

# **Air Quality Monitoring 2007 for Hamilton, Tokoroa, Taupo, Te Kuiti, Matamata and Putaruru**

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**Air Quality Monitoring  
2007 for Hamilton,  
Tokoroa, Taupo, Te Kuiti,  
Matamata and Putaruru**

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**Environment Waikato**

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**February 2008**

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## Executive Summary

The main air contaminant of concern in the Waikato Region is PM<sub>10</sub> (particles in the air less than 10 microns in diameter). The Ministry for the Environment introduced a National Environmental Standard (NES) for PM<sub>10</sub> of 50 µg m<sup>-3</sup> (24-hour average) in September 2004. The NES requires air quality monitoring to take place in areas that are likely to exceed the standard for PM<sub>10</sub>. However, one allowable exceedence is permitted each year. Under the NES any subsequent breach of the PM<sub>10</sub> standard must be publicly notified within a month of it occurring.

During 2007, PM<sub>10</sub> monitoring was carried out at Hamilton, Tokoroa, Taupo, Te Kuiti, Matamata and Putaruru. In addition, monitoring of benzene, toluene and xylene was carried out in several locations in Hamilton.

In 2006 Environment Waikato decided to report air quality monitoring results on a yearly basis from 1 September to 31 August each year. This 2007 report continues with the September to August reporting period.

Results from the 2006 and 2007 monitoring period show that concentrations of PM<sub>10</sub> in excess of the NES were measured in Tokoroa, Taupo, Te Kuiti and Putaruru. The highest measurement for the monitoring period was 91 µg m<sup>-3</sup> (24-hour average) and was measured in Tokoroa. The maximum PM<sub>10</sub> concentration of 72 µg m<sup>-3</sup> (24-hour average) measured at Taupo was higher than concentrations recorded in previous years. Te Kuiti recorded a maximum PM<sub>10</sub> concentration of 58 µg m<sup>-3</sup> while Putaruru recorded a maximum PM<sub>10</sub> concentration of 56 µg m<sup>-3</sup> over a 24 hour period. Concentrations of PM<sub>10</sub> in Matamata were within the NES despite the apparent prevalence of meteorological conditions conducive to elevated concentrations. Based on these data, it would seem unlikely that PM<sub>10</sub> concentrations in Matamata would be in breach of the NES in the near future.

Eleven exceedances of the NES for PM<sub>10</sub> were recorded in Tokoroa. Six exceedances were recorded in Taupo, four in Te Kuiti and two exceedances of the NES for PM<sub>10</sub> were recorded in Putaruru.

In addition to the NES, MfE provides guidelines for ambient air quality. An annual guideline of 20 µg m<sup>-3</sup> is provided for PM<sub>10</sub>. The (1 Sept 2006 to 31 Aug 2007) annual average PM<sub>10</sub> concentrations for Hamilton, Tokoroa, Taupo, Te Kuiti, Matamata and Putaruru were 15, 17, 14, 17, 12 and 16 µg m<sup>-3</sup> respectively.

Air quality monitoring of benzene, toluene and xylene was carried out at a number of monitoring sites in Hamilton. The results suggest a decrease in benzene concentrations in Hamilton with 2007 concentrations all less than the 2010 guideline for benzene of 3.6 µg m<sup>-3</sup> (annual average). Concentrations of toluene and xylene were well within acceptable levels.

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## 1 Introduction

The main air contaminant of concern in the Waikato Region is PM<sub>10</sub> (particles in the air less than 10 microns in diameter). Historically, concentrations of PM<sub>10</sub> have exceeded national environmental standards (NES) in Hamilton, Tokoroa, Taupo and Te Kuiti during the winter months.

During 2007, concentrations of PM<sub>10</sub> were measured at six sites in the Waikato Region. These were Hamilton, Tokoroa, Taupo, Te Kuiti, Matamata and Putaruru.

National Environmental Standards for ambient air quality (Table 1.1) were introduced in September 2004 (MfE, 2004). Based on air quality monitoring in other urban areas of New Zealand it would seem unlikely that concentrations of NES contaminants other than PM<sub>10</sub> would be in breach. Consequently most of the resources for air quality monitoring in the Waikato Region have focused on PM<sub>10</sub>. The NES includes specifications for monitoring PM<sub>10</sub> in areas where breaches are likely.

In addition to the NES, MfE provides guidelines for ambient air quality (Table 1.2) and air quality indicator categories to assist in the presentation and management of air quality in New Zealand (Table 1.3). Air quality monitoring data in this report are presented relative to air quality guidelines and these indicator categories. These categories provide a useful perspective on the overall quality of the air and provide a valuable tool for evaluating trends in concentrations over time.

Previous air quality monitoring in the Waikato Region includes monitoring of PM<sub>10</sub> at Hamilton, Tokoroa, Taupo, Te Kuiti, and Matamata. Passive sampling for benzene has been carried out since 2003 in Hamilton. Monitoring for arsenic and PAHs was also carried out during 2007 in Hamilton but will be reported separately at the conclusion of the monitoring period.

Table 1.1: National Environmental Standards for ambient air quality (MfE, 2004)

Contaminant	NES values		
	Concentration <sup>a</sup>	Averaging Period	Allowable exceedences per year
Carbon monoxide	10 mg m <sup>-3</sup>	8-hour	1
Particles (PM <sub>10</sub> )	50 µg m <sup>-3</sup>	24-hour	1
Nitrogen dioxide	200 µg m <sup>-3</sup>	1-hour	9
Sulphur dioxide <sup>b</sup>	350 µg m <sup>-3</sup>	1-hour	9
Sulphur dioxide <sup>b</sup>	570 µg m <sup>-3</sup>	1-hour	0
Ozone	150 µg m <sup>-3</sup>	1-hour	0

Table 1.2: Ambient air quality guidelines for New Zealand (MfE 2002)

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

Notes for Tables 1.1 and 1.2:

<sup>a</sup> All values apply to the gas measured at standard conditions of temperature (0° C) and pressure (1 atmosphere).

<sup>b</sup> The sulphur dioxide guideline values do not apply to sulphur acid mist.

<sup>c</sup> The hydrogen sulphide value is based on odour nuisance and may be unsuitable for use in geothermal areas.

<sup>d</sup> 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: Environmental Performance Indicator categories for air quality (MfE, 2002)

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

Although these Ministry for the Environment categories are primarily used as air quality indicators, at local government level the Waikato Regional Plan (WRP) takes a further regulatory step by specifying designated policy responses that should correspond to each zone. Under Section 6.1.3 of the WRP, air quality in the “Excellent” category is to be protected, while “Good” air quality is to be maintained or protected. “Acceptable” air quality is to be maintained. Air quality in the “Alert” category is to be maintained or enhanced. For air quality in the “Action” category, the only designated policy response is to aim to enhance (improve) the situation.

## 1.1 Reporting period

This 2007 Annual Air Quality Monitoring Report uses the same reporting period as the *‘Environment Waikato 2006 Air Quality Monitoring Report’* (Smith 2006). The 2006 report uses a 12 month reporting period from the 1 September. The monitoring period used in this report is from 1 September 2006 to 31 August 2007.

The new reporting period was introduced in 2006 by Environment Waikato for a number of reasons including ensuring that results are reported as soon as possible after the peak winter PM<sub>10</sub> concentrations as well as ensuring compliance with the reporting requirements under the NES.

## 2 Methodology

The method used to monitor PM<sub>10</sub> concentrations can have some impact on the results obtained. In 2007 a number of sites had gravimetric reference method samplers run in conjunction with the historical methods. Results were used to determine site specific differences between methods. Where these comparisons were made, results for the September 2006 to August 2007 period were adjusted for gravimetric equivalence by Environment Waikato staff. Data prior to this monitoring period were not adjusted.

During 2007 PM<sub>10</sub> concentrations at Peachgrove Road in Hamilton were monitored using a Tapered Elemental Oscillation Microbalance (TEOM) with a sample temperature setting of 40 degrees centigrade. Additional gravimetric sampling was carried out at this site using a sequential partisol sampler from November 2006. TEOM data from 1 September 2007 were adjusted using equation 2.1.

$$\text{Hamilton - logTEOM} = (\text{logGrav} + 0.270) / 1.194 \quad \text{Equation 2.1}$$

Since September 2005 the method of monitoring used at the Tokoroa site was a ThermoAndersen FH62 C14 BAM. A sequential partisol gravimetric sampler was co located at this site since May 2007. Equation 2.2 shows the adjustments made to the FH62 data from 1 September 2007 for consistency with the gravimetric method.

$$\text{Tokoroa - logFH62BAM} = (\text{logGrav} + 0.050) / 1.092 \quad \text{Equation 2.2}$$

In Taupo, gravimetric sampling was conducted at the Gillies Street site from March 2007. Concentrations of PM<sub>10</sub> measured using the BAM from March 2007 were adjusted based equation 2.3. From September 2006 to March 2007 PM<sub>10</sub> data for Taupo was collected at the Primary School site and are not able to be adjusted because no gravimetric data are available for that site.

$$\text{Taupo - FH62BAM} = (\text{Grav} + 1.843) / 1.414 \quad \text{Equation 2.3}$$

Concentrations of PM<sub>10</sub> at Te Kuiti, Matamata and Putaruru site were measured using an ESM (Andersen) FH 62 C14 Beta Attenuation Monitor (BAM). No comparison between the BAM and gravimetric methods has been carried out at these sites.

In Hamilton passive sampling for the volatile organic compounds (VOCs) benzene, ethyl-benzene, toluene and xylenes (BTEX) was carried out using 3M Passive Diffusion Monitors for the 12 month period 1 September 2006 – 31 August 2007.

Hourly average meteorological data, including temperature, wind speed and wind direction were obtained from each monitoring site in the Waikato Region, except for the Putaruru site. Meteorological data were compared with PM<sub>10</sub> on days when pollution was elevated.

Most sites in the Waikato air quality monitoring network have been managed by Environment Waikato staff since August 2005. Prior to that the monitoring network was operated and maintained by NIWA. The Partisol Model 2000 PM<sub>10</sub> sampler at the Taupo site is operated by the Institute of Geological and Nuclear Sciences (GNS) on behalf of Environment Waikato.

Hourly data from the BAM monitors are recorded by the instrument and logged by an iQuest iRIS 320 datalogger. Results are telemetered hourly to Environment Waikato and stored in the hydrotel database.

## 3 Hamilton

### 3.1 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, ethyl-benzene, toluene and xylenes (BTEX). The Peachgrove Road site is located on the south-east side of Hamilton City. During 2007, PM<sub>10</sub> and BTEX were measured at Peachgrove Road. The site meets the requirements of the “Residential Peak” site classification as described in *Good Practice Guideline for Air Quality Monitoring and Data Management* (MfE, 2000). The location of the air quality monitoring network in Hamilton is shown Figure 3.1.

During 2007, PM<sub>10</sub> monitoring at Peachgrove Road was carried out using a Tapered Elemental Oscillating Microbalance (TEOM) with a sample temperature setting of 40°C. The PM<sub>10</sub> data were collected at the Peachgrove Road site as ten minute averages and subsequent concentration of hourly averages were made from these data. Daily averages of PM<sub>10</sub> data were available for all days for 2007, compared with 99% of days for 2006.

Passive sampling for the volatile organic compounds (VOCs) benzene, ethyl-benzene, toluene and xylenes was carried out using 3M Passive Diffusion Monitors at the three established Hamilton BTEX sites over the 12 month period 1 September 2006 – 31 August 2007. 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 Hill Laboratories 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).

On request of the elected Waikato Regional Council, three additional passive monitoring BTEX sites were added in Hamilton (making a total of six) from December 2006. These new stations are located in Tristram Street, Greenwood Street, and outside Hamilton Intermediate School (Peachgrove Road). For these sites, 12 months of data for the reporting period ending 31 August 2007 is not available. However, benzene results from the new sites for the 12 month period ending December 2007 are provided in Figure 3.5.

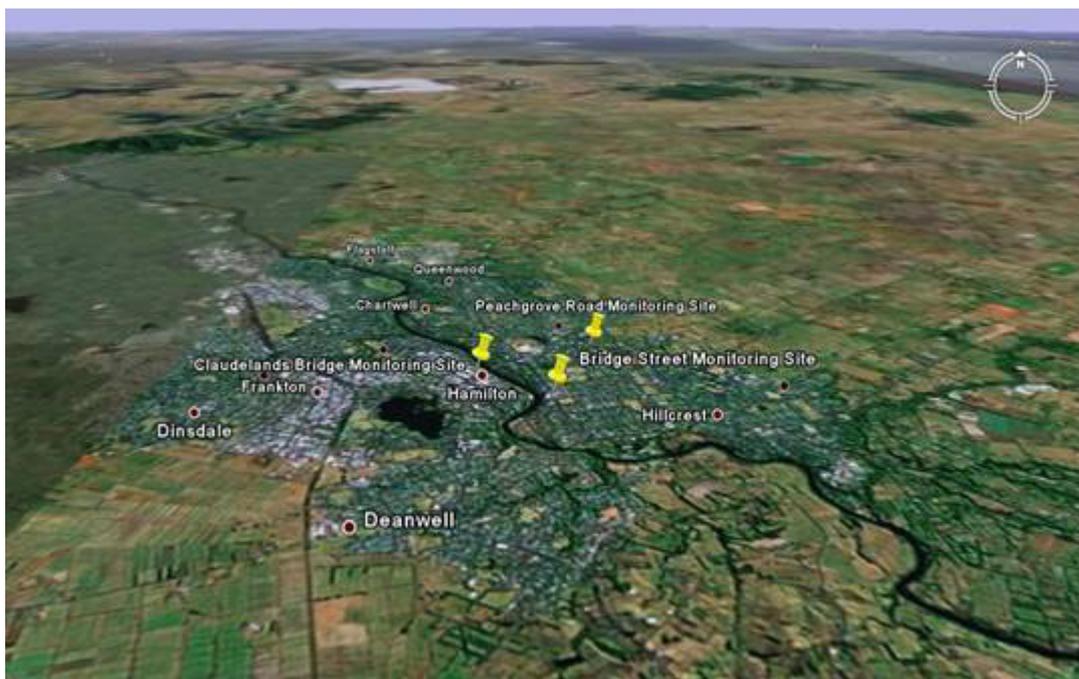


Figure 3.1: Hamilton air quality monitoring sites (Source: Google Earth 2008)

### 3.2 PM<sub>10</sub> Concentrations for Hamilton

No exceedences of the air quality guideline and the NES for PM<sub>10</sub> (50  $\mu\text{g m}^{-3}$ , 24-hour average) were recorded in Hamilton during 2007. Figure 3.2 shows the 24 hour average PM<sub>10</sub> concentrations measured at Hamilton during 2007. The highest measured PM<sub>10</sub> concentration was 46  $\mu\text{g m}^{-3}$ . This compares with the 2006 highest 24 hour average PM<sub>10</sub> concentration of 66  $\mu\text{g m}^{-3}$ .

The NES allow one exceedence of 50  $\mu\text{g m}^{-3}$  (24-hour average) per year and requires any subsequent breach to be publicly notified within a month of it occurring. In 2006 there were two exceedences of the NES and Environment Waikato notified one exceedence. No breaches were notified for Hamilton during 2007.

