

Air quality monitoring report for Hamilton, Tokoroa, Taupo, Te Kuiti, Putaruru, Turangi, Cambridge and Te Awamutu- Kihikihi - 2014

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Executive summary

Air quality monitoring in the Waikato Region focuses primarily on concentrations of PM₁₀, the main air contaminant of concern. The National Environmental Standards for Air Quality (NESAQ) has set a maximum concentration limit for PM₁₀ of 50 µg/m³ when averaged over 24 hours (referred to as an ambient air quality standard). The NESAQ allows for one exceedance of this standard per rolling 12 month period. More than one exceedance within a rolling 12-month period is a breach of the standard. The NESAQ requires air quality monitoring to take place in areas that are likely to exceed the standard for PM₁₀.

The 2011 amendment to the NESAQ has introduced extended timeframes for Airsheds¹ to comply with the standard for PM₁₀. Airsheds are split in to three categories depending on the average number of exceedances the airshed has for the previous five year period.

1. The first category includes airsheds with 10 or more exceedances a year. These airsheds must achieve no more than three exceedances by 1 September 2016 and no more than one exceedance by 1 September 2020. The Waikato Region has one such airshed that falls within this category, namely Tokoroa.
2. The second category includes airsheds with more than one exceedance but less than 10 exceedances. This category of airshed must achieve no more than one exceedance by 1 September 2016. Based on the air quality monitoring data collected up to the end of 2014, the Waikato Region has three airsheds that fall within this category, namely Taupo, Te Kuiti and Putaruru.
3. The third category includes all other airsheds which are currently complying and must continue to achieve no more than one exceedance of the standard.

During 2014, concentrations of PM₁₀ were measured by Waikato Regional Council in eight out of the region's 20 gazetted airsheds with two stations located in the Hamilton airshed and one each in the Tokoroa, Taupo, Te Kuiti, Putaruru, Turangi, Cambridge and Te Awamutu-Kihikihi airsheds. Carbon monoxide (CO), nitrogen dioxide (NO₂), benzene, toluene, ethylbenzene and xylenes and PM_{2.5} were also measured by Waikato Regional Council in Hamilton during 2014.

This report compares contaminant concentrations measured in these airsheds to the NESAQ standards and to the Ministry for the Environment's air quality guidelines and indicator categories.

There were two airsheds which breached the NESAQ PM₁₀ standard over the winter of 2014.

1. Tokoroa – Nine exceedances were recorded in Tokoroa (the lowest number since 2003) with a maximum concentration of 69 µg/m³ recorded.
2. Putaruru – Two exceedances were also recorded in Putaruru with a maximum concentration of 73 µg/m³ recorded, resulting in a five-year extension of the airshed's polluted (secondary category) status.

Te Kuiti and Taupo continue to indicate a significant improvement with no exceedances recorded this year. A statistical analysis of seasonal PM₁₀ data collected in Hamilton, Te Kuiti and Taupo indicates that concentrations have decreased over the previous six or more year period. No statistically significant change has been identified for Tokoroa and the previous decreasing trend identified for Putaruru is no longer significant based on inclusion of the 2014 data.

¹ An airshed is an air quality management area that has been defined by a regional council or unitary authority as an area that potentially could or is known to breach the standards for air quality. These airshed designations must be gazetted by the Ministry for the Environment.

In Hamilton, PM_{2.5} concentrations exceeded the World Health Organisation (WHO) guideline of 25 µg/m³ (24-hour average) on five days during 2014 and coincided with the five days when PM₁₀ was most elevated.

Concentrations of CO in Hamilton were well below the NESAQ standard of 10 mg/m³ (8-hour average) during 2014. While concentrations of NO₂ in Hamilton were below the NESAQ standard of 200 µg/m³, concentrations reached just under 50% of the standard during 2014.

Concentrations of benzene in Hamilton were within the national guideline of 3.6 µg/m³ and an improving or “levelling” trend is evident for annual average concentrations at all sites. The highest annual concentration was measured at the Greenwood Street monitoring site and was 2.5 µg/m³. Concentrations of toluene, ethylbenzene and xylene were also well within acceptable international criteria.

1 Introduction

The National Environmental Standards for Air Quality (NESAQ) has mandated ambient air quality standards (maximum concentration limits) for five contaminants along with averaging periods and number of allowable exceedances (refer to Table 1.1). A breach of the standards occurs when more than the allowable number of exceedances occurs within the specified period.

The concept of an “airshed” is defined by the NESAQ regulations as an “air quality management area” that has been identified by Regional Councils and Unitary Authorities and made public. The Waikato Region has 20 such “airsheds” which typically have boundaries that approximate the town boundaries of urban centres (refer to Figure 1.1).

In the Waikato Region the main air contaminant of concern is PM₁₀ (particles in the air less than 10 microns in diameter). PM₁₀ is generated from burning fuels such as wood, coal or oil from domestic fires, vehicles and industry, as well as natural sources such as sea salt, dust, pollens and volcanic activity.

A standard for PM₁₀ has been set at 50 micrograms per cubic metre of air (50 µg/m³) when averaged over 24-hours. The standard allows for one exceedance per 12 month period. More than one exceedance over this period triggers a breach of the standard. Concentrations of PM₁₀ have historically exceeded the ambient air quality standard in Hamilton, Tokoroa, Taupo, Te Kuiti and Putaruru during winter months. The main source of PM₁₀ concentrations in these areas during the winter months is solid fuel burning for domestic home heating.

