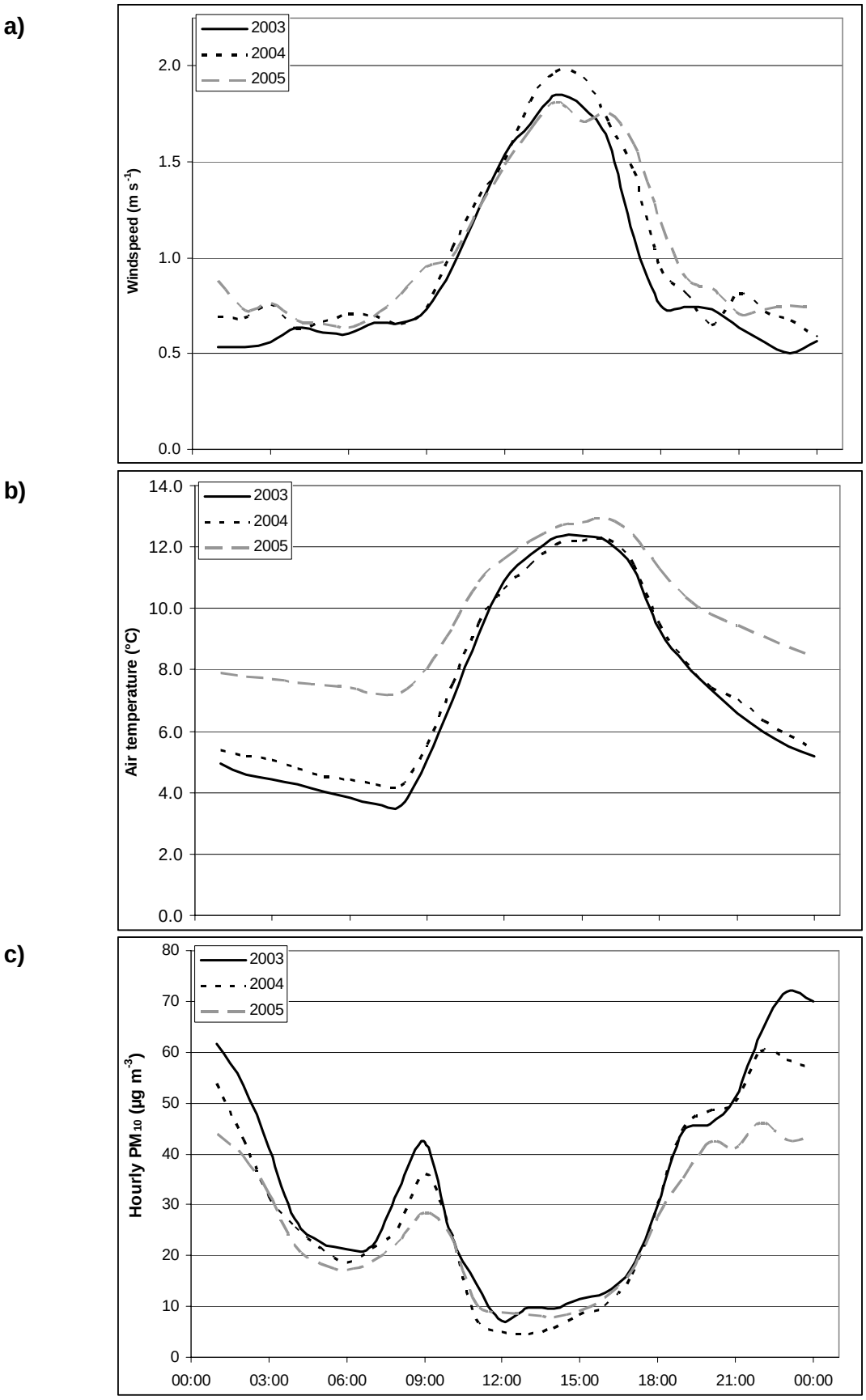


Figure 5-9: Monthly ensemble averages showing diurnal courses of a) windspeed; b) air temperature; and c) PM_{10} concentrations for July 2003, 2004 and 2005 at Te Kuiti.

6 Air quality monitoring in Matamata

Matamata is located approximately 41km East of Hamilton and has a population of 6,078 residents with 2,382 households (based on 2001 census data). Air quality monitoring in Matamata commenced in June 2005 at the Matamata Playcentre grounds on Farmers Road (Figure 6-1). The Farmers Road site is consistent with the "Residential Neighbourhood" site classification as described in *Good Practice Guideline for Air Quality Monitoring and Data Management* (MfE 2000).

The monitoring method used to measure PM_{10} concentrations at Matamata playcentre is a ThermoAndersen FH62C14 BAM. Meteorological data are also collected, including windspeed and direction at 6m height, ambient air temperature and relative humidity. The site was installed by Watercare Services Ltd and is operated and maintained by Environment Waikato staff.

PM_{10} data are continuously measured by the FH62 BAM and logged at ten minute intervals.