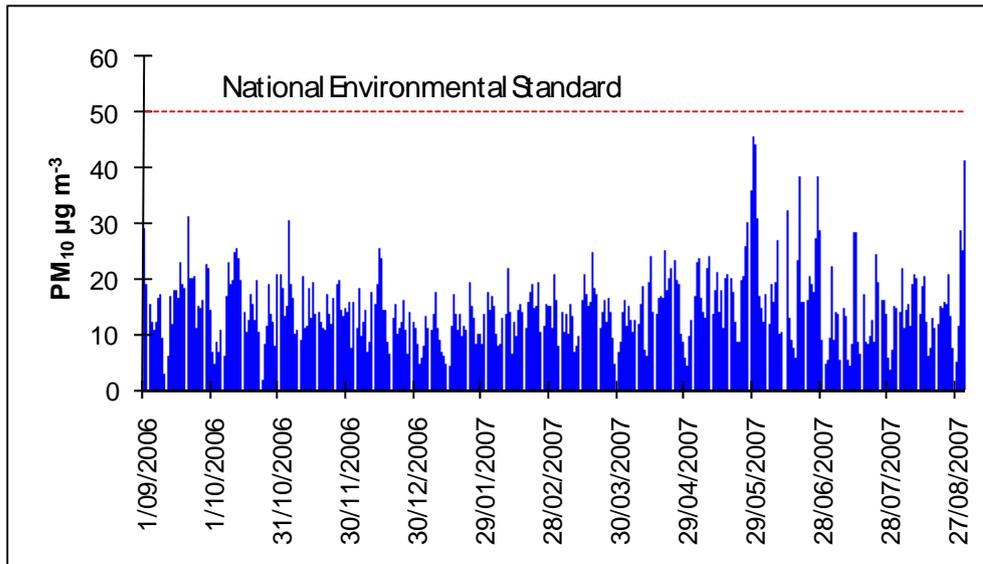


Figure 3.2: 24-hour average PM<sub>10</sub> concentrations measured at Peachgrove Road during 2007

Figure 3.3 compares daily PM<sub>10</sub> concentrations measured from 2000 to 2007 to the MfE air quality indicator categories (shown in Table 1.3). The majority of the PM<sub>10</sub> concentrations measured were less than 66% of the air quality guideline, within the “acceptable” and “good” air quality categories. The proportion of PM<sub>10</sub> concentrations in the alert or action categories for 2007 is similar to previous years at less than 5% of days. Seasonal variations in the distribution of PM<sub>10</sub> concentrations for 2007 are shown in Figure 3.4.

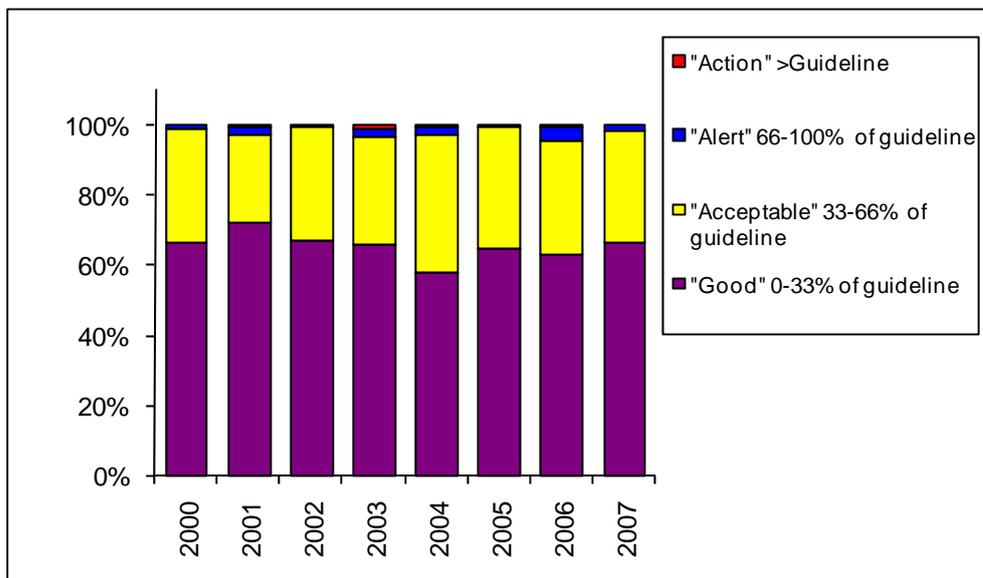


Figure 3.3: Comparison of PM<sub>10</sub> concentrations measured at Peachgrove Road in Hamilton from 2000 to 2007 to MfE air quality indicator categories

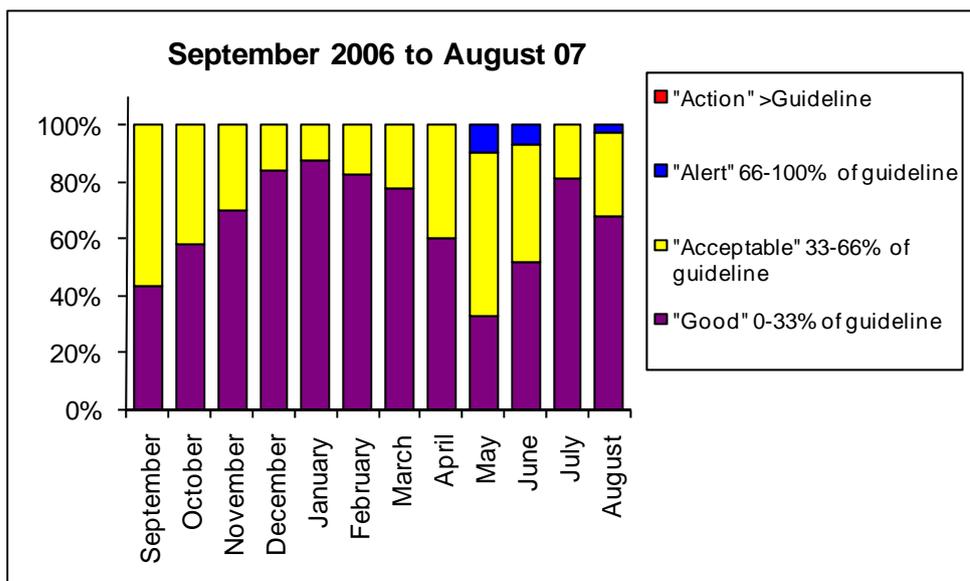


Figure 3.4: Comparison of daily PM<sub>10</sub> concentrations each month from September 2006 to August 2007 to MfE air quality indicator categories

The annual average PM<sub>10</sub> concentration for Hamilton for 2007 was 15 µg m<sup>-3</sup>. This compares with previous maximums of 15 to 17 µg m<sup>-3</sup>. MfE specifies an annual average guideline for PM<sub>10</sub> of 20 µg m<sup>-3</sup>. The NES does not include an annual average concentration for PM<sub>10</sub>.

Table 3.1 shows summary statistics for PM<sub>10</sub> monitoring results from the Hamilton site since monitoring commenced in 1998 based on a September to August monitoring period.

Table 3.1: Summary of PM<sub>10</sub> concentrations measured at Peachgrove Road in Hamilton from 2000- 2007

	2000	2001	2002	2003	2004	2005	2006	2007
"Good" 0-33% of guideline	67%	72%	67%	66%	58%	65%	63%	66%
"Acceptable" 33-66% of guideline	32%	25%	32%	31%	39%	35%	33%	32%
"Alert" 66-100% of guideline	1%	2%	1%	3%	3%	0%	4%	2%
"Action" >Guideline	0%	1%	0%	1%	0%	0%	1%	0%
Percentage of valid data	61%	68%	92%	91%	95%	76%	99%	100%
Annual average ( $\mu\text{g m}^{-3}$ )	15	15	15	16	17	15	16	15
Measured exceedences		2	0	3	1	0	2	0
Guideline exceedences (extrapolated)	0	3	0	3	1	0	2	0
Annual maximum (24-hr average $\mu\text{g m}^{-3}$ )	43	67	36	62	55	33	66	46
Number of records	222	250	336	333	347	276	363	364

### 3.3 Concentrations of Benzene, Toluene and Xylenes

Monitoring of benzene commenced in Hamilton in 2003 at the Peachgrove Road air monitoring site and at a high-density traffic area at Bridge Street. An additional benzene sampling site was established in 2004 at the intersection of Claudelands Road and Victoria St (Claudelands Bridge). This is also a high density traffic area. Three additional sites were established in 2006 in Tristram Street, Greenwood Street and at Hamilton Intermediate School.

Benzene concentrations in Hamilton are within the Ministry for the Environment's current guideline for benzene of  $10 \mu\text{g m}^{-3}$  per year (Table 3.2) and met the 2010 annual guideline of  $3.6 \mu\text{g m}^{-3}$ . The highest average annual concentration was  $3.5 \mu\text{g m}^{-3}$  and was measured at the Greenwood Street monitoring site.

Results for 2006/2007 show that benzene concentrations have continued to decline since monitoring commenced in 2003 (Figure 3.5). This is in line with previous predictions (Smith, 2006) that suggest changes in fuel specifications and improved vehicle technology may result in a decrease in benzene from motor vehicles.

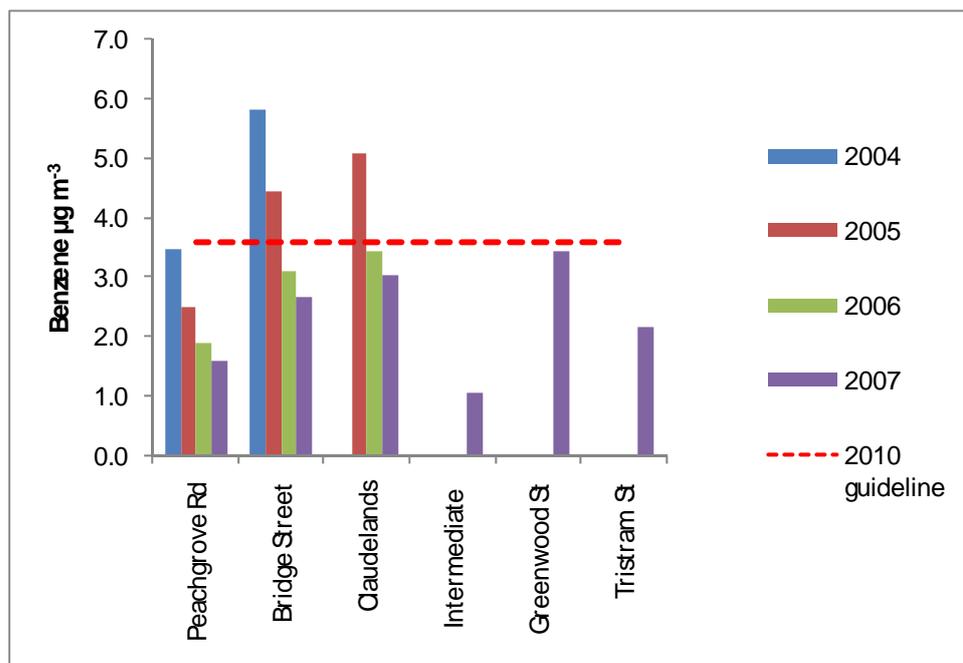


Figure 3.5: Annual average benzene measured at Hamilton sites for periods Feb 2003 – Feb 2004, July 2004 – July 2005, Sept 2005 – Sept 2006 and Dec 2006 – Dec 2007

Toluene and xylene were also measured at the benzene monitoring sites for each year. An MfE document discussing amendments to the 1994 ambient air quality guidelines suggests an annual threshold of  $190 \mu\text{g m}^{-3}$  and  $950 \mu\text{g m}^{-3}$  for toluene and total xylenes respectively (MfE 2000). Concentrations of benzene and xylene measured in Hamilton at all sites were significantly lower than the thresholds suggested by MfE (2000).

Table 3.2: Annual average concentrations of volatile organic compounds (VOCs) at Hamilton sites between December 2006 – December 2007. All figures are in units of  $\mu\text{g m}^{-3}$ .

	Bridge St	Peachgrove Road	Claudlands	Intermediate	Greenwood Street	Tristram Street	Guideline <sup>a</sup>
Benzene	2.7	1.6	3.0	1.1	3.5	2.2	3.6 (10 <sup>a</sup> )
Toluene	11.4	7.1	13.2	4.7	17.5	10.3	190 <sup>b</sup>
Total Xylenes	9.7	5.5	10.6	3.9	11.5	8.0	950 <sup>b</sup>

<sup>a</sup> The current guideline for benzene of  $10 \mu\text{g m}^{-3}$  will reduce to  $3.6 \mu\text{g m}^{-3}$  in 2010.

<sup>b</sup> There are currently no guideline values for toluene and xylenes. Threshold values used here are from proposed amendments to the 1994 ambient air quality guidelines.

### 3.4 Meteorology in Hamilton

Variations in meteorological conditions and hourly average  $\text{PM}_{10}$  concentrations on the six days when the 24-hour average  $\text{PM}_{10}$  measured in Hamilton using the TEOM concentration exceeded  $66 \mu\text{g m}^{-3}$  (MfE “acceptable” air quality) are shown in Figure 3.6.

The six days included three consecutive days from 28 to 30 May, 19 and 27 June and 31 August. The corresponding  $\text{PM}_{10}$  concentrations (24-hour average) were 36, 46, 44, 38, 38 and  $41 \mu\text{g m}^{-3}$ .

On most of these days, two peaks in  $\text{PM}_{10}$  concentrations were observed, one during the evening, and the second occurring in the morning around 9am. This is fairly typical of diurnal profiles for elevated  $\text{PM}_{10}$  concentrations in urban areas of New Zealand, although in many areas, the evening peak is higher relative to the morning peak than what is observed for Hamilton. Higher concentrations occur at these times under low wind speeds. Daily variations in concentrations were less apparent on 31 August when concentrations were elevated throughout the day.

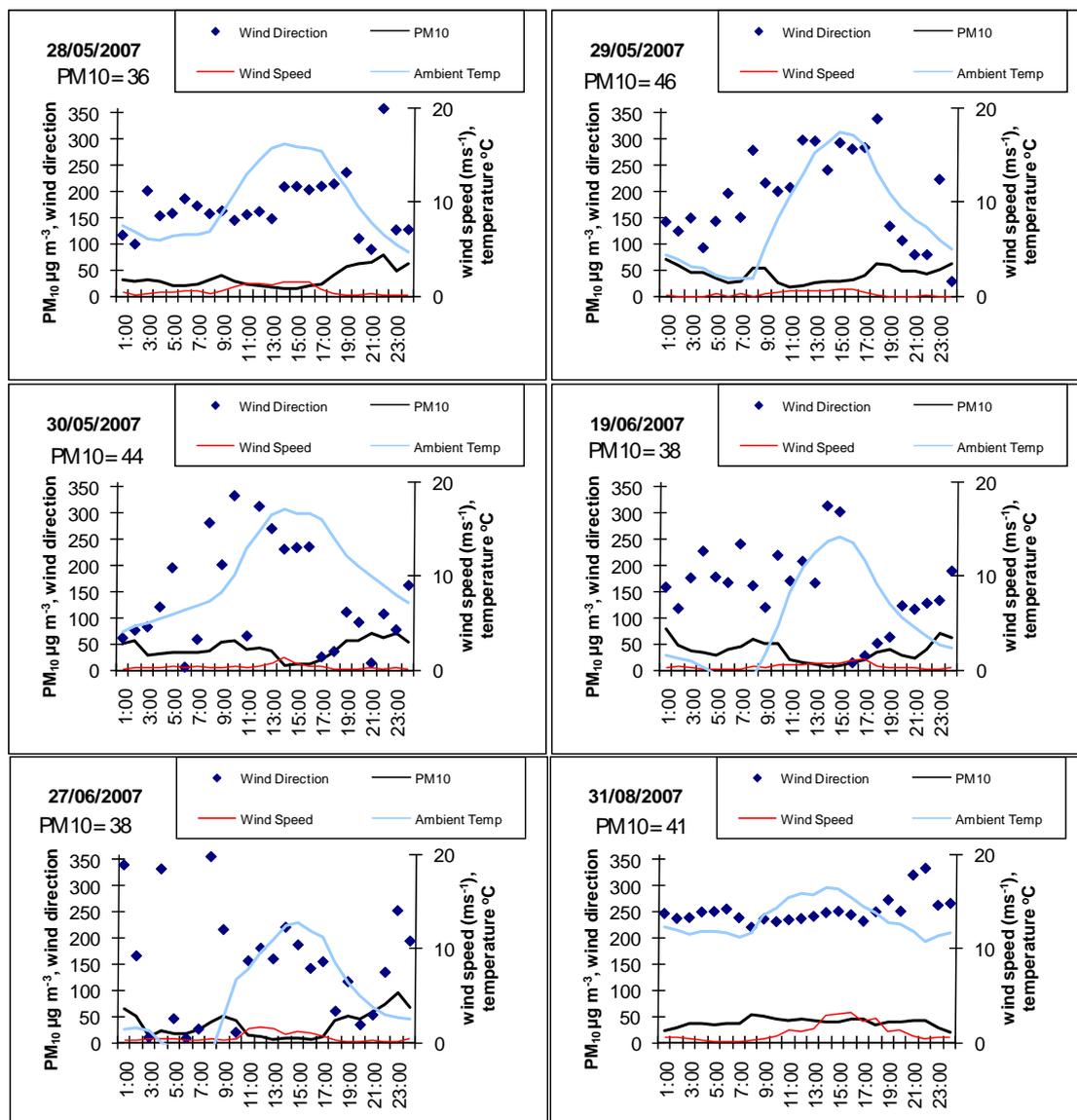


Figure 3.6: Hourly average PM<sub>10</sub>, wind speed, wind direction and temperature on days when PM<sub>10</sub> concentrations exceeded the 66% of the NES at the Peachgrove Road site

Hourly wind direction and wind speed, measured at Peachgrove Road, are shown in Figure 3.7 for the months May to August 2007. Results suggest a greater frequency of westerly winds and higher wind speeds during August than for the preceding months. Southerly winds were most predominant during mid June and mid July.