Under the NESAQ an airshed is classified as a polluted airshed if it has average PM₁₀ exceedances of more than one per 12 month period, for the immediately prior five year period. To get re-classified as non-polluted, a polluted airshed needs to have no more than 1 exceedance per 12 months for a period of five years.

The NESAQ requires a ban on the use of any new open fireplaces installed inside domestic dwellings 12 months after an airshed first becomes classified as polluted. Restrictions are also imposed on air discharges from industry that have significant PM₁₀ emissions which contribute to a polluted airshed.

In 2014, PM₁₀ concentrations were measured in Hamilton, Tokoroa, Taupo, Te Kuiti, Putaruru, Turangi, Cambridge and Te Awamutu-Kihikihi. In Hamilton additional monitoring was carried out for PM_{2.5} (particles in the air less than 2.5 microns in diameter), carbon monoxide, oxides of nitrogen as well as benzene, ethyl benzene, toluene and xylenes. Prior to April 2013, monitoring of PM₁₀ has also taken place in Matamata, Ngaruawahia and Waihi². Monitoring of PM₁₀, sulphur dioxide and oxides of nitrogen were also monitored at two locations within Huntly airshed in 2014 by Genesis Energy. Both monitoring sites are owned and operated by Genesis Energy Ltd as part of the Huntly Power Station resource consent monitoring requirements.

The required target date for compliance with the NESAQ for PM₁₀ was reviewed in 2011 and revised from 2013 to 2016 for most airsheds in New Zealand. Airsheds with more than one exceedance but less than 10 exceedances of the 50 µg/m³ standard have to achieve no more than one exceedance by 1 September 2016. Airsheds that have 10 or more exceedances of 50 µg/m³ have an interim target of no more than three exceedances by 1 September 2016 and a final target of no more than one exceedance

² The Waihi air quality monitoring site was disestablished at the beginning of 2012 and the Matamata and Ngaruawahia monitoring stations were disestablished in April 2013. Previous monitoring of PM₁₀ in these three airsheds over a period of four or more years indicates that PM₁₀ concentrations are well below the NESAQ 24-hour standard of 50 µg/m³ (apart from Australian dust storm related exceedances in 2009). This disestablishment of monitoring sites where three or more years of monitoring has indicated no exceedances of the NESAQ is part of an ongoing monitoring strategy to re-deploy monitoring equipment in airsheds where air quality has not yet been monitored.

by 1 September 2020. Based on monitoring data collected up to 2014, Tokoroa has to meet the interim 2016 target of no more than three exceedances and the 2020 target of no more than one exceedance. Taupo, Te Kuiti and Putaruru must achieve no more than one exceedance by 2016. All other airsheds within the Waikato region must always meet the standard of no more than one exceedance per rolling 12 month period i.e. the requirement for compliance is current.

Based on previous monitoring, most other contaminants are unlikely to be in breach of their respective NESAQ standards or ambient air quality guidelines in urban areas of the Waikato. Generally, the majority of resources for air quality monitoring in the Waikato Region has focused on PM₁₀. However, there is evidence that nitrogen dioxide can be reasonably elevated in urban areas of Hamilton where there is a high density of traffic.



Figure 1-1: Map of Waikato Region indicating the 20 urban centres that have been gazetted as airsheds.

Table 1-1 National Environmental Standards for Air Quality (MfE, 2004).

Contaminant	NESAQ values		
	Concentration ^a	Averaging period	Allowable exceedances per 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 ^b	350 µg m ⁻³	1-hour	9
Sulphur dioxide ^b	570 µg m ⁻³	1-hour	0
Ozone	150 µg m ⁻³	1-hour	0

The Ministry for the Environment provides guidelines for ambient air quality (refer to Table 1.2) and air quality indicator categories to assist in the presentation and management of air quality in New Zealand (refer to 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 an indicative tool for evaluating trends in concentrations over time.

Table 1-2 Ambient air quality guidelines for New Zealand (MfE 2002).

Contaminant	2002 guideline values	
	Concentration ^a	Averaging Period
Carbon monoxide	30 mg m ⁻³	1-hour
	10 mg m ⁻³	8-hour
Particles (PM ₁₀)	50 µg m ⁻³	24-hour
	20 µg m ⁻³	Annual
Nitrogen dioxide	200 µg m ⁻³	1-hour
	100 µg m ⁻³	24-hour
Sulphur dioxide ^b	350 µg m ⁻³	1-hour
	120 µg m ⁻³	24-hour
Ozone	150 µg m ⁻³	1-hour
	100 µg m ⁻³	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 (calc. monthly)
Benzene (year 2002)	10 µg m ⁻³	Annual
Benzene (year 2010)	3.6 µg m ⁻³	Annual
1,3-Butadiene	2.4 µg m ⁻³	Annual
Formaldehyde	100 µg m ⁻³	30-minutes
Acetaldehyde	30 µg m ⁻³	Annual
Benzo(a)pyrene	0.0003 µg m ⁻³	Annual
Mercury (inorganic) ^d	0.33 µg m ⁻³	Annual
Mercury (organic)	0.13 µg m ⁻³	Annual
Chromium VI ^d	0.0011 µg m ⁻³	Annual
Chromium metal & chromium III	0.11 µg m ⁻³	Annual
Arsenic (inorganic) ^d	0.0055 µg m ⁻³	Annual
Arsine	0.055 µg m ⁻³	Annual

Notes for Tables 1.1 and 1.2:

^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 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 exceedances if trends are not curbed
Action	More than 100% of the guideline	Exceedances of the guideline are a cause for concern and warrant action, particularly if they occur on a regular basis

Although the MfE categories are primarily used as air quality indicators, the Waikato Regional Plan takes a further regulatory step by specifying designated policy responses that should correspond to each zone. Policy 3 of the Air Module of the Waikato Regional Plan contains regional ambient air quality categories and the designated response that the Council will take when developing air quality management framework. Policy 3 states that 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.