Figure 6-1: Location of Matamata playcentre monitoring site.

Figure 6-2: Matamata playcentre monitoring site.

6.1 Concentrations of PM_{10}

During 2005, there were no observations of PM_{10} concentrations in excess of 50µg m^{-3} since monitoring commenced in June 2005 (Figure 6-3). The maximum measured PM_{10} concentration was 36µg m^{-3} (24-hour average) and occurred on 21 July 2005.

Because monitoring did not commence until 20 June 2005, data are only available for six months during 2005. Further analysis and summary statistics of PM_{10} data are therefore unwarranted.

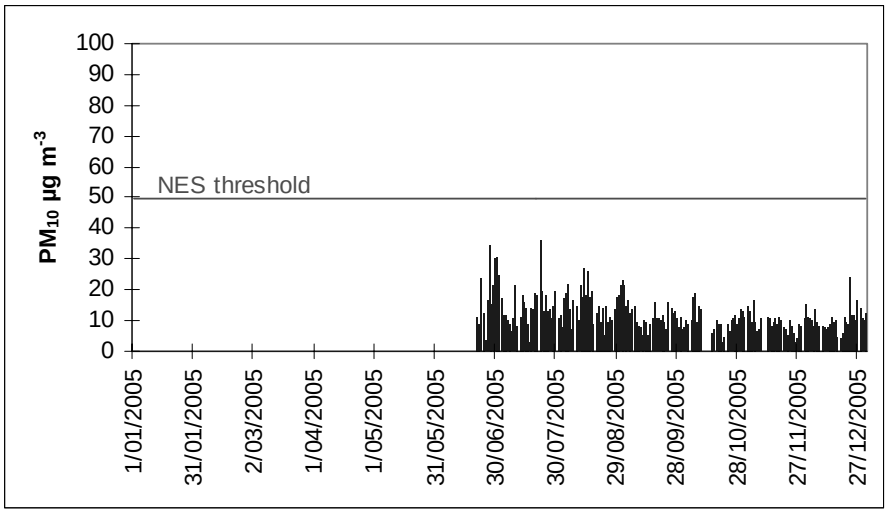


Figure 6-3: 24-hour average concentrations of PM_{10} in Matamata during 2005

6.2 Meteorology

Windroses and ambient air temperature data are presented in Figure 6-4 and Figure 6-5 respectively. No interpretation is made of the meteorological data because only six months' data were available and no PM_{10} exceedances were recorded during this time.

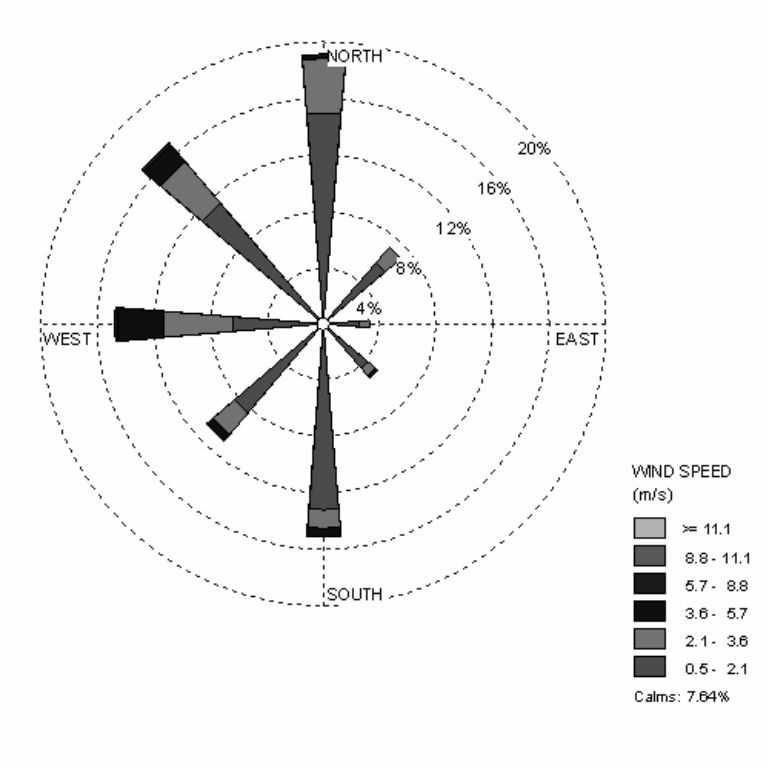


Figure 6-4: Windrose plot for data collected at Matamata 20 June – 31 December 2005.