Wind speeds were lowest during May with only a small proportion of days recording speeds greater than 2 ms<sup>-1</sup>. The most consistent period of low wind speed was from 28 to 31 May (wind less than 1.5 ms<sup>-1</sup>).

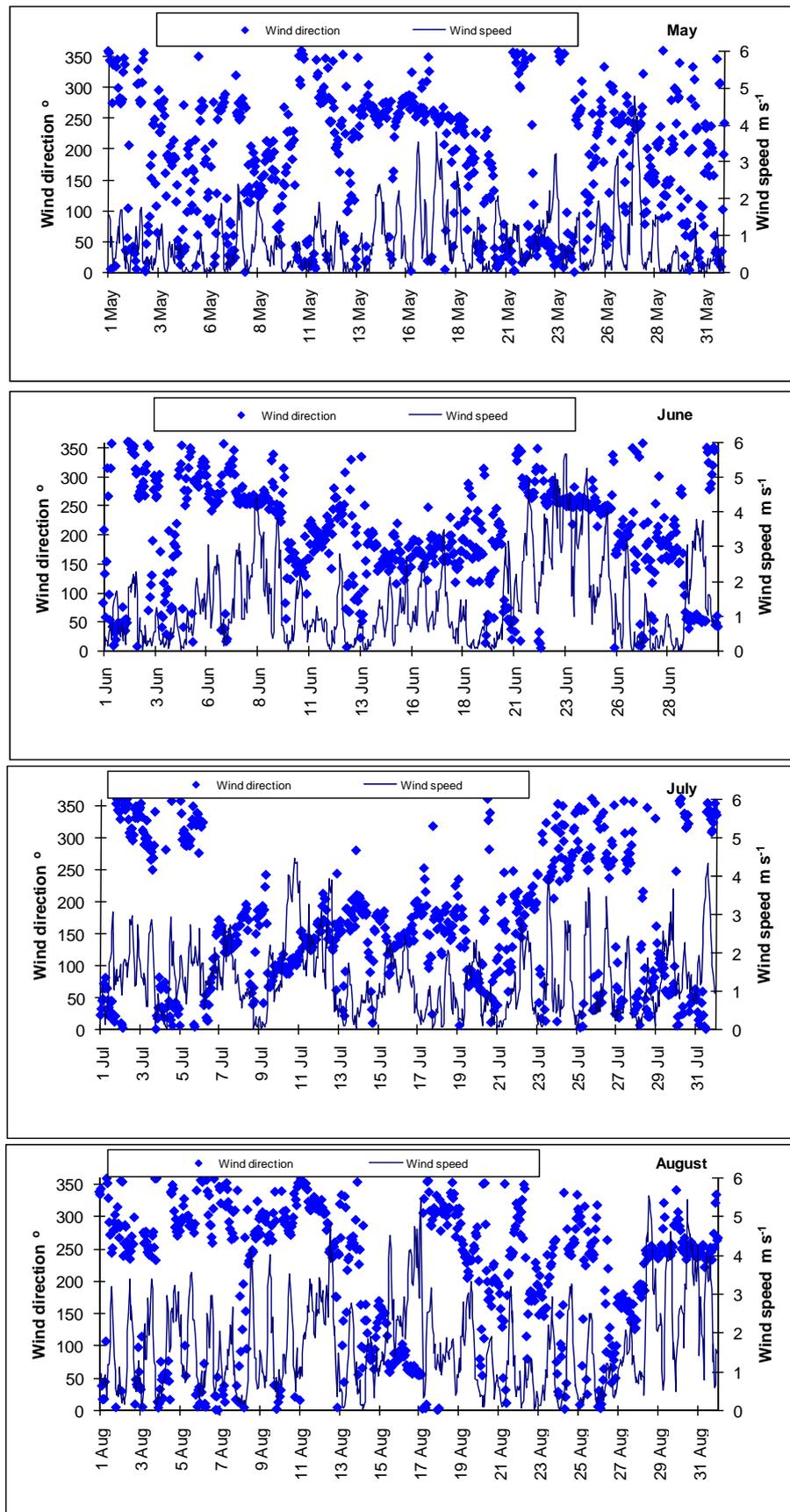


Figure 3.7: Hourly average wind speed and wind direction at the Peachgrove Road site for May to August 2007

## 4 Tokoroa

### 4.1 Air Quality Monitoring in Tokoroa

Air quality monitoring for PM<sub>10</sub> has been carried out in Tokoroa since 2001 at the Billah Street Reserve air quality monitoring site. This site is located west of central Tokoroa. 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 meets the requirements of the “Residential Neighbourhood” site classification as described in *Good Practice Guideline for Air Quality Monitoring and Data Management* (MfE, 2000).

From 2001 to September 2005, the monitoring method used to measure PM<sub>10</sub> concentrations at Billah Street was a MET ONE series 1020 Beta Attenuation Monitor (BAM). From September 2005 the monitoring method was a ThermoAndersen FH62 C14 BAM. The MET ONE instrument was replaced because of unacceptable data loss caused by frequent tape failure. PM<sub>10</sub> data were collected by the FH62 BAM at ten minute intervals. The location of the air quality monitor in Tokoroa is shown in Figure 4.1.

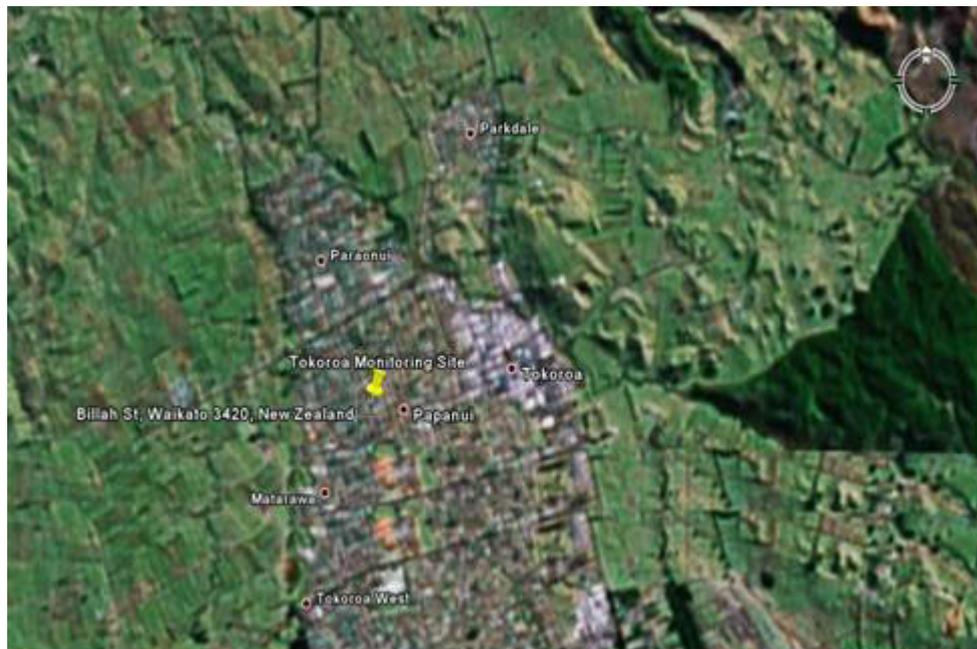


Figure 4.1: Tokoroa air quality monitoring site (Source: Google Earth 2008)

### 4.2 PM<sub>10</sub> concentrations in Tokoroa

Daily average PM<sub>10</sub> concentrations measured at the Tokoroa site from September 2006 to August 2007 are shown in Figure 4.2. Concentrations in excess of the NES occurred on 11 occasions during the months May to August. The maximum PM<sub>10</sub>

concentrations was  $91 \mu\text{g m}^{-3}$  and was recorded on 29 May. The maximum measured  $\text{PM}_{10}$  concentrations at the Tokoroa site during 2006 was  $62 \mu\text{g m}^{-3}$ .

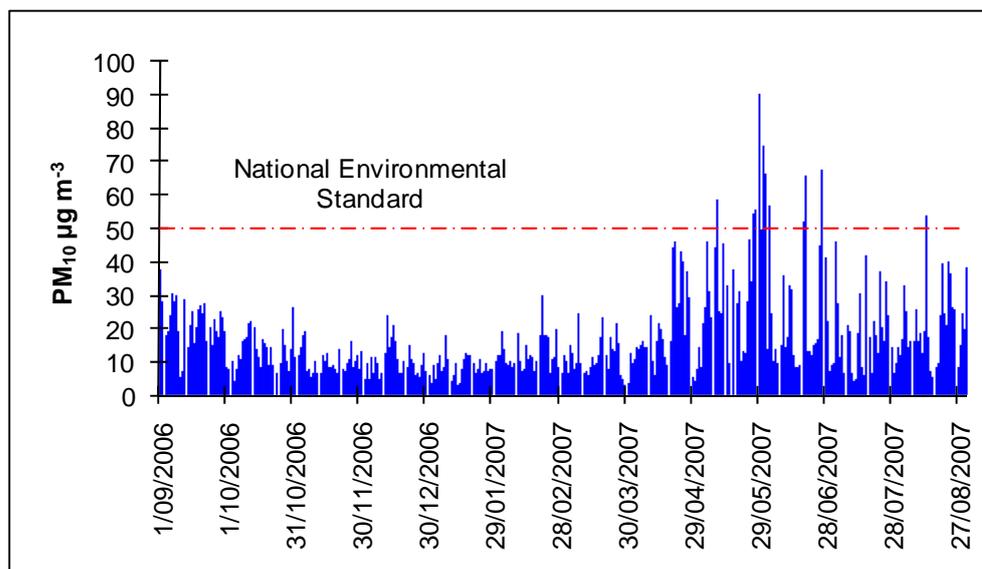


Figure 4.2: Daily winter  $\text{PM}_{10}$  concentrations measured in Tokoroa during 2007

Changes in  $\text{PM}_{10}$  concentrations relative to air quality indicator categories at the Tokoroa site in 2006 and 2007 are shown in Figure 4.3. In the case of Tokoroa, the Met One Beta-Attenuation Monitor (BAM) was changed to an FH 62 instrument in September 2005, and a change in baseline readings was observed at that point (Smith, 2006). During 2007, site-specific calibration against a gravimetric method was carried out. Comparison of results from the two co-located instruments now suggest that:

- The previous BAM was recording an artificially high baseline reading, because the new instrument is accurate (compared to the gravimetric standard method) at low  $\text{PM}_{10}$  concentrations, and
- The new BAM requires a significant upward correction across the mid and upper ranges, in the order of approximately 24% at a  $\text{PM}_{10}$  concentration of  $50 \mu\text{g m}^{-3}$ . Although site-specific calibration data is only available for the newer instrument, it is also likely that the older BAM would have required a similar range correction to bring its results into line with gravimetric results in Tokoroa (pers comm., Nick Kim, Environment Waikato 2008).

The net result of these two corrections for all data collected in Tokoroa prior to September 2005 would be to reduce the annual average, but increase the peaks (and the non-compliance frequency).

In this (annual) report the approach taken has been to report only calibration-corrected data collected on the newer FH 62 BAM during the monitoring years 2006 and 2007. Retrospective estimates of air quality in Tokoroa from 2001-2005 may form a part of future work involving analysis of trends.

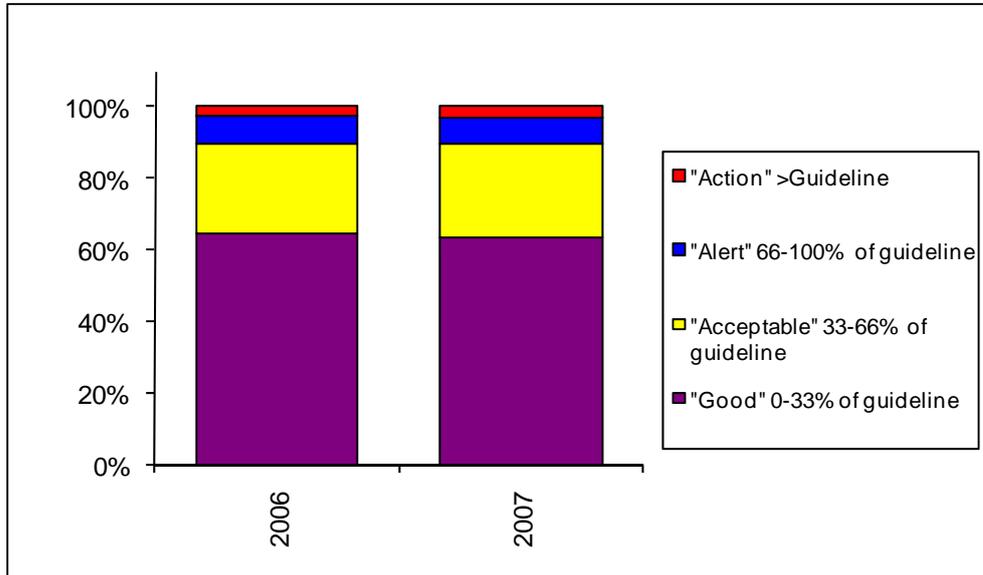


Figure 4.3: Comparison of PM<sub>10</sub> concentrations measured in Tokoroa from 2006 to 2007 to MfE air quality indicator categories

Seasonal variations in the distribution of PM<sub>10</sub> concentrations for 2007 are shown in Figure 4.4.

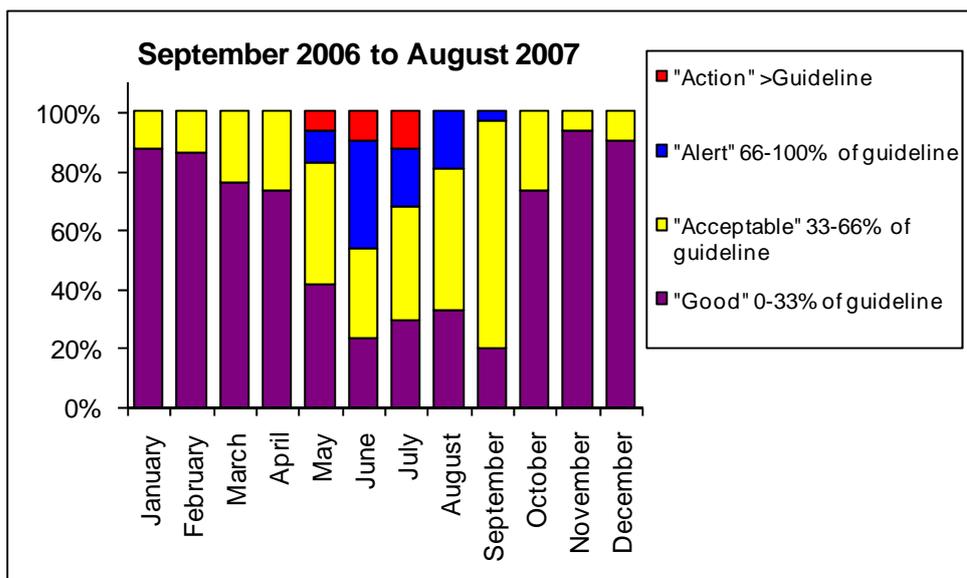


Figure 4.4: Comparison of daily PM<sub>10</sub> concentrations each month during September 2006 to August 2007 to MfE air quality indicator categories

The estimated annual average PM<sub>10</sub> concentration for Tokoroa for 2007 is 17 µg m<sup>-3</sup>. This is similar to the 2006 annual average but lower than for previous years. Summary statistics for PM<sub>10</sub> monitoring results are shown in Table 4.1.