There are no national guidelines or standards for PM_{2.5} (particles in the air less than 2.5 microns in diameter). The World Health Organisation guidelines are therefore the most relevant for application in New Zealand (refer to Table 1.4).

Table 1-4 World Health Organisation guidelines for PM_{2.5} (2005).

Concentration	Averaging Period
25 µg m ⁻³	24-hour
10 µg m ⁻³	Annual

1.1 Reporting period

The reporting period for PM₁₀ was from 1 January to 31 December 2014 (a calendar year). In 2006 Waikato Regional Council introduced a September to August reporting period. This reporting period was introduced for a number of reasons including ensuring that results were reported as soon as possible after the peak winter PM₁₀ concentrations. However, the 2011, 2012, 2013 and 2014 annual air quality reports have been prepared based on a reporting period of January to December. This is the same format as historical reports and is consistent with other regional council reporting around the country.

The reporting period for carbon monoxide was 6 March 2014 to 10 June 2014 and the reporting period for oxides of nitrogen was 10 June 2014 to 10 September 2014 (two consecutive three month surveys).

The reporting period for benzene, toluene, ethylbenzene and xylenes (BTEX) was 18 December 2014 to 18 December 2014. Aligning the reporting period for BTEX with the

calendar year is not feasible as it would require staff to deploy passive sampling equipment on 1 January. This 10 day misalignment with the calendar year is of little concern when reporting annual averages and it is not expected that there would be any difference in the annual averages if the passive samplers were instead deployed on 1 January each year.

2 Methodology

Measured concentrations of PM₁₀ can be influenced by the method used to monitor PM₁₀. From 2006 a number of air quality monitoring sites in the Waikato region have had gravimetric samplers run in conjunction with existing Beta Attenuation Monitors (BAMs). Waikato Regional Council staff have used the results to determine site specific differences between methods and data and have adjusted accordingly, where appropriate, for gravimetric equivalence. Prior to 2007, data were not adjusted. Some adjustment equations were updated in 2010 as a result of additional monitoring and these equations have been used in the 2011, 2012, 2013 and 2014 reports.

Prior to 2014, PM₁₀ concentrations were monitored at the now decommissioned Peachgrove Road air quality monitoring site in Hamilton, using a Tapered Elemental Oscillation Microbalance (TEOM) with a sample temperature setting of 40 degrees centigrade. Concentrations of PM₁₀ measured using the TEOM were adjusted based on equation 2.1.

$$\text{Corrected PM}_{10} = 1.19975 \times \text{RawTEOM} - 3.9182 \quad \text{Equation 2.1}$$

In Tokoroa, a ThermoAndersen FH62 C14 BAM has been used to monitor air quality since 2005. A Sequential Partisol gravimetric sampler was co-located at this site. Equation 2.2 shows the adjustments made to the FH62 data for consistency with the gravimetric method.

$$\text{Corrected PM}_{10} = 10^{(1.09945 \log \text{BAM} - 0.08595)} \quad \text{Equation 2.2}$$

Gravimetric sampling was conducted at the Gillies Street site in Taupo from March 2007. Concentrations of PM₁₀ measured using the FH62 C14 BAM during 2011 were adjusted based on equation 2.3.

$$\text{Corrected PM}_{10} = 1.255 \text{BAM} - 1.538 \quad \text{Equation 2.3}$$

Air quality data at the Putaruru site have been adjusted based on Equation 2.4. This equation was updated in 2010.

$$\text{Corrected PM}_{10} = 1.106 \text{BAM} - 2.38 \quad \text{Equation 2.4}$$

Concentrations of PM₁₀ at Hamilton (Ohaupo Road and Claudelands Event Centre), Te Kuiti, Matamata, Ngaruawahia and Turangi sites were measured using an FH62 C14 BAM. No adjustments have been made to concentrations measured at these sites. In the case of Te Kuiti and Matamata, reference method sampling has confirmed that no adjustment of BAM data is necessary. For the other sites, the possible need for any site-specific correction remains to be assessed.

At the Hamilton (Claudelands Event Centre), Tokoroa, Taupo and Te Kuiti air quality monitoring sites, meteorological data, including temperature, wind speed and wind direction were collected. Relative humidity was also collected at Hamilton (Claudelands Event Centre) and Taupo. Meteorological data were not available for the Putaruru, Turangi, Cambridge and Te Awamutu sites. At sites where it was available, meteorological data were compared with PM₁₀ on days when pollution was elevated.

Waikato Regional Council staff has managed most sites in the Waikato air quality monitoring network since August 2005. Prior to that the monitoring network was operated and maintained by NIWA. The Partisol Model 2000 PM₁₀ sampler at the Taupo site was operated by the Institute of Geological and Nuclear Sciences Ltd (GNS) on behalf of Waikato Regional Council.