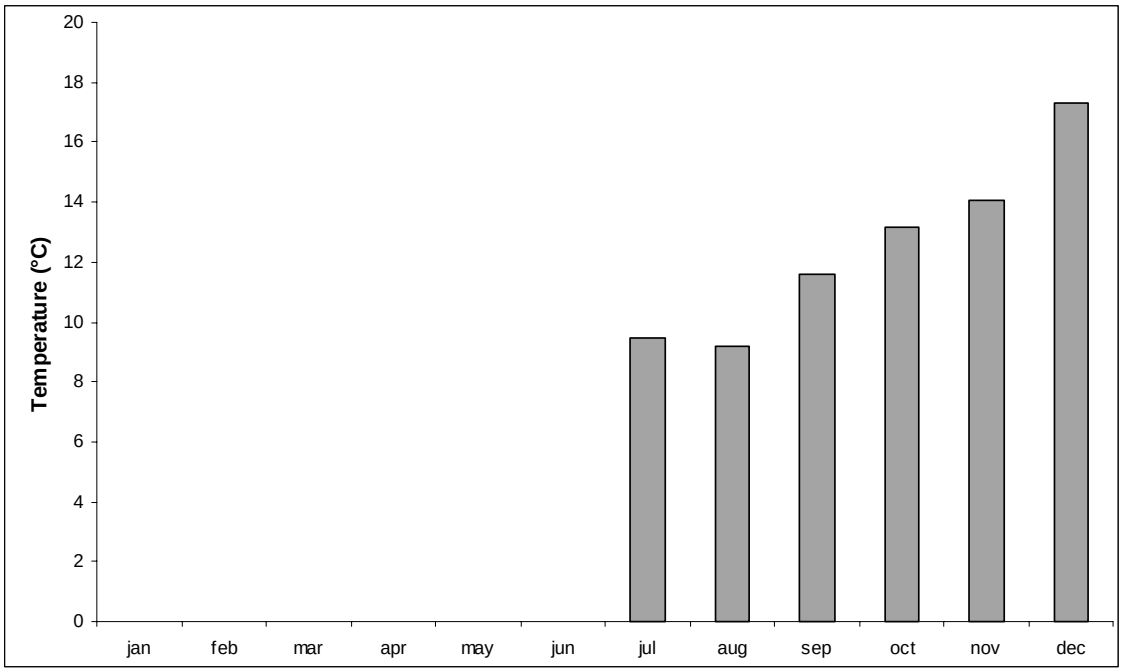


Figure 6-5: Monthly mean air temperatures for 2005 at Matamata.

7 Summary

Ambient air quality monitoring in the Waikato during 2005 was carried out at monitoring sites in Hamilton, Tokoroa, Taupo, Te Kuiti and Matamata. Contaminant monitoring focussed mainly on concentrations of PM_{10}, the main air pollutant of concern in the Waikato, although some passive sampling of benzene was also undertaken at Hamilton sites.

The poorest air quality in the Waikato Region was observed at the Tokoroa site. Concentrations of PM_{10} during 2005 exceeded the ambient air quality guideline of 50 µg m^{-3} on 30 occasions and this would equate to 29 breaches of the NES, had it been effective for the entire year. This is less than the annual maximum number of exceedences of 41, measured during 2004. The maximum PM_{10} concentration measured in Tokoroa during 2005 was 89µg m^{-3} and this, along with two other peaks of similar magnitude, occurred in July. This compares with the maximum 24 hour concentration recorded at Tokoroa of 97µg m^{-3}, measured in 2004.

Unusually elevated concentrations of PM_{10} appear to have been observed at Tokoroa between Dec 2003 – Sept 2005 and this may be a consequence of variations of wind conditions or instrumentation error.

At Taupo, one exceedence of the 50µg m^{-3} guideline for PM_{10} was measured during 2005. Because the sampling regime is limited to monitoring one-day-in-three, extrapolation would suggest around three exceedances for 2005. This is less than the 12 estimated for 2003 and the six exceedances estimated for both 2002 and 2004, although concentrations of PM_{10} in Taupo would have exceeded the NES for PM_{10} in each of these years.

The maximum 24 hour average PM_{10} concentration at Te Kuiti was 54 µg m^{-3} and two exceedances of the 50 µg m^{-3} guideline were recorded in 2005.

No PM_{10} exceedances were recorded at Hamilton during 2005 and the highest PM_{10} concentration was observed during December. However, data were not collected between 15 May – 19 July 2005 and it is entirely possible that the highest PM_{10} concentration occurred, but was undetected, during this period. It is also possible that PM_{10} exceedances may have occurred during the time of instrument failure, but without data this is no more than speculation. Daily comparison of the TEOM data with a gravimetric instrument is recommended during winter 2006

Monitoring of benzene at Hamilton for 12 months in 2004–2005 showed concentrations at sites monitored during the preceding 12 month monitoring period were lower than results from 2003–2004. It is possible that this is an early indication of a declining trend, although the limited monitoring period is too small to be certain of any trends. Benzene concentrations are within the current MfE guidelines, but would exceed the guideline value that will become operative in 2010.

In general, all areas show similar seasonal variations in PM_{10} concentrations, with higher values occurring during the winter months. Interannual trends of PM_{10} concentrations were not apparent at any of the monitoring sites.

A new PM_{10} monitoring site was established at Matamata in June 2005 and while exceedances have not been observed since the monitoring commenced, the dataset is too short to allow for further analysis and interpretation of the data.

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