Table 4.1: Summary of PM<sub>10</sub> concentrations measured at the Tokoroa monitoring site for the year ending 31 August 2006 to 2007.

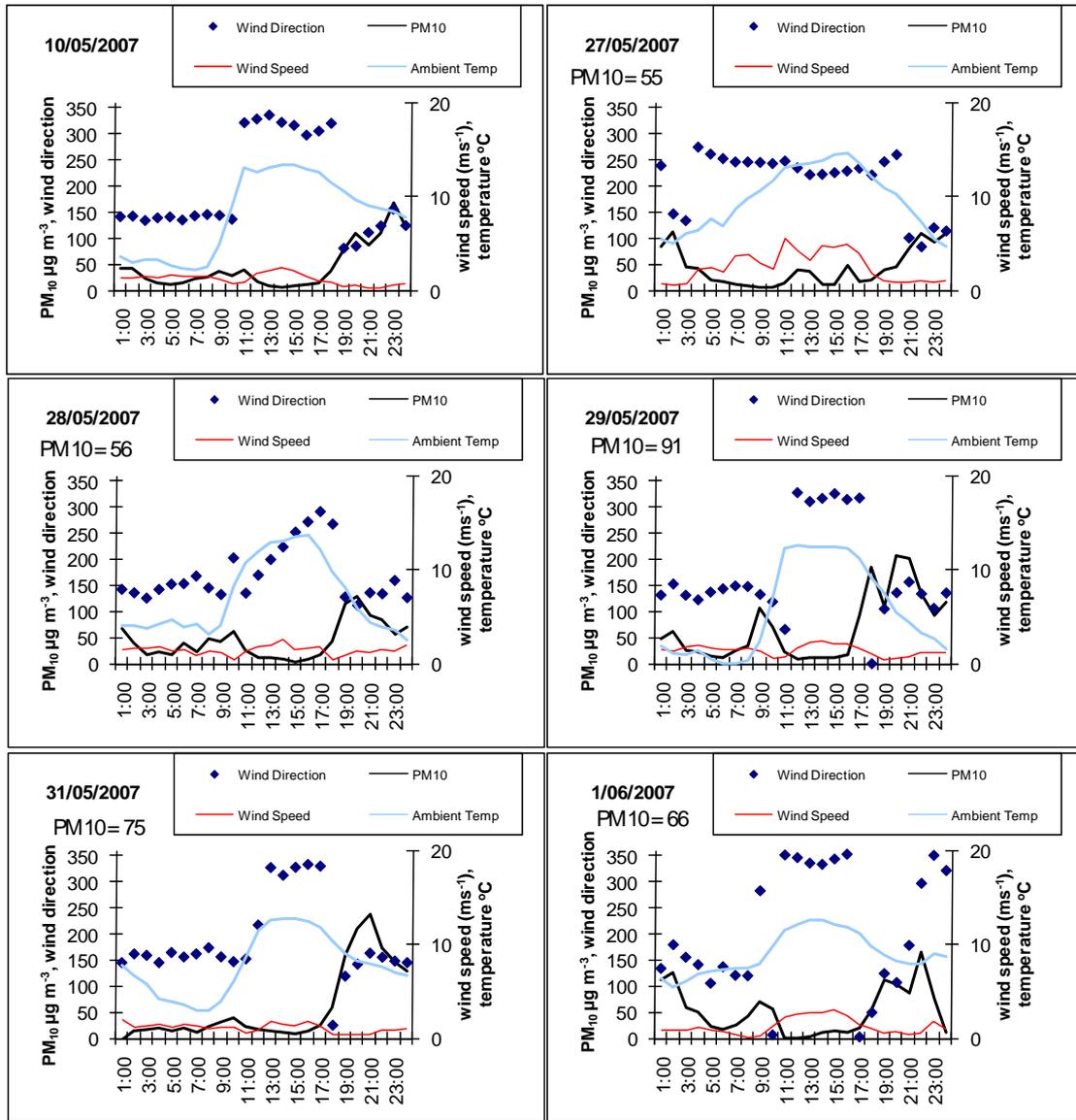
	2006	2007
"Good" 0-33% of guideline	65%	63%
"Acceptable" 33-66% of guideline	25%	26%
"Alert" 66-100% of guideline	8%	7%
"Action" >Guideline	3%	3%
Percentage of valid data	97%	100%
Annual average ( $\mu\text{g m}^{-3}$ )	17	17
NES exceedences	9	11
Annual maximum ( $\mu\text{g m}^{-3}$ )	62	91
Number of records	354	365

### 4.3 Meteorology in Tokoroa

Variations in meteorological conditions and hourly average PM<sub>10</sub> concentrations on the eleven days when the 24-hour average PM<sub>10</sub> measured at Tokoroa exceeded the NES are shown in Figure 4.5.

The highest peak in PM<sub>10</sub> concentrations generally occurred during the early evening, with a second peak in concentrations occurring in the early morning. This is fairly typical of diurnal profiles for elevated PM<sub>10</sub> concentrations in urban areas of New Zealand. Higher concentrations occur at these times under low wind speeds.

On most days, winds were typically from the south east direction when PM<sub>10</sub> concentrations were elevated. Temperatures ranged from less than zero degrees Celsius during the nighttime and morning, increasing to up to around 15 degrees Celsius during the afternoon.



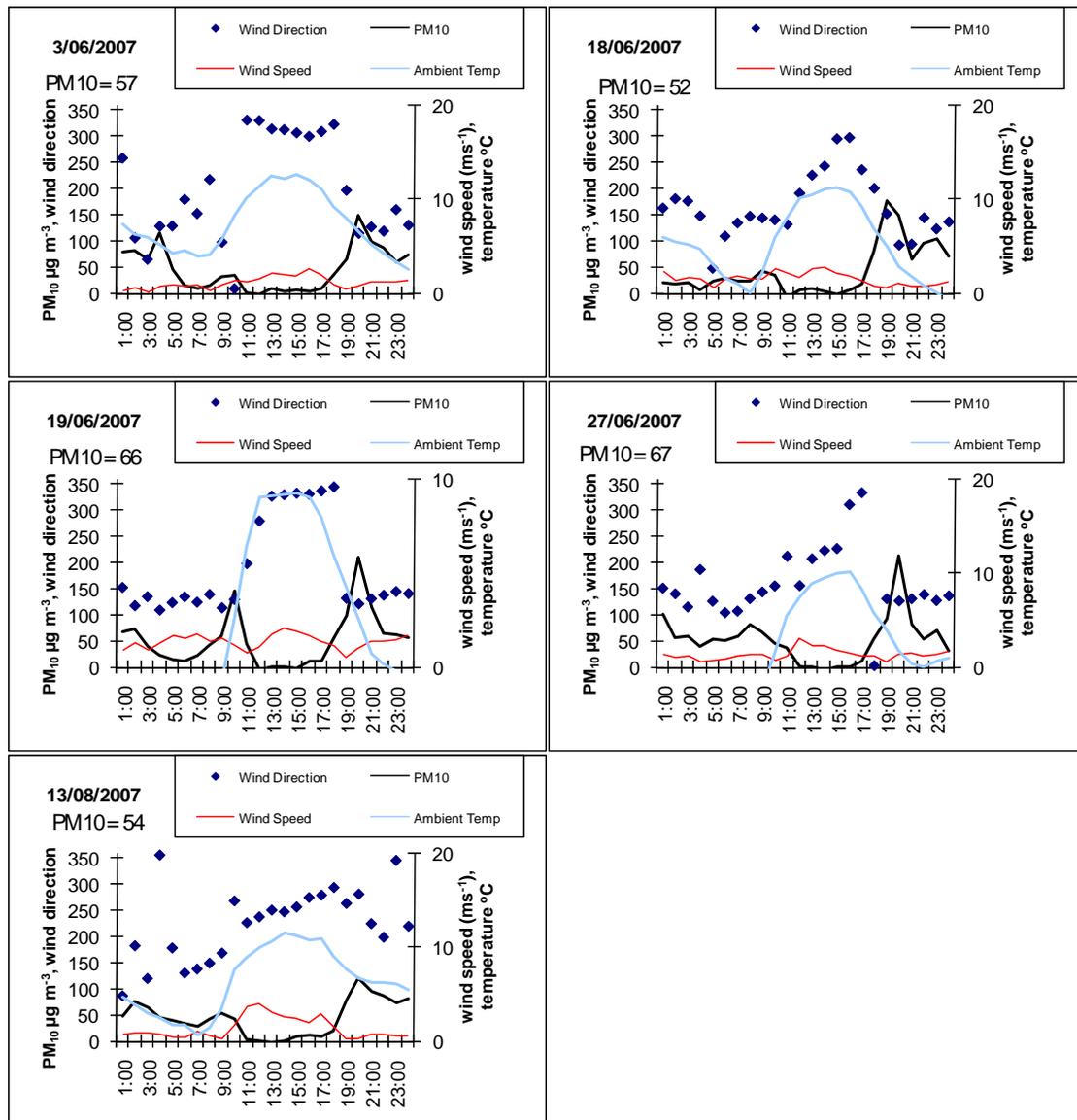


Figure 4.5: Hourly average PM<sub>10</sub>, wind speed, wind direction and temperature on days when PM<sub>10</sub> concentrations exceeded the NES at the Tokoroa site

Hourly wind direction and wind speed, measured at the monitoring site in Tokoroa, are shown in Figure 4.6 for the months May to August 2007.

The main wind directions are north west and south east. The wind speed was greater than 2 m s<sup>-1</sup> for much of the winter, although periods of low wind speeds were apparent at times. May shows the greatest prevalence of low wind speeds for winter 2007 and consequently has the greatest number of PM<sub>10</sub> breaches.

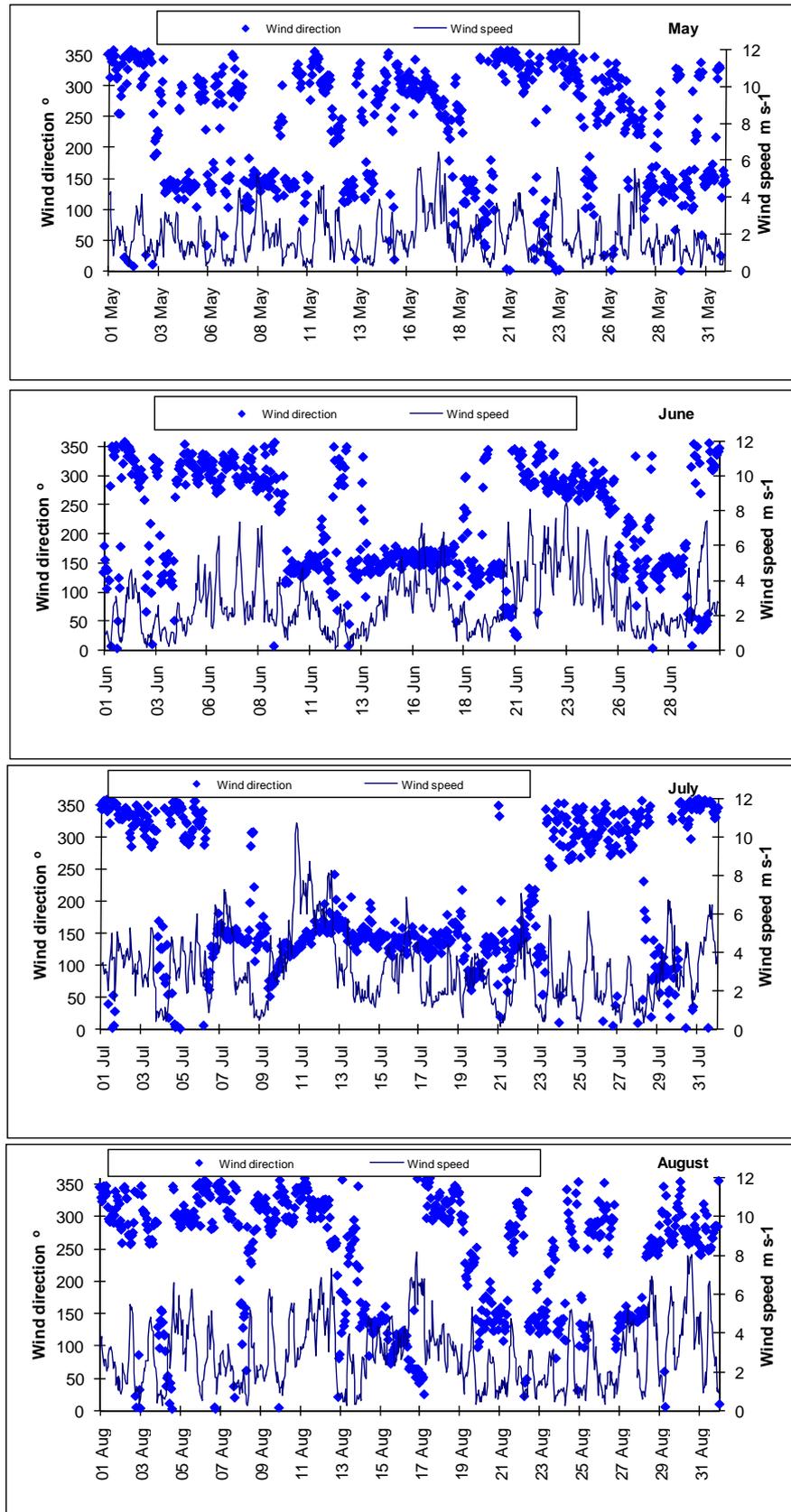


Figure 4.6: Hourly average wind speed and wind direction in Tokoroa for May to August 2007

## 5 Taupo

### 5.1 Air Quality Monitoring in Taupo

From March 2007, PM<sub>10</sub> concentrations were measured using a FH 62 C14 BAM at the Gillies Avenue Reserve site. Gravimetric sampling using a Rupprecht and Patashnick Partisol Model 2000 PM<sub>10</sub> sampler also took place at the Gillies Avenue Site during 2007. The site is located in central Taupo and was established as a monitoring site in November 2000. The site meets the requirements of the “Residential Neighbourhood” site classification as described in Good Practice Guideline for Air Quality Monitoring and Data Management (MfE, 2000).

Prior to 2005, PM<sub>10</sub> was monitored in Taupo on a 1-day-in-3 basis at the Gillies Avenue Reserve site using a Rupprecht and Patashnick Partisol Model 2000 PM<sub>10</sub> sampler. In January 2005 a FH 62 C14 Beta Attenuation Monitor (BAM) continuous PM<sub>10</sub> monitoring station was established at Taupo Primary School. The site meets the requirements of the “Residential Neighbourhood” site classification (MfE, 2000).

Operation of the Gillies Avenue Reserve Partisol Model 2000 PM<sub>10</sub> sampler continued throughout 2006 to evaluate the spatial variation of PM<sub>10</sub> concentrations between Gillies Avenue and Taupo Primary School.

The maximum recorded 24 hour PM<sub>10</sub> concentration at the Taupo Primary School site in 2006 was 24.8 µg m<sup>-3</sup> whereas the maximum recorded 24 hour PM<sub>10</sub> concentration at the Gillies Avenue Reserve site was 89 µg m<sup>-3</sup>. The results from the 2006 Monitoring Report (Smith, 2006) found that the Taupo Primary School site was not a suitable site for compliance with NES Regulation 15, that requires monitoring at the location where contaminant concentrations (or frequency of exceedances) are greatest. On 17 March 2007 the FH 62 C14 BAM was moved from Taupo Primary School back to the Gillies Avenue Reserve site.

Gravimetric sampling using the Partisol Model 2000 PM<sub>10</sub> sampler also took place at the Gillies Avenue Site during 2007. The sampling regime during 2007 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 2007.

Meteorological instrumentation was installed when the FH62 BAM was installed at the Primary School site in 2006. Wind speed, wind direction, air temperature, and relative humidity data were measured.