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

3 Hamilton

3.1 Air quality monitoring in Hamilton

In Hamilton air quality has been measured, prior to 2014, at a monitoring site in Peachgrove Road located on the south-east side of Hamilton City since November 1997. The site met the requirements of the “Residential Peak” site classification as described in the ‘*Good Practice Guideline for Air Quality Monitoring and Data Management 2009*’ report (MfE, 2009). During 2014,

The monitoring station at Peachgrove Road was decommissioned on 18 October 2013 because the property, previously owned by Mighty River Power, changed ownership in December 2013 and Waikato Regional Council was required to remove the station as part of the sale agreement. A replacement station has been installed, as of April 2014, in the grounds of Claudelands Events Centre on Heaphy Terrace. This new station is currently operating as the main “residential” monitoring site for Hamilton. During 2014, daily and hourly average PM₁₀ and PM_{2.5} concentrations were measured at the Claudelands site using two separate FH 62 BAMs.

From March 2012, air quality has also been measured at a second monitoring site located adjacent to the NZ Blood Service at the Waikato Hospital on the corner of Ohaupo Road and Lorne Street. This site is traffic and industry focussed. During 2014, daily and hourly average PM₁₀ concentrations were measured at the site using a FH 62 BAM.

From 6 March 2014 to 10 June 2014 carbon monoxide was monitored and from 10 June 2014 to 10 September 2014 oxides of nitrogen were monitored at Ohaupo Road using an Ecotech ML/EC 9830 CO analyser (gas phase infrared) and a Ecotech ML/EC 9841 NO_x analyser (gas phase chemiluminescence) respectively. Operational aspects of the carbon monoxide and oxides of nitrogen monitoring including maintenance, calibration and quality assurance were carried out by Watercare Ltd for Waikato Regional Council.

Benzene, ethyl-benzene, toluene and xylenes (BTEX) have also been monitored at various locations of high traffic around Hamilton. These include Bridge Street, Claudelands Road, Peachgrove Road Intermediate School, Greenwood Street and Tristram Street.

Passive sampling for the volatile organic compounds (VOCs) benzene, ethyl-benzene, toluene and xylenes was carried out using 3M Passive Diffusion Monitors. 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).

Figure 3.1 shows the main Claudelands air quality monitoring station site (Monitoring Station 1 on the eastern side of the Waikato River) and the Ohaupo Road monitoring station site (Monitoring Station 2 on the western side of the Waikato River).



Figure 3-1: Hamilton Airshed and air quality monitoring station sites. Station 1 is located at Claudelands Events Centre grounds, and Station 2 is located at Ohaupo Rd (*Station 1 was previously located at Peachgrove Rd).

3.2 PM₁₀ concentrations for Hamilton

There were no PM₁₀ exceedances of 50 µg/m³ (24-hour average) measured in Hamilton during 2014. A maximum 24 hour average concentration of 46 µg/m³ was measured on 15 June at the Claudelands site and a maximum 24 hour average concentration of 32 µg/m³ was measured on 28 May at the Ohaupo Road site. This compares with eight exceedances³ in 2013 and a maximum of 136 µg/m³ (caused by works associated with the upgrading of the Peachgrove Road/Te Aroha Street/Ruakura Road intersection), no exceedances during 2012, one exceedance during 2011, no exceedances during 2010 and two exceedances with concentrations of 54 µg/m³ measured during 2009. A further exceedance in 2009 (the previous maximum PM₁₀ concentration recorded at Hamilton) with a concentration of 101 µg/m³ coincided with a dust storm event in Australia.

There were five PM_{2.5} exceedances of the World Health Organisation (WHO) guideline of 25 µg/m³ (24-hour average) measured during 2014. A maximum 24 hour average PM_{2.5} concentration of 46 µg/m³ was measured on 15 June at the Claudelands site which is the same day as the maximum PM₁₀ concentration was recorded. The five PM_{2.5} exceedances coincided with the five days when PM₁₀ was most elevated (refer to Table 3.1). On average over these five days, PM_{2.5} represented approximately 95% of the PM₁₀ concentration.

³ An application was made to the Minister for the Environment in August 2013 and an exemption for the eight exceedances was provided by the Minister in November 2013. As a result, the exceedances do not count towards determining the polluted status of the Hamilton airshed i.e. Hamilton remains a non-polluted airshed and the industry offset and open fire place ban regulations of the NESAQ are not triggered.

Table 3-1: Exceedances of the WHO guideline for 24-hour average PM_{2.5} compared with PM₁₀ concentrations.

Date	PM _{2.5} concentration (µg/m ³)	PM ₁₀ concentration (µg/m ³)
17/05/2014	32	34
28/05/2014	36	37
14/06/2014	26	29
15/06/2014	46	46
10/08/2014	26	29

Daily PM₁₀ and PM_{2.5} concentrations measured at Hamilton during 2014 are shown in Figures 3.2, 3.3 and 3.4.

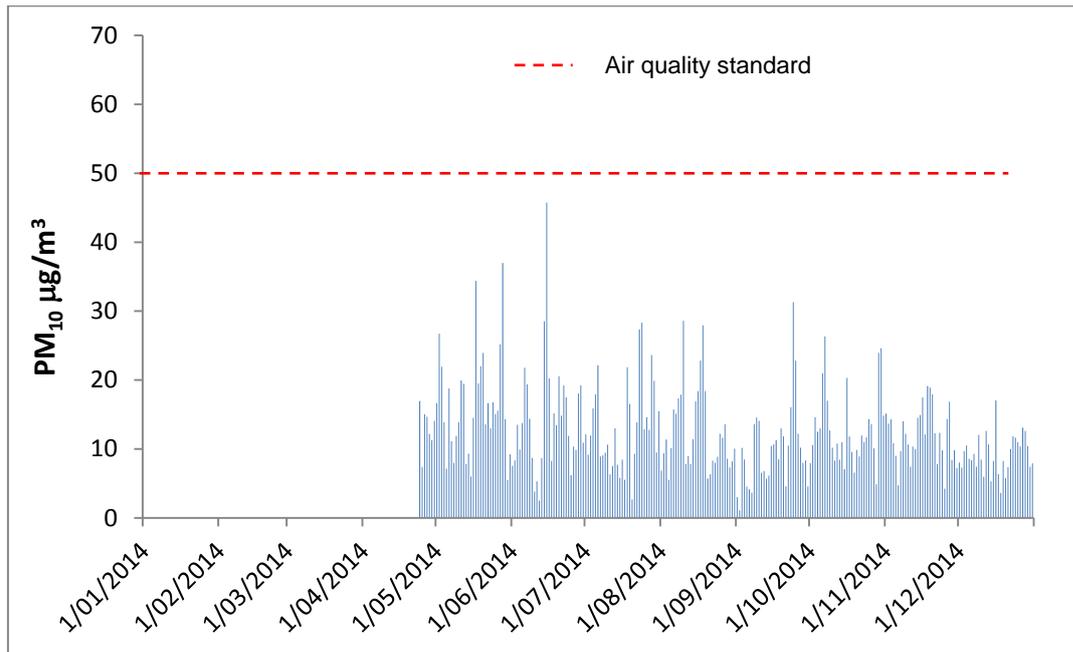


Figure 3-2: Daily average PM₁₀ concentrations measured at Claudelands during 2014.

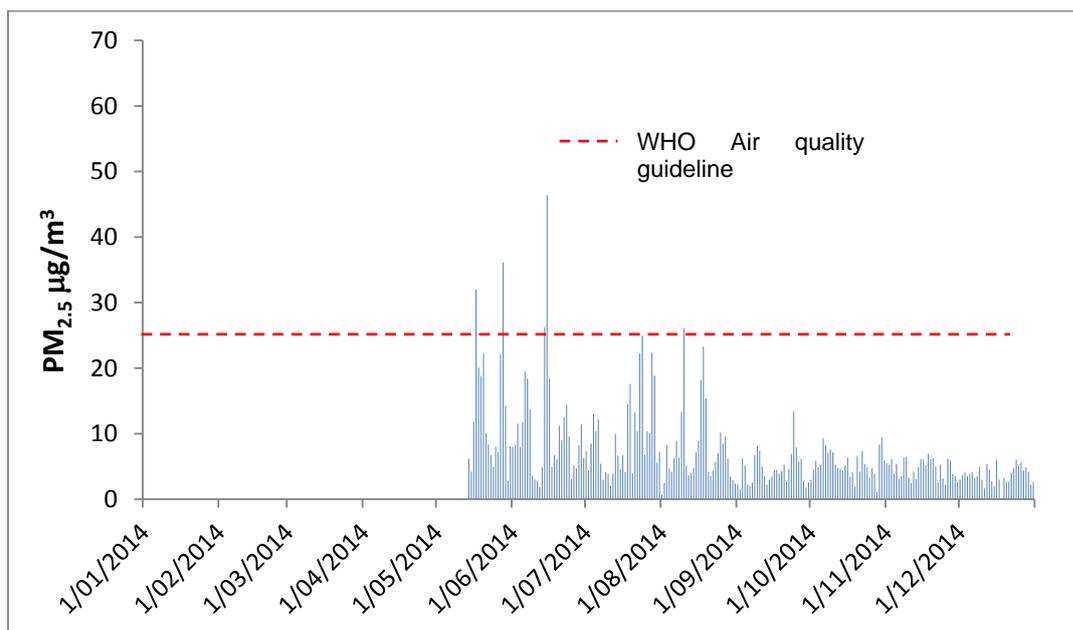


Figure 3-3: Daily average PM_{2.5} concentrations measured at Claudelands during 2014.

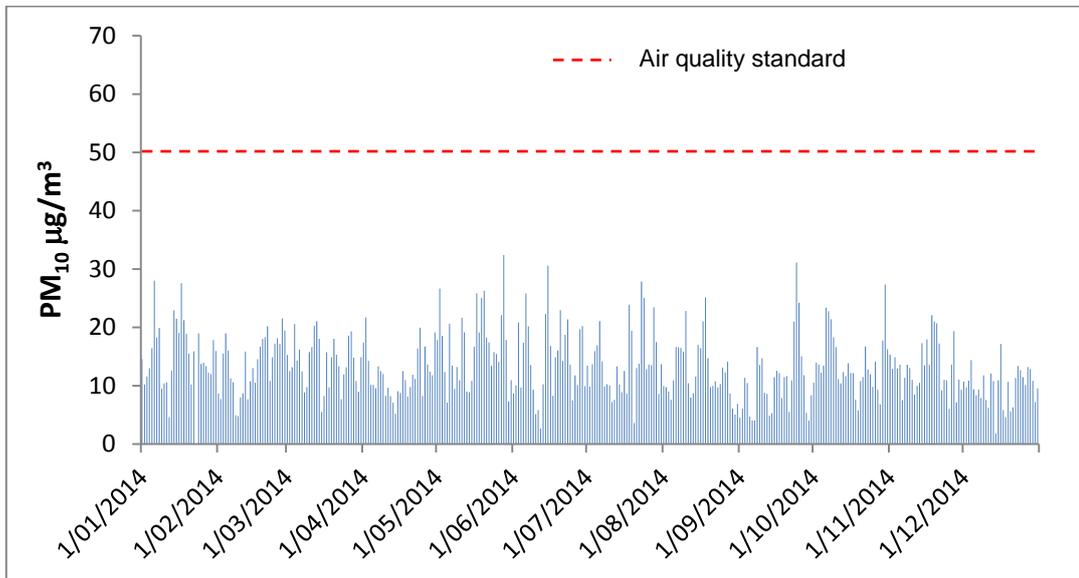


Figure 3-4: Daily average PM₁₀ concentrations measured at Ohaupo Road during 2014.