The location of monitoring sites in Taupo is shown in Figure 5.1.

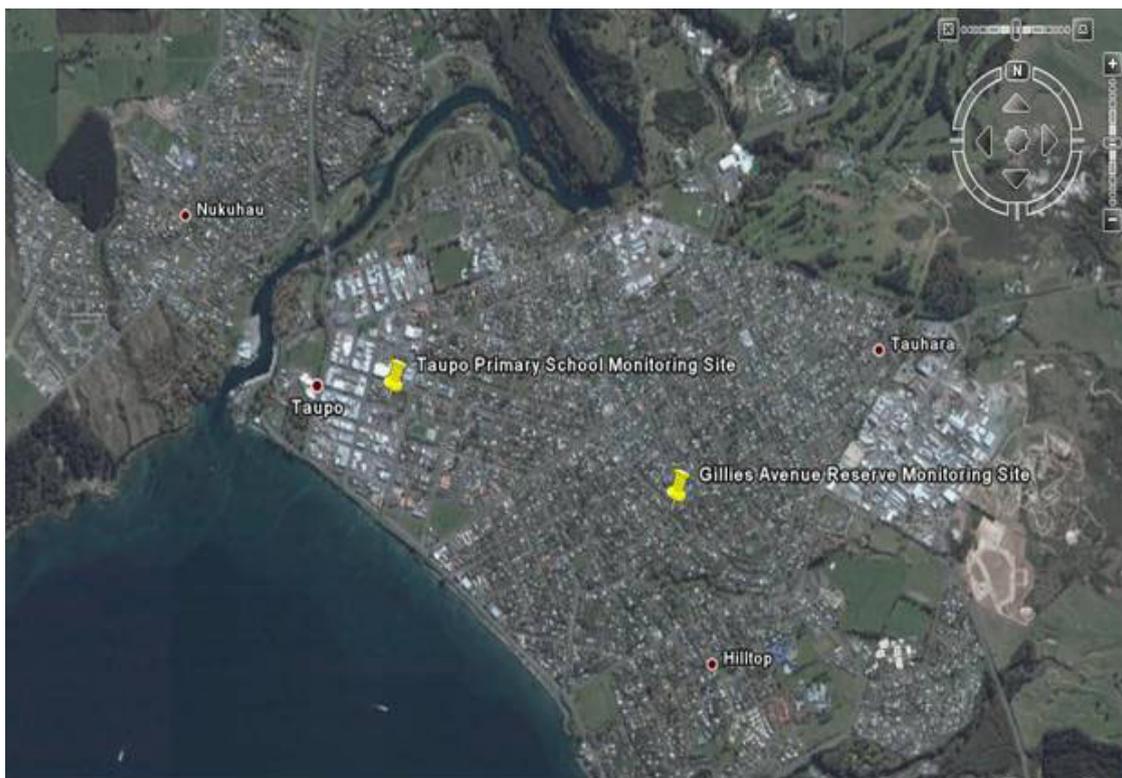


Figure 5.1: Taupo air quality monitoring site (Source: Google Earth 2008)

## 5.2 PM<sub>10</sub> concentrations in Taupo

Daily average PM<sub>10</sub> concentrations measured at the Taupo site during 2007 are shown in Figure 5.2. Six breaches of the NES were recorded at the Taupo site. The maximum measured PM<sub>10</sub> concentration during 2007 was 72  $\mu\text{g m}^{-3}$ . Prior to 2007, the highest PM<sub>10</sub> concentration measured at Taupo was 65  $\mu\text{g m}^{-3}$  and was measured in 2004 using the gravimetric partisol sampler.

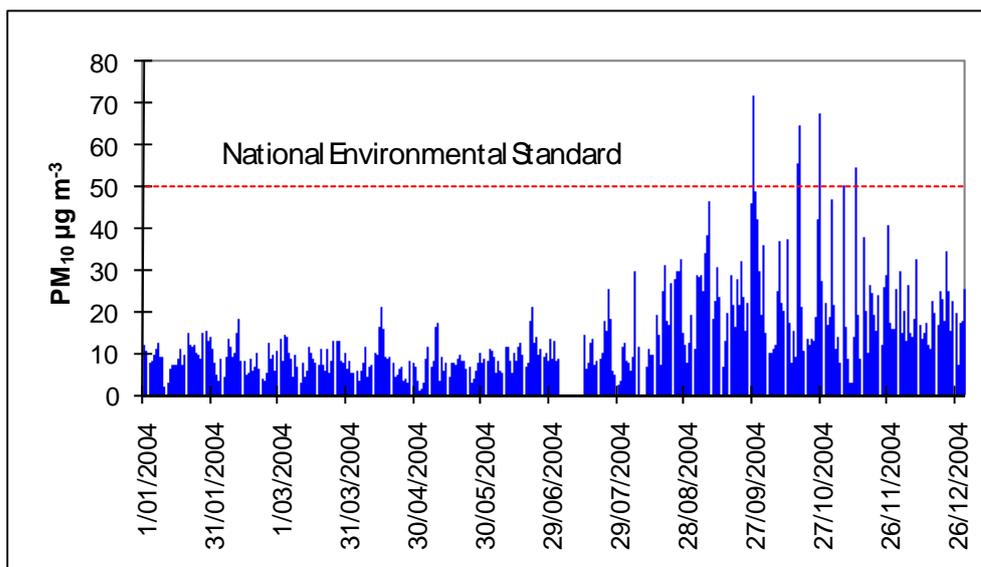


Figure 5.2: Daily winter PM<sub>10</sub> concentrations measured at the Taupo site during 2007

Changes in PM<sub>10</sub> concentrations relative to air quality indicator categories at the Taupo site from 2001 to 2007 are shown in Figure 5.3. Results suggest that PM<sub>10</sub> concentrations measured during 2007 were lower than previous years on average.

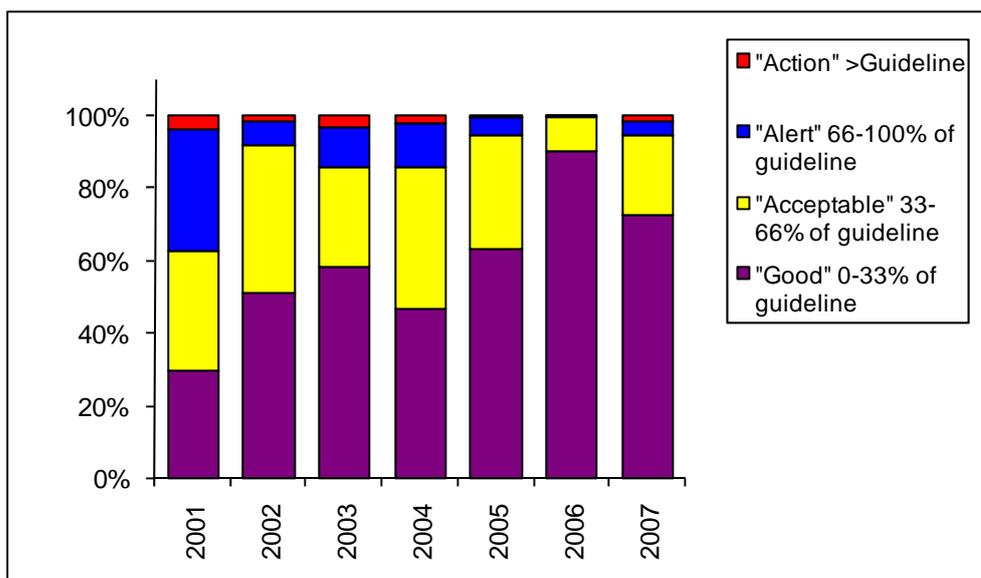


Figure 5.3: Comparison of PM<sub>10</sub> concentrations measured at the Taupo site from 2001 to 2007 to MfE air quality indicator categories

Seasonal variations in the distribution of PM<sub>10</sub> concentrations for 2007 are shown in Figure 5.4.

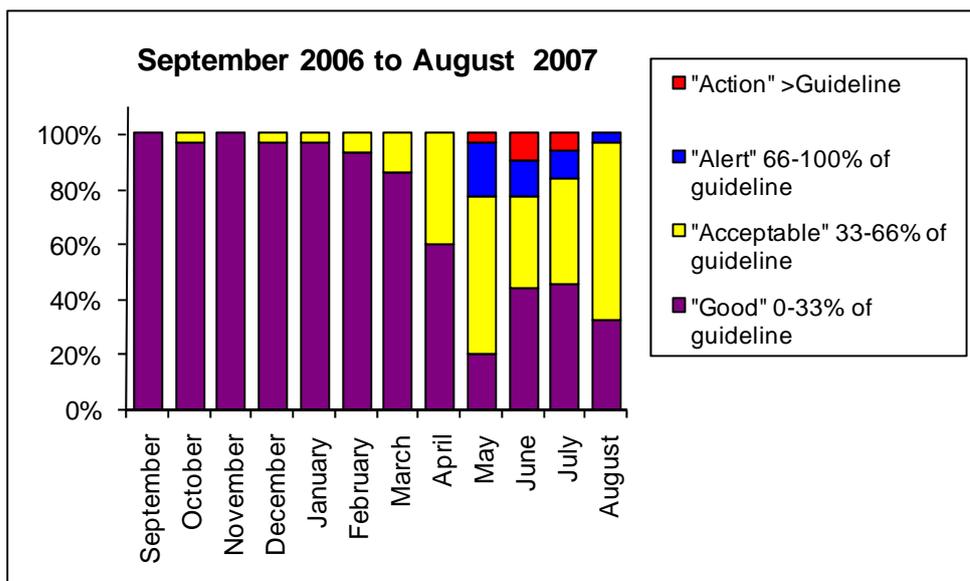


Figure 5.4: Comparison of daily PM<sub>10</sub> concentrations each month during September 2006 to August 2007 to MfE air quality indicator categories

The annual average PM<sub>10</sub> concentration for Taupo for 2007 is 14 µg m<sup>-3</sup>. This compares with an air quality guideline for annual average PM<sub>10</sub> of 20 µg m<sup>-3</sup> (MfE, 2000). Summary statistics for PM<sub>10</sub> monitoring results are shown in Table 5.1.

Table 5.1: Summary of PM<sub>10</sub> concentrations measured at the Taupo monitoring site from 2001 to 2007

	2001	2002	2003	2004	2005	2006	2007
"Good" 0-33% of guideline	29%	51%	58%	46%	61%	89%	72%
"Acceptable" 33-66% of guideline	33%	41%	28%	39%	31%	10%	22%
"Alert" 66-100% of guideline	33%	7%	11%	13%	5%	0%	4%
"Action" >Guideline	4%	2%	3%	2%	1%	0%	2%
Percentage of valid data	7%	16%	32%	26%	30%	69%	96%
Annual average ( $\mu\text{g m}^{-3}$ )		17	18	19	15	10	14
Exceedences (extrapolated)	14	6	13	7	3	0	6
Annual maximum ( $\mu\text{g m}^{-3}$ )	57	54	62	65	52	41	72
Number of records	24	59	116	95	111	253	351

### 5.3 Meteorology in Taupo

Figure 5.5 shows hourly average PM<sub>10</sub> concentrations on days when the 24-hour average PM<sub>10</sub> measured at Taupo exceeded 50  $\mu\text{g m}^{-3}$ . With the exception of 18 June, all days showed a larger peak in concentrations during the evening period and a smaller peak during the morning period. On 18 June, concentrations peaked at around 250  $\mu\text{g m}^{-3}$  (one hour average) at around 1 pm. Both the magnitude and timing of the peak is unusual for ambient air quality in Taupo and may reflect some local source contributing to PM<sub>10</sub> concentrations.

Figure 5.5 suggests that PM<sub>10</sub> concentrations in Taupo appear to occur when the wind is from an easterly direction and when wind speeds are low.

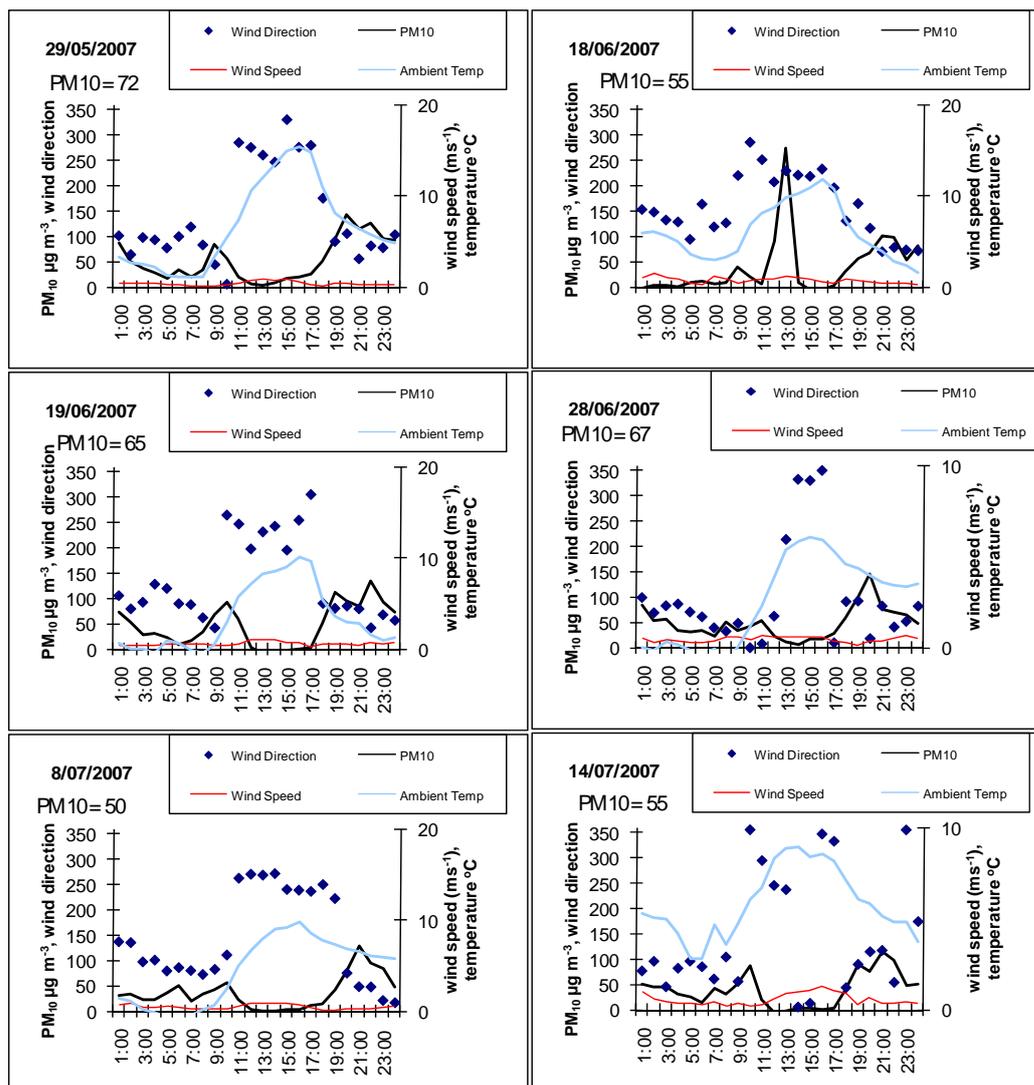


Figure 5.5: Hourly average PM<sub>10</sub>, wind speed, wind direction and temperature on days when PM<sub>10</sub> concentrations exceeded the NES at the Taupo site

Hourly wind direction and wind speed, measured at the monitoring site in Taupo, are shown in Figure 5.6 for the months May to August 2007.

As with previous years, the predominant wind direction is westerly. The wind speed was greater than 2 m s<sup>-1</sup> for much of the winter, although periods of low wind speeds were apparent at times. The greatest prevalence of low wind speeds for winter 2007 occurs in June and coincides with the period when the highest PM<sub>10</sub> concentrations were recorded.