Figure 3.5 compares daily PM₁₀ concentrations measured from 2000 to 2014, for Peachgrove Road/ Claudelands site, to the MfE air quality indicator categories (shown in Table 1.3). During 2014 the majority of the PM₁₀ concentrations measured were less than 33% of the air quality guideline and similar to the indicator category mix observed in 2012.

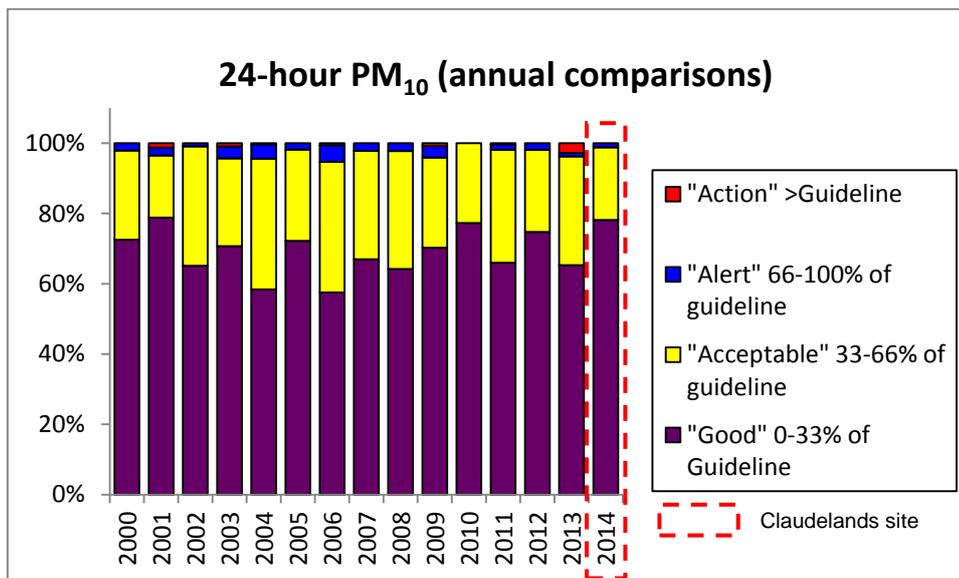


Figure 3-5: Comparison of PM₁₀ concentrations measured at Peachgrove Road/ Claudelands site in Hamilton from 2000 to 2014 to air quality indicator categories.

Figure 3.6 shows the seasonal variations in the distribution of PM₁₀ concentrations during 2014 for Claudelands with an increased proportion of concentrations above 33% of the air quality category during the winter months.

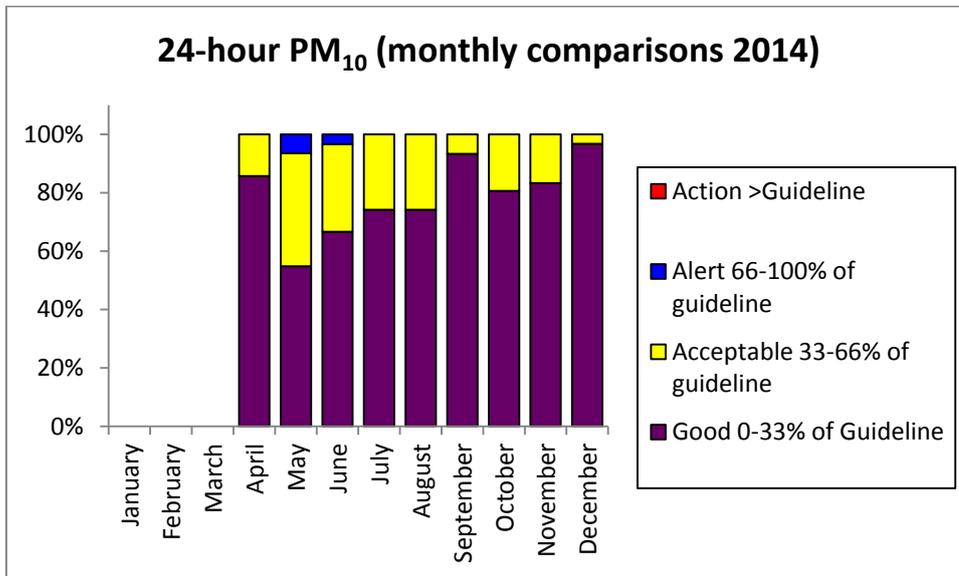


Figure 3-6: Comparison of daily PM₁₀ concentrations measured at Claudelands each month during 2014 to air quality indicator categories.

Figure 3.7 compares daily PM₁₀ concentrations measured from 2012, 2013 and 2014, for Ohaupo Road, to the MfE air quality indicator categories (shown in Table 1.2). During 2014 the majority of the PM₁₀ concentrations measured were less than 33% of the air quality guideline, similar to 2012 and 2013.