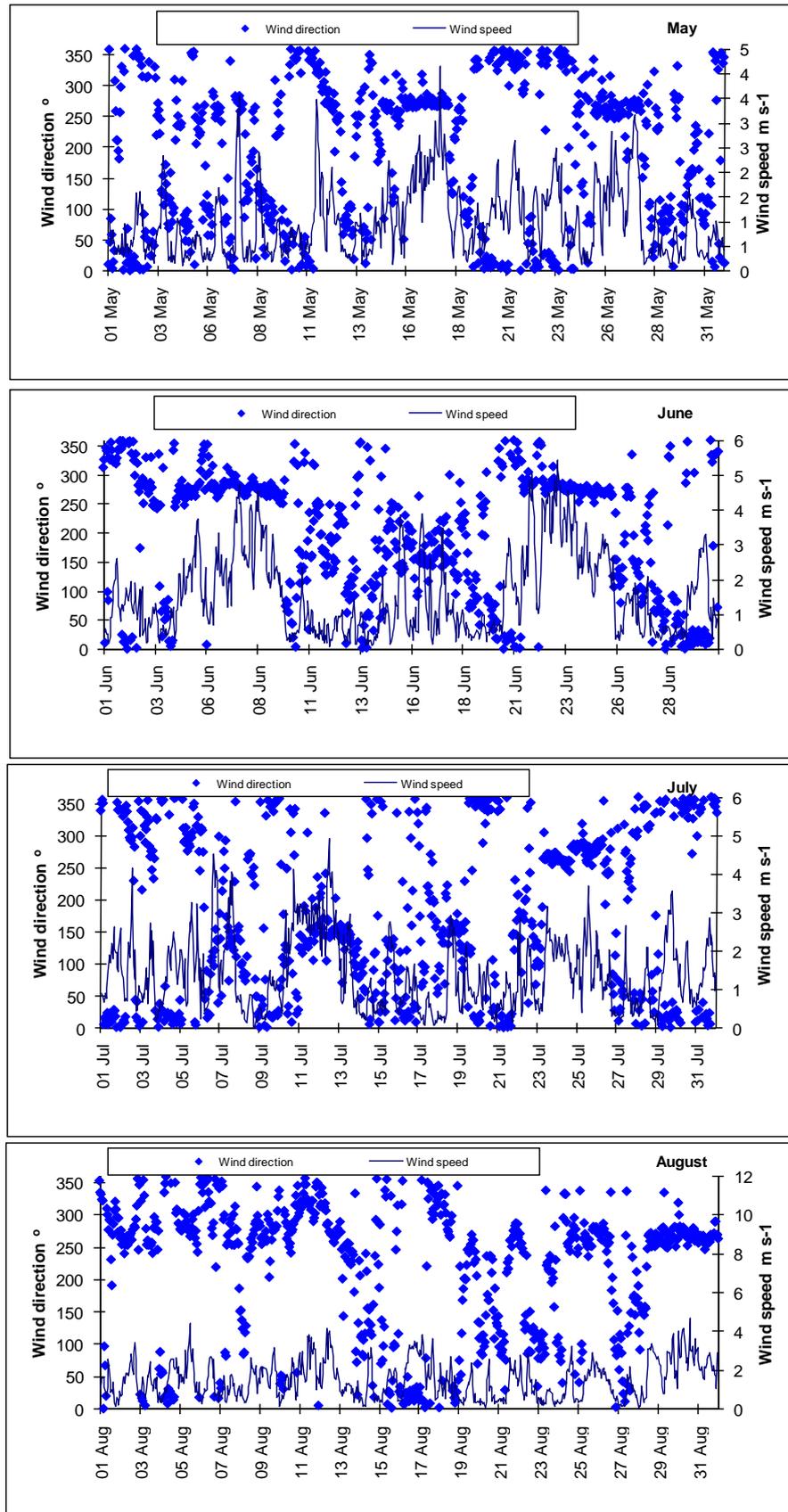


Figure 5.6: Hourly average wind speed and wind direction in Taupo for May to August 2007

## 6 Te Kuiti

### 6.1 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. This is the same site as used since 2003 and for the 1998 PM<sub>10</sub> monitoring in Te Kuiti (Figure 6.1). 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, 2002). The site meets the requirements of the “Residential Neighbourhood” site classification as described in *Good Practice Guideline for Air Quality Monitoring and Data Management* (MfE, 2000).

In 2007, concentrations of PM<sub>10</sub> were measured at the site using an ESM (Anderson) FH 62 C14 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.

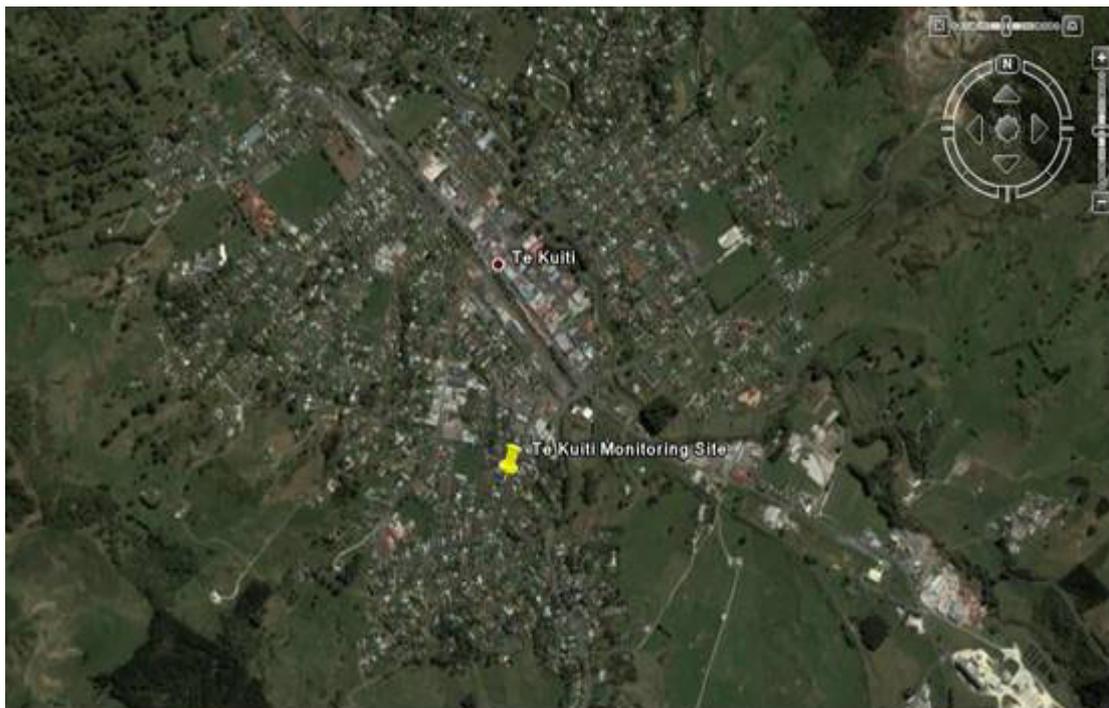


Figure 6.1: Te Kuiti air quality monitoring site (Source: Google Earth 2008)

### 6.2 PM<sub>10</sub> Concentrations in Te Kuiti

Daily average PM<sub>10</sub> concentrations measured at the Te Kuiti site during 2007 are shown in Figure 6.2. The maximum measured PM<sub>10</sub> concentrations at Te Kuiti during 2007 was 58 µg m<sup>-3</sup>. Four breaches of the NES were recorded at the Te Kuiti site. In 2006 seven breaches occurred and the highest concentration was 70 µg m<sup>-3</sup>.

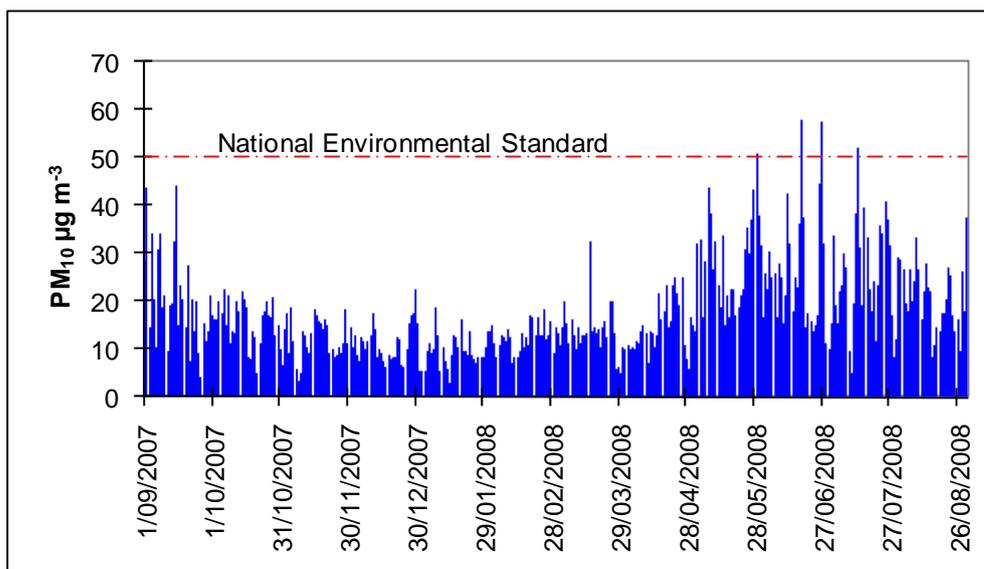


Figure 6.2: Daily winter PM<sub>10</sub> concentrations measured at the Te Kuiti site during 2007.

Changes in PM<sub>10</sub> concentrations relative to air quality indicator categories at Te Kuiti from 2001 to 2007 are shown in Figure 6.3. Results suggest that PM<sub>10</sub> concentrations measured during 2007 were similar to those measured in 2004, 2005 and 2006.

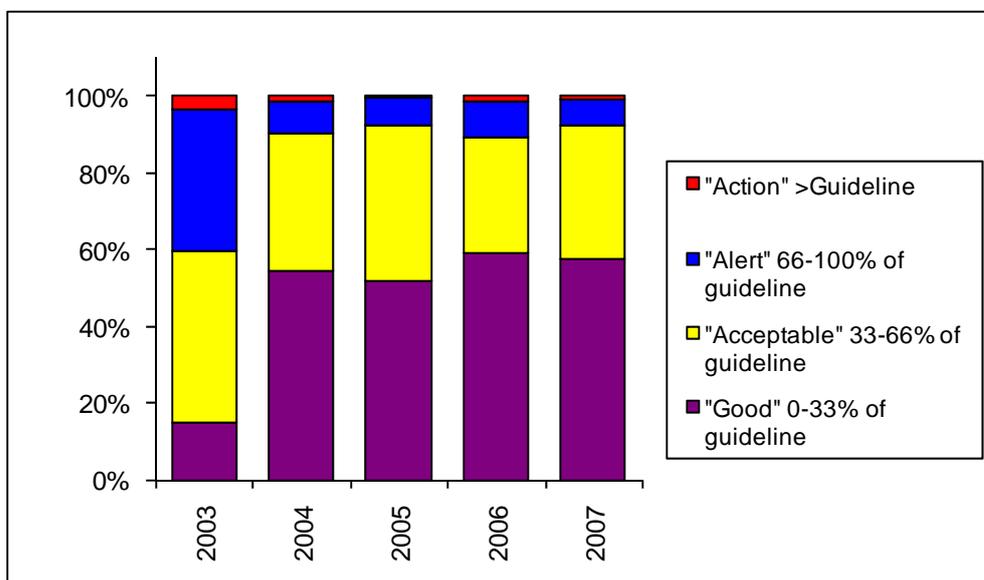


Figure 6.3: Comparison of PM<sub>10</sub> concentrations measured at the Te Kuiti site from 2000 to 2007 to MfE air quality indicator categories

Seasonal variations in the distribution of PM<sub>10</sub> concentrations for 2007 are shown in Figure 6.4.

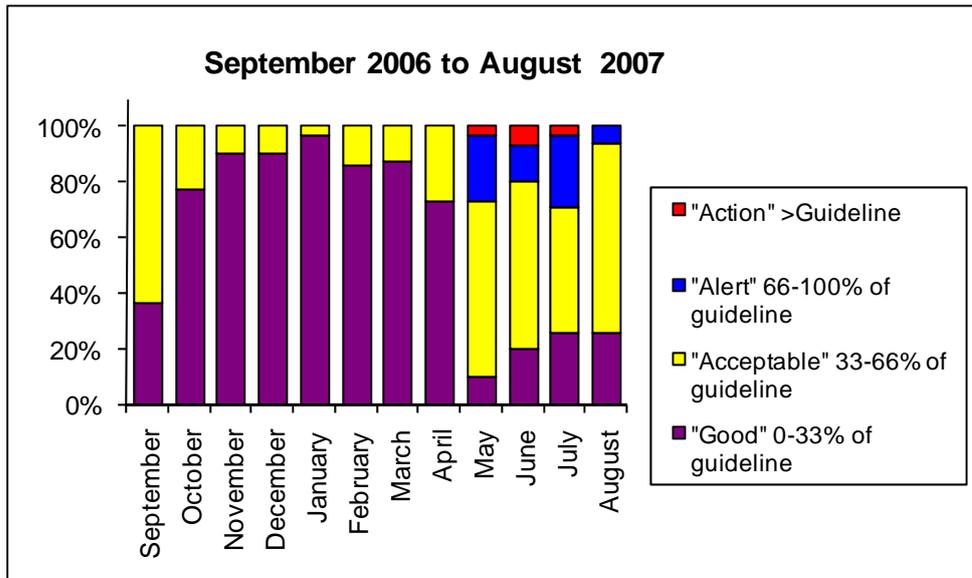


Figure 6.4: Comparison of daily PM<sub>10</sub> concentrations each month during September 2006 to August 2007 to MfE air quality indicator categories

The annual average PM<sub>10</sub> concentration for Te Kuiti for 2007 is 17 µg m<sup>-3</sup> and is largely consistent with annual average concentrations from 2003 to 2006. Summary statistics for PM<sub>10</sub> monitoring results are shown in Table 6.1.

Table 6.1: Summary of PM<sub>10</sub> concentrations measured at the Te Kuiti monitoring site from 2003 to 2007

	2003	2004	2005	2006	2007
"Good" 0-33% of guideline	15%	54%	51%	59%	57%
"Acceptable" 33-66% of guideline	44%	36%	40%	30%	35%
"Alert" 66-100% of guideline	37%	9%	7%	9%	7%
"Action" >Guideline	3.7%	1.4%	1%	2%	1%
Percentage of valid data	30%	95%	92%	99%	100%
Annual average ( $\mu\text{g m}^{-3}$ )	18	18	18	18	17
Measured exceedences	4	5	2	7	4
Annual maximum ( $\mu\text{g m}^{-3}$ )	59	61	54	70	58
Number of records	108	347	336	363	364

### 6.3 Meteorology in Te Kuiti

Figure 6.5 shows variations in hourly average PM<sub>10</sub> and meteorological variables on days when 24-hour average PM<sub>10</sub> concentrations exceeded the NES in Te Kuiti.

Concentrations of PM<sub>10</sub> typically peak in the evening period around 9 pm but remain elevated throughout the night and early morning period. A second peak in concentrations typically occurs in the morning around 9 am. On most days, PM<sub>10</sub> concentrations decrease to less than 10  $\mu\text{g m}^{-3}$  during the afternoon. The wind direction on high pollution evenings appears to be predominantly southerly. Wind speeds are low for most of the day with a slight increase occurring between mid day and 7 pm.

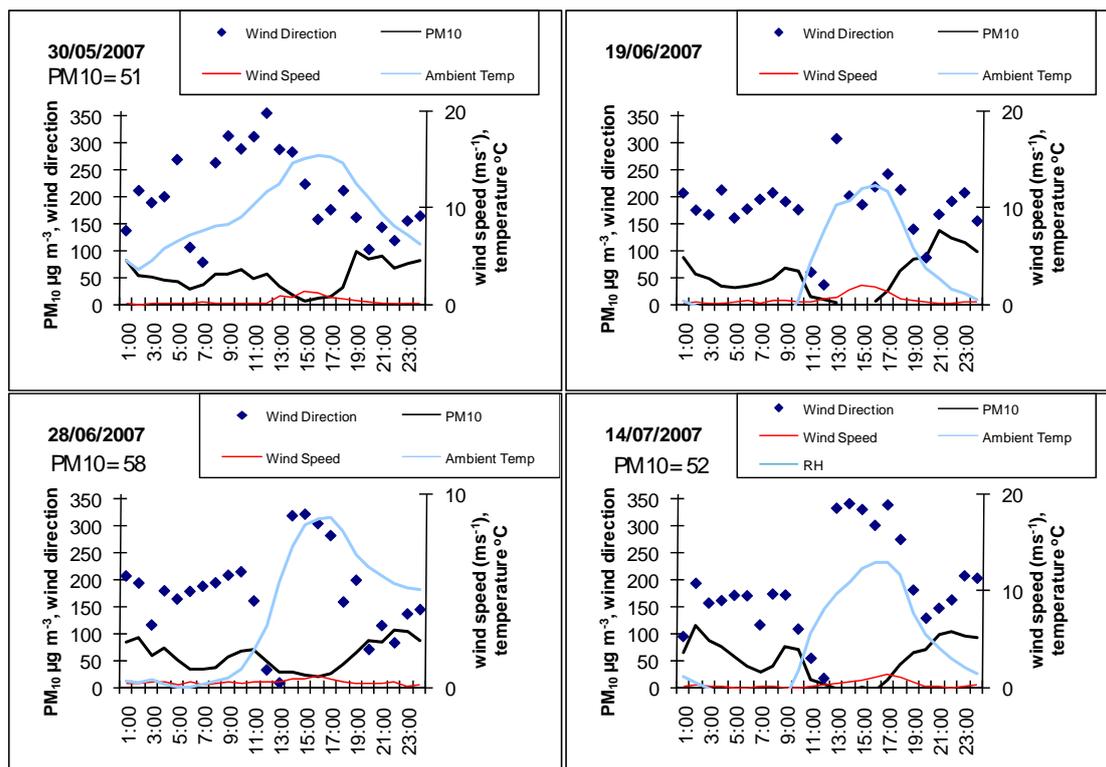


Figure 6.5: Hourly average PM<sub>10</sub>, wind speed, wind direction and temperature on days when PM<sub>10</sub> concentrations exceeded the NES at the Te Kuiti site

Hourly wind direction and wind speed, measured at the monitoring site in Te Kuiti are shown in Figure 6.6 for the months May to August 2007.

As with previous years, the predominant wind direction is westerly. The wind speed was greater than 2 m s<sup>-1</sup> for much of the winter, although periods of low wind speeds were apparent at times. The greatest prevalence of low wind speeds for winter 2007 occurs in June and coincides with the period when the highest PM<sub>10</sub> concentrations were recorded.

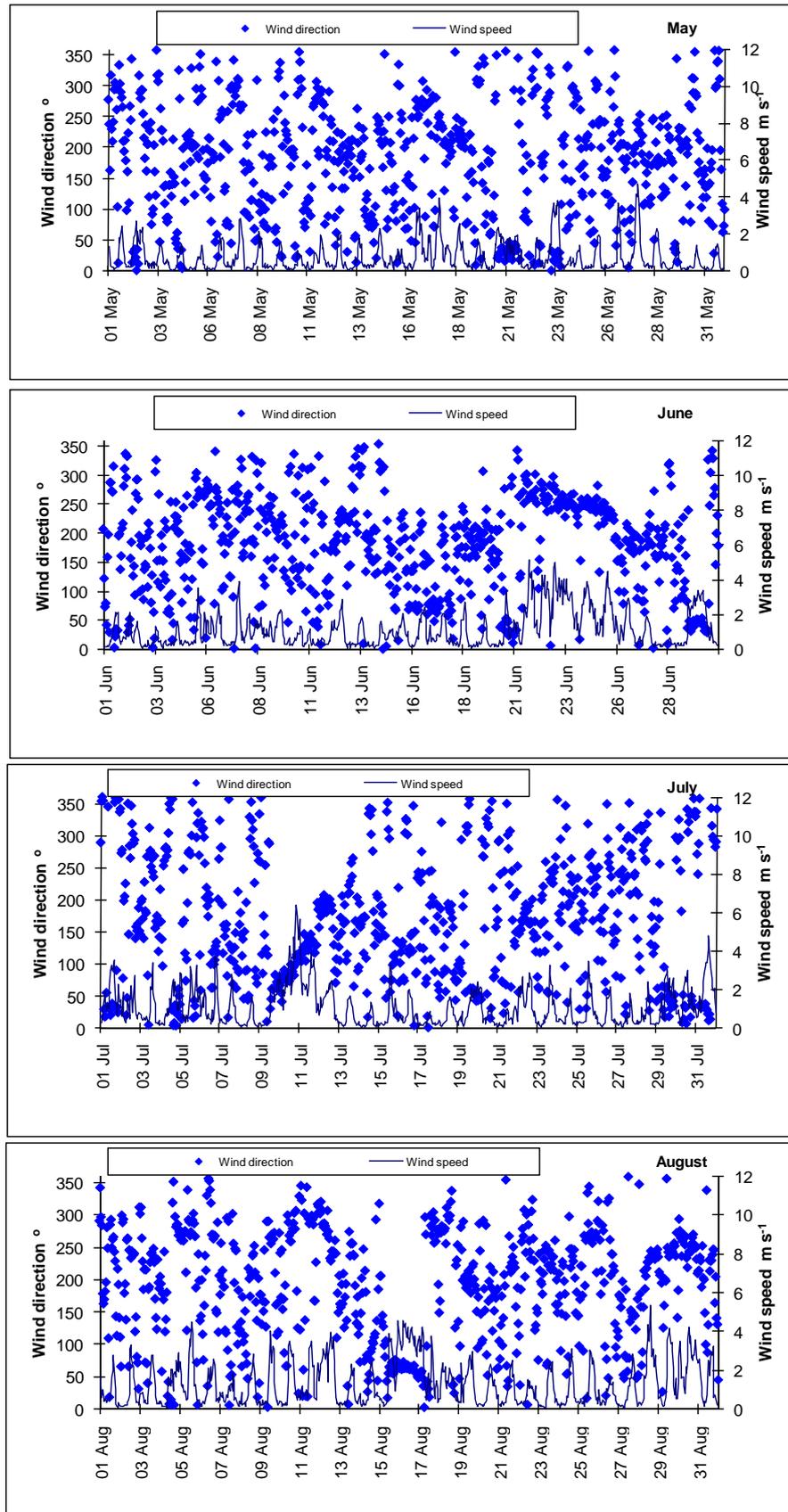


Figure 6.6: Hourly average wind speed and wind direction in Te Kuiti for May to August 2007

## 7 Matamata

### 7.1 Air Quality Monitoring in Matamata

Matamata is located approximately 41 km 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 7.1). The Farmers Road site meets the requirements of 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<sub>10</sub> concentrations at Matamata Playcentre is a ThermoAndersen FH 62 C14 BAM. Meteorological data are also collected, including wind speed and direction at 6 meters, ambient air temperature and relative humidity. The site was installed by Watercare Services Ltd and is operated and maintained by Environment Waikato staff. PM<sub>10</sub> data are continuously measured by the FH62 BAM and logged at ten minute intervals.

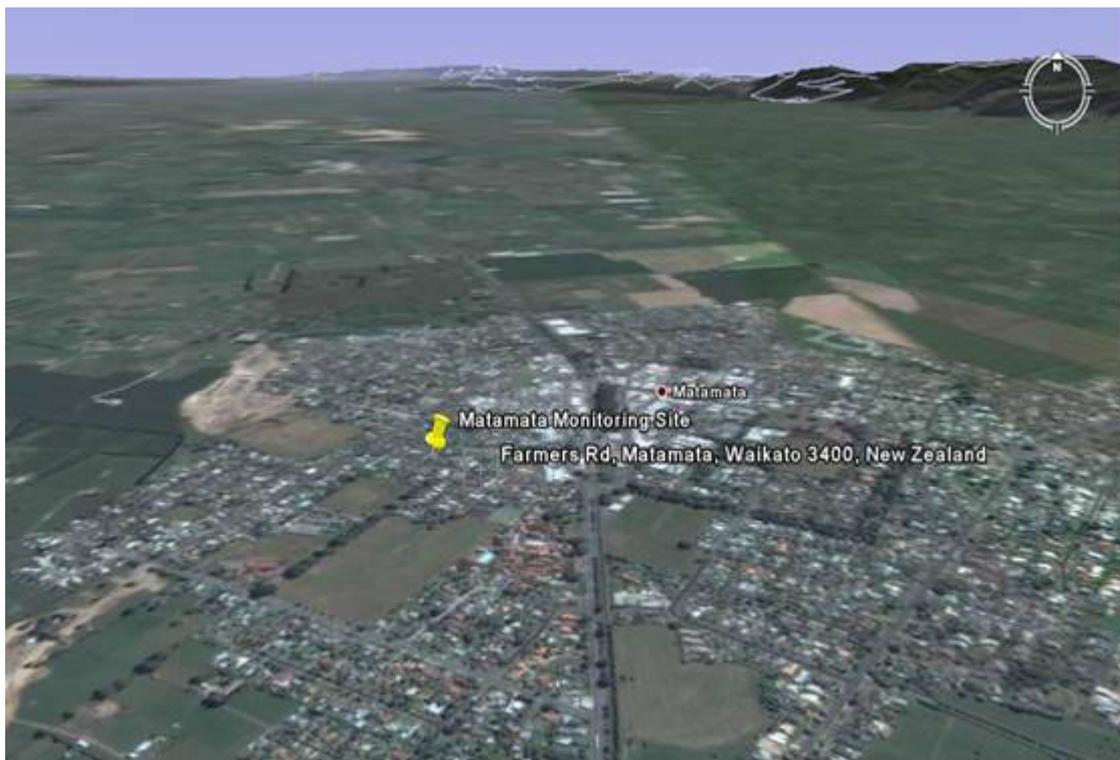


Figure 7.1: Matamata air quality monitoring site (Source: Google Earth 2008)

### 7.2 PM<sub>10</sub> Concentrations in Matamata

Daily average PM<sub>10</sub> concentrations measured at the Matamata site during 2007 are shown in Figure 7.2. The maximum measured PM<sub>10</sub> concentrations recorded at the

Matamata site during 2007 was  $34 \mu\text{g m}^{-3}$ . This compares with a 2006 maximum concentration of  $38 \mu\text{g m}^{-3}$ . No breaches of the NES have been recorded at the Matamata air quality monitoring site since monitoring commenced.

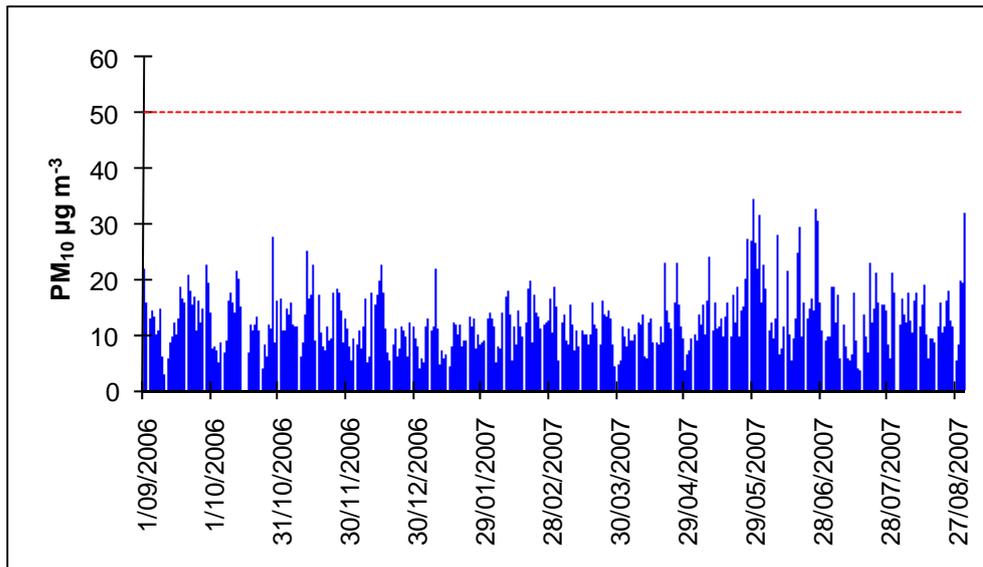


Figure 7.2: Daily winter PM<sub>10</sub> concentrations measured at the Matamata site during 2007

Figure 7.3 compares PM<sub>10</sub> concentrations measured at Matamata to the MfE (2000) air quality indicator category. Results suggest that PM<sub>10</sub> concentrations measured at Matamata are typically less than 66% of the NES.

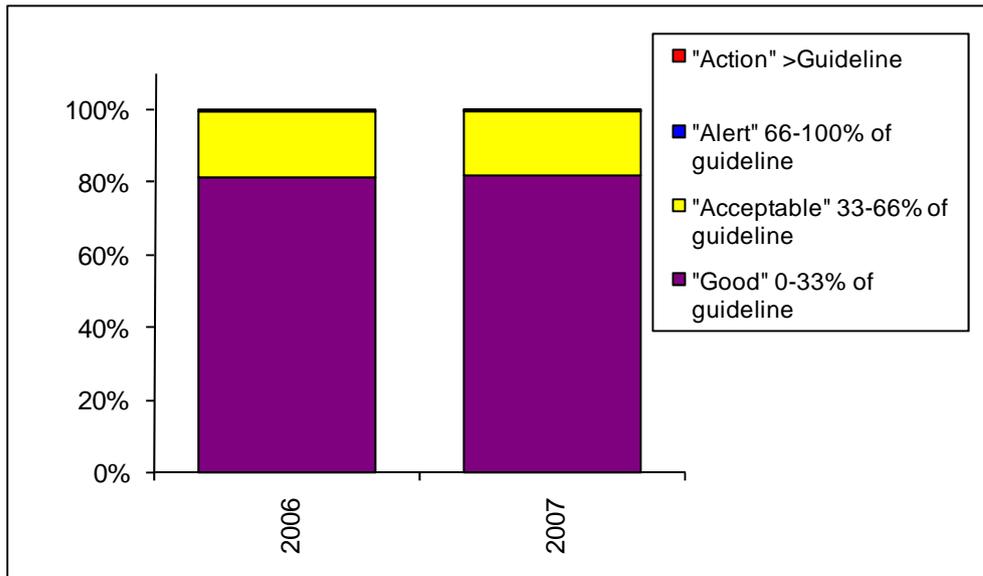


Figure 7.3: Comparison of PM<sub>10</sub> concentrations measured at the Matamata site from 2006 to 2007 to MfE air quality indicator categories

Seasonal variations in the distribution of PM<sub>10</sub> concentrations for 2007 are shown in Figure 7.4.

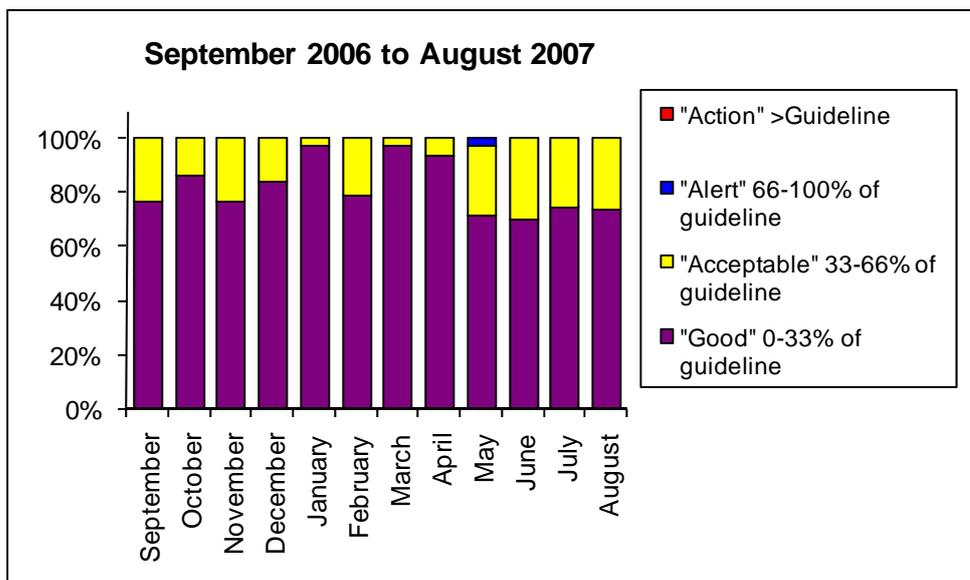


Figure 7.4: Comparison of daily PM<sub>10</sub> concentrations each month during September 2006 to August 2007 to MfE air quality indicator categories

The annual average PM<sub>10</sub> concentration for Matamata for 2007 is 13 µg m<sup>-3</sup>. Summary statistics for PM<sub>10</sub> monitoring results are shown in Table 7.1.