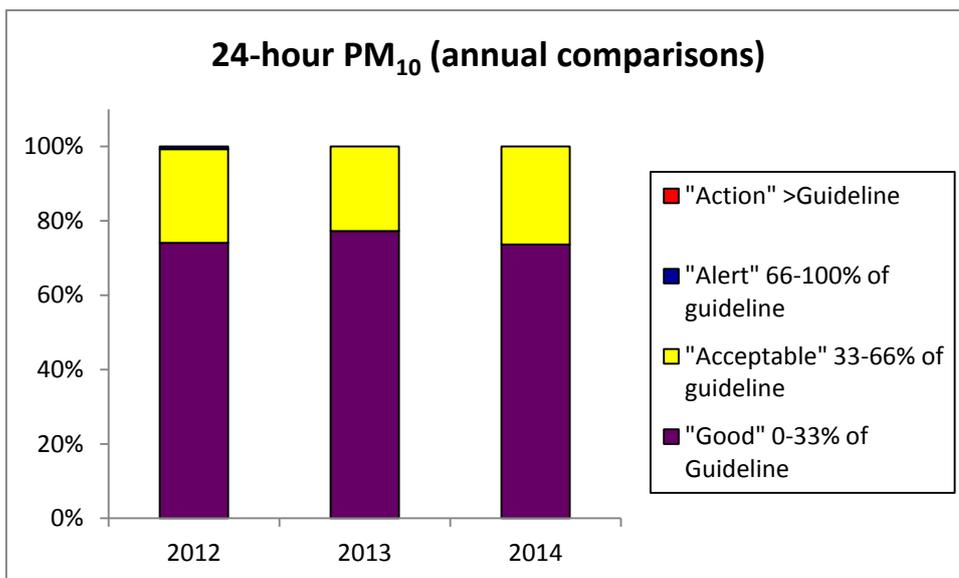


Figure 3-7: Comparison of PM₁₀ concentrations measured at Ohaupo Road in Hamilton from 2012 to 2014 to air quality indicator categories.

Figure 3.8 shows the seasonal variations in the distribution of PM₁₀ concentrations during 2014 for Ohaupo Road with an increased proportion of concentrations above 33% of the air quality category during the winter months

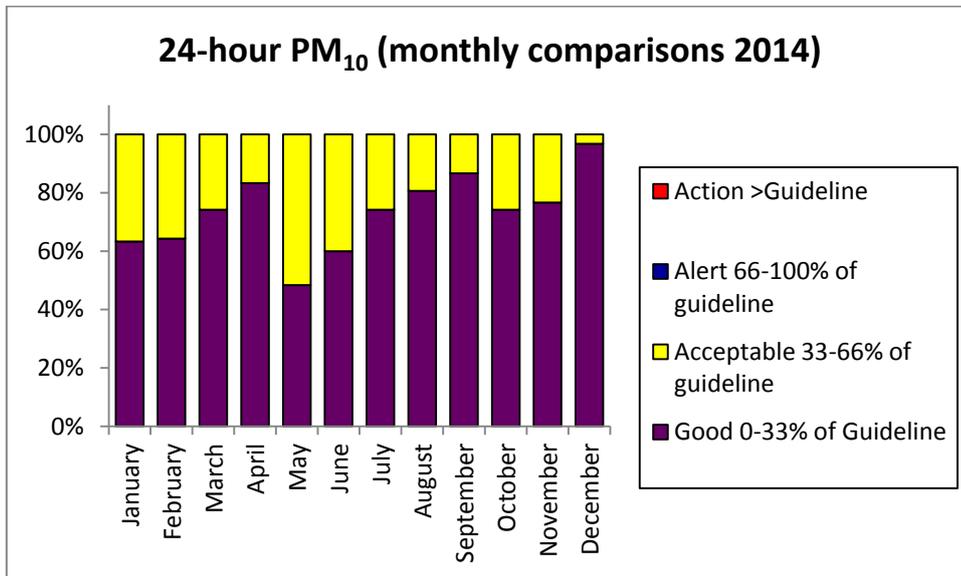


Figure 3-8: Comparison of daily PM₁₀ concentrations measured at Ohaupo Road in Hamilton each month during 2014 to air quality indicator categories.

Figure 3.9 shows the variations in the monthly average PM₁₀ concentrations during 2014 for Claudelands and Ohaupo Road which were very similar for both stations.

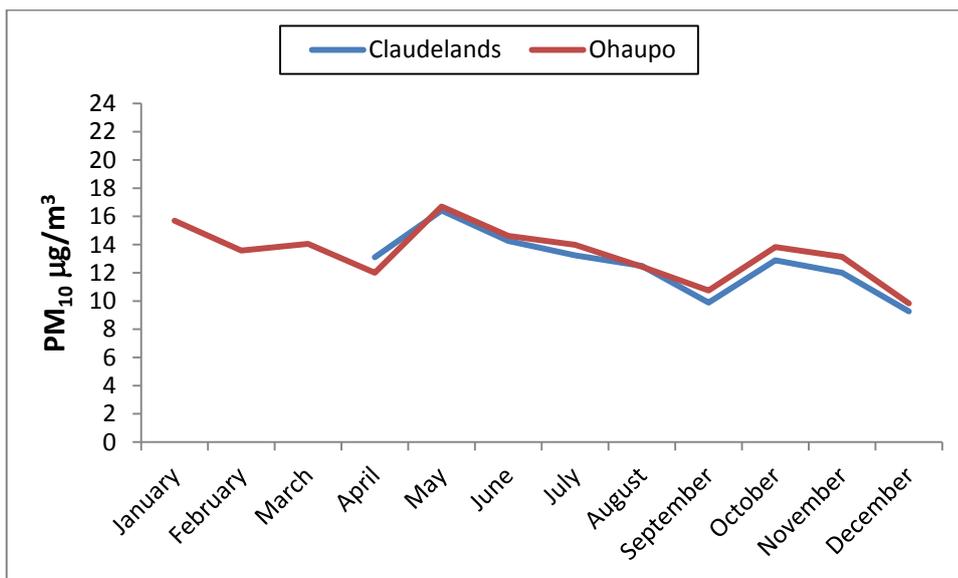


Figure 3-9: Comparison of monthly PM₁₀ concentrations measured at Claudelands and Ohaupo Road in Hamilton in 2014.