Table 7.1: Summary of PM<sub>10</sub> concentrations measured at the Matamata monitoring site from 2006 to 2007

	2006	2007
"Good" 0-33% of guideline	81%	81%
"Acceptable" 33-66% of guideline	18%	18%
"Alert" 66-100% of guideline	1%	0%
"Action" >Guideline	0%	0%
Percentage of valid data	98%	99%
Annual average ( $\mu\text{g m}^{-3}$ )	13	13
Measured exceedences	0	0
Annual maximum ( $\mu\text{g m}^{-3}$ )	38	34
Number of records	357	362

### 7.3 Meteorology in Matamata

Hourly wind direction and wind speed, measured at the Matamata site are shown in Figure 7.5 for the months May to August 2007.

During 2007, May was the month with the lowest wind speed at Matamata with the majority of the month recording speeds of less than  $2 \text{ ms}^{-1}$ . Although wind speeds were higher during June and July, these months also showed periods of several days when wind speeds did not exceed  $2 \text{ ms}^{-1}$ . The results suggest that opportunities for NES breaches have occurred during 2007. It would therefore be reasonable to conclude that PM<sub>10</sub> concentrations in Matamata are unlikely to exceed the NES in the near future.

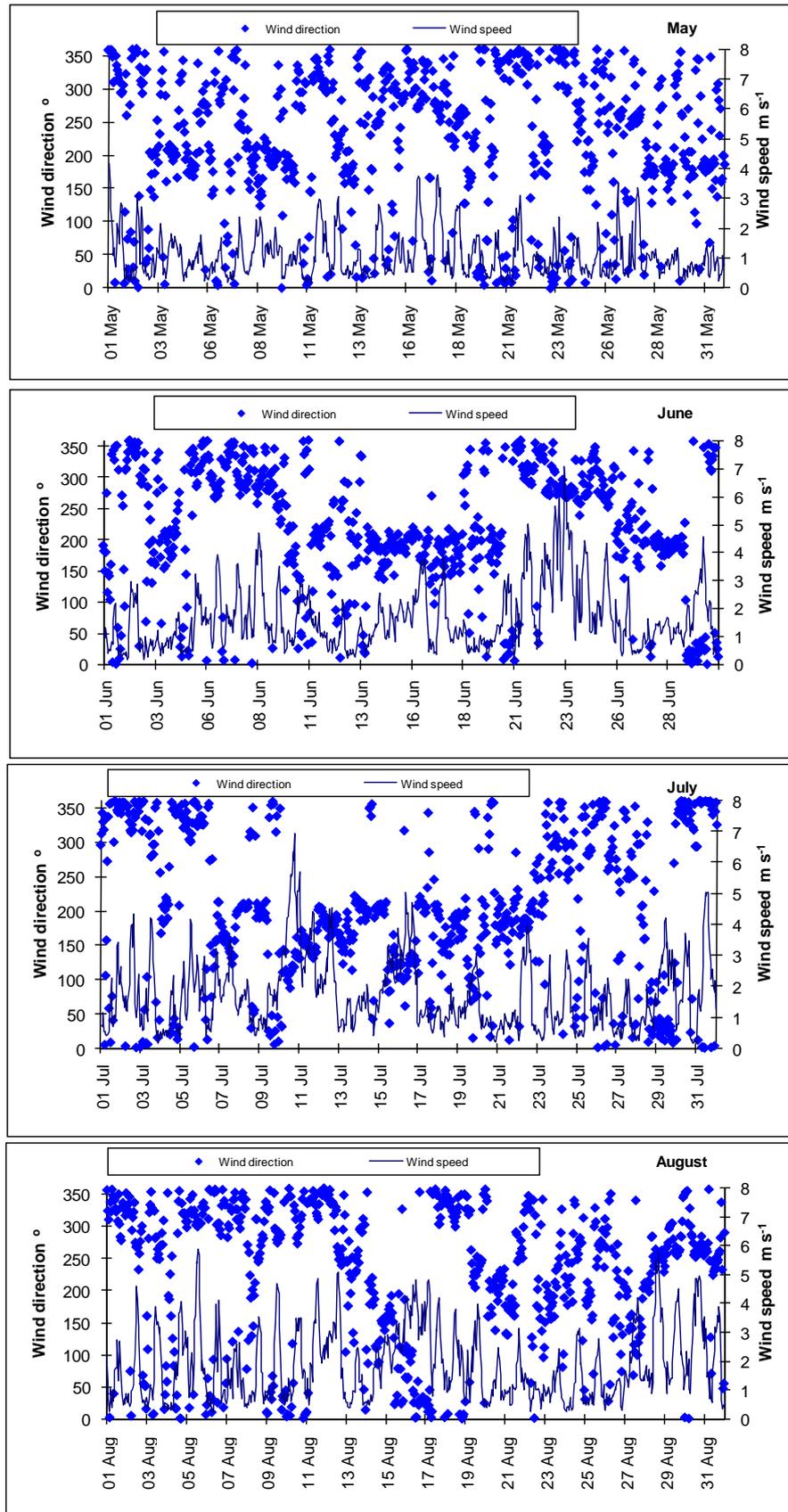


Figure 7.5: Hourly average wind speed and wind direction in Matamata for May to August 2007

## **8 Putaruru**

### **8.1 Air Quality Monitoring in Putaruru**

Putaruru is located in the South Waikato District, mid-way between Tokoroa and Tirau on State Highway One. It is 65 kilometres southeast of Hamilton and is close to Lake Arapuni on the Waikato River. The town occupies a flat to gently undulating site, and to the east the land rises to the Mamaku Range. Putaruru has a population of around 3000 people.

In July 2006 a new monitoring site was established at the Bowling Club on Arapuni Street in Putaruru (Figure 8.1). The map reference for the site is NZMS260 T15:533-457. Daily concentrations of PM<sub>10</sub> have been measured since the site was established.

The monitoring method used to measure PM<sub>10</sub> concentrations at Putaruru is a ThermoAndersen FH 62 C14 BAM (Figure 8.2).



Figure 8.1 Location of Putaruru monitoring site (Source: Google Earth 2008)



Figure 8.2: Putaruru air quality monitor (Source: Environment Waikato)

## 8.2 PM<sub>10</sub> Concentrations in Putaruru

Figure 8.3 shows daily average PM<sub>10</sub> concentrations measured at the Putaruru site during 2007. Two NES breaches were recorded at the Putaruru site. The maximum

measured PM<sub>10</sub> concentrations was 56 µg m<sup>-3</sup> and was recorded on 10 May 2007. The maximum 24-hour PM<sub>10</sub> concentration measured during 2006 was 40 µg m<sup>-3</sup>.

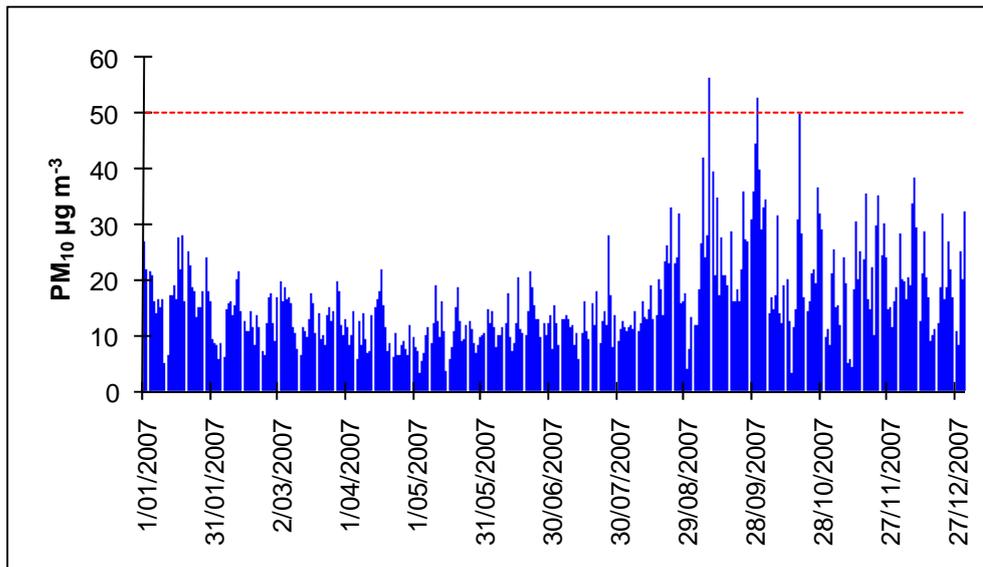


Figure 8.3: Daily winter PM<sub>10</sub> concentrations measured at the Pataruru site during 2007.

Concentrations of PM<sub>10</sub> relative to air quality indicator categories at the Putaruru site for 2006 and 2007 are shown in Figure 8.4. Note that the reporting year is September to August and that monitoring did not commence in 2006 until July. Thus results for 2006 are for the winter period (July and August) whereas 2007 data includes all months.

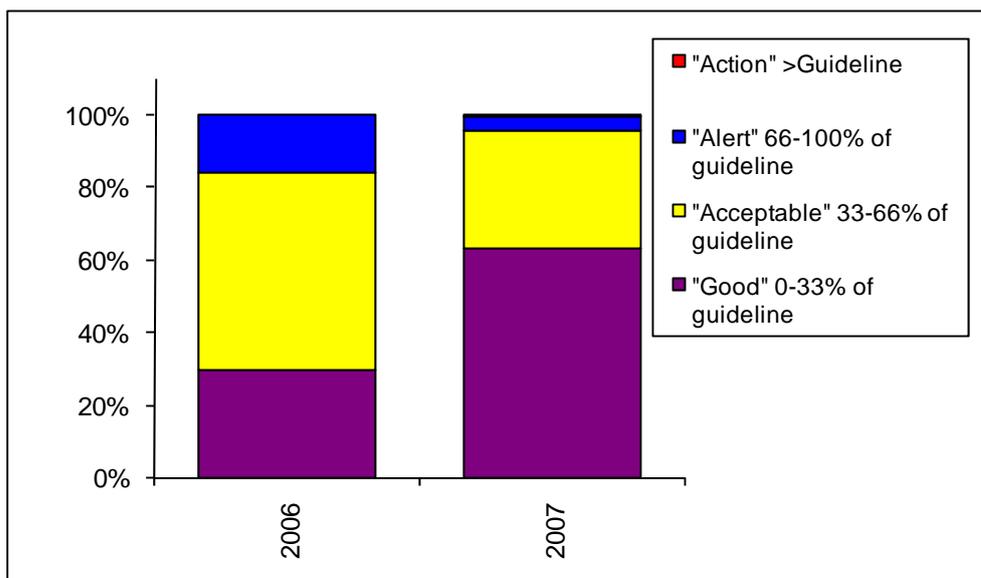


Figure 8.4: Comparison of PM<sub>10</sub> concentrations measured at the Putaruru site in 2006 - 2007 to MfE air quality indicator categories

Seasonal variations in the distribution of PM<sub>10</sub> concentrations are shown in Figure 8.5.

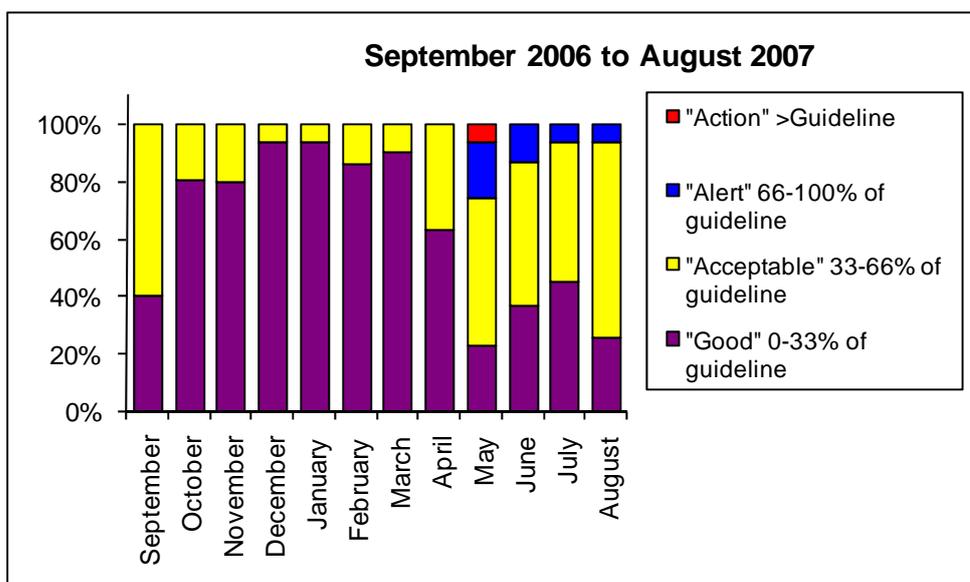


Figure 8.5: Comparison of daily PM<sub>10</sub> concentrations each month during September 2006 to August 2007 to MfE air quality indicator categories

The estimated annual average PM<sub>10</sub> concentration for Putaruru for 2007 is 16 µg m<sup>-3</sup>. Summary statistics for PM<sub>10</sub> monitoring results are shown in Table 8.1.

Table 8.1: Summary of PM<sub>10</sub> concentrations measured at the Putaruru monitoring site for 2007

	2007
"Good" 0-33% of guideline	63%
"Acceptable" 33-66% of guideline	33%
"Alert" 66-100% of guideline	4%
"Action" >Guideline	1%
Percentage of valid data	100%
Annual average ( $\mu\text{g m}^{-3}$ )	16
Measured exceedences	2
Annual maximum ( $\mu\text{g m}^{-3}$ )	56
Number of records	364

## 9 Summary

During 2007 PM<sub>10</sub> concentrations were measured at six sites in the Waikato Region. These were Hamilton, Tokoroa, Taupo, Te Kuiti, Matamata and Putaruru.

Concentrations of PM<sub>10</sub> in excess of the NES were measured in, Tokoroa, Taupo, Te Kuiti and Putaruru. The maximum measured PM<sub>10</sub> concentrations and number of breaches in each location is shown in Table 9.1. Annual average concentrations are also shown and compare with the MfE guideline for annual averages of 20 µg m<sup>-3</sup>.

Table 9.1: Summary of PM<sub>10</sub> monitoring results for September 2006 to August 2007

	Hamilton µg m <sup>-3</sup>	Tokoroa µg m <sup>-3</sup>	Taupo µg m <sup>-3</sup>	Te Kuiti µg m <sup>-3</sup>	Matamata µg m <sup>-3</sup>	Putaruru µg m <sup>-3</sup>
Maximum PM <sub>10</sub> concentration	46	91	72	58	34	56
Measured NES exceedences	0	11	6	4	0	2
Annual Average	15	17	14	17	13	16

Air quality monitoring of benzene, toluene and xylene was carried out at a number of monitoring sites in Hamilton. Results suggest a decrease in benzene concentrations in Hamilton with 2007 concentrations all less than the 2010 guideline for benzene of 3.6 µg m<sup>-3</sup> (annual average). Concentrations of toluene and xylene were well within acceptable levels.

An evaluation of the meteorological conditions at all sites shows all locations except Taupo experienced low wind speeds during May. An evaluation PM<sub>10</sub> concentrations and meteorological conditions in Matamata suggest that PM<sub>10</sub> concentrations are unlikely to exceed the NES in the near future.

No meteorological monitoring was carried out at Putaruru. Both NES breaches at this site occurred during May 2007 when meteorological conditions at most sites were most conducive to elevated PM<sub>10</sub>.

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