Figure 3.10 shows the number of days when 50 µg/m³ was exceeded, the maximum concentration and the 2nd highest concentration from 2006 to 2014 for Peachgrove Road/ Claudelands. The years 2009 and 2013 are considered abnormal due to the occurrence of exceptional circumstances. An elevated exceedance with a concentration of 101 µg/m³ occurred in 2009 as result of the Australian dust storm. Eight exceedances with a maximum concentration of 136 µg/m³ occurred in 2013 as a result of the works associated with the upgrading of the Peachgrove Road/Te Aroha Street/Ruakura Road intersection. Since 2010 the general pattern of one or no exceedances (ignoring 2013) indicates that the NES is likely to continue to be complied with.

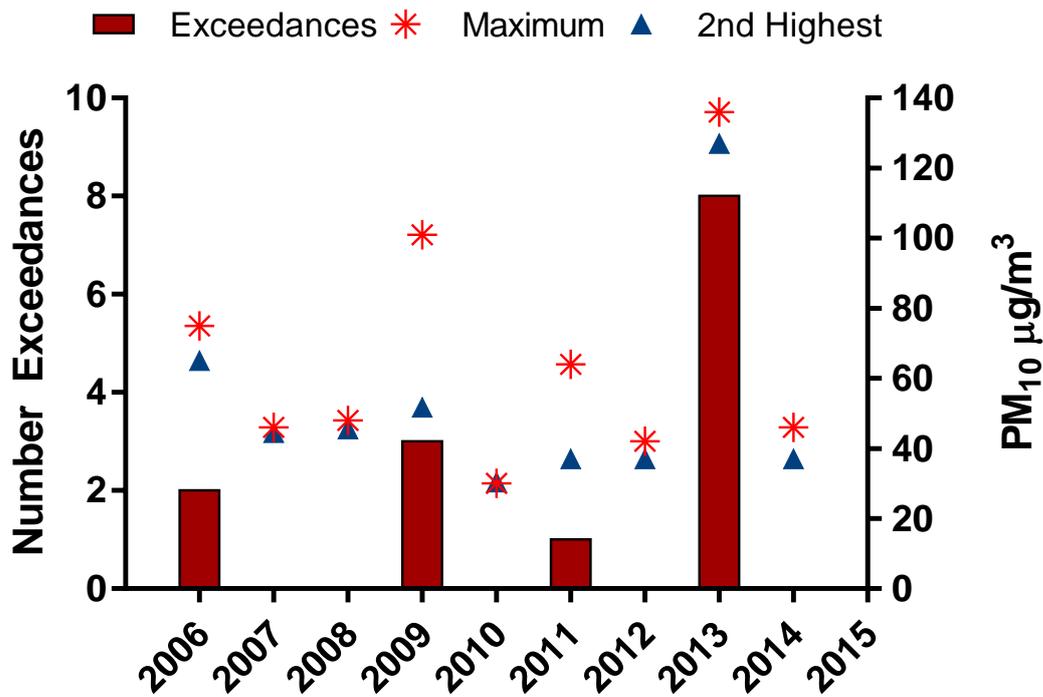


Figure 3-10: Number of days when 50 µg/m³ was exceeded at Peachgrove Road/ Claudelands compared with the maximum concentration and the 2nd highest concentration measured from 2006 to 2014.

The annual average PM₁₀ concentration for Ohaupo Road for 2014 was 13.4 µg/m³ which is similar in magnitude to previous years for both Ohaupo Road and Peachgrove Road. For Claudelands, a winter seasonal average is more appropriate to mitigate the bias of the missing data prior to late April 2014. The winter average (May to August) for 2014 was 14.1 µg/m³ which is similar to previous years at Ohaupo Rd and Peachgrove Rd. The Ministry for the Environment specifies an annual average guideline for PM₁₀ of 20 µg/m³ (MfE, 2002). An annual average PM₁₀ concentration is not specified in the NES.

Summary statistics for PM₁₀ monitoring data from the Ohaupo Road site for 2012 to 2014 and from the Peachgrove Road/ Claudelands site from 2000 to 2014 are shown in Table 3.2 and 3.3 respectively. Since 2007 concentrations measured at the Peachgrove Road site were adjusted for differences between the TEOM and gravimetric sampling methods as detailed in Section 2 of this report.

Table 3-2: Summary of PM₁₀ concentrations measured at Ohaupo Road in Hamilton for 2012 to 2014.

Indicator	2012	2013	2014
"Good" 0-33% of guideline	74%	77%	74%
"Acceptable" 33-66% of guideline	25%	23%	26%
"Alert" 66-100% of guideline	0.8%	0%	0%
"Action" >Guideline	0%	0%	0%
Percentage of valid data	73%	100%	100%
Annual average (µg/m ³)	13.5	13.3	13.4
Measured exceedances	0	0	0
99.7 %ile PM ₁₀ concentration (µg/m ³)	37	30	31
2 nd High PM ₁₀ concentration (µg/m ³)	35	30	31
Annual maximum (µg/m ³)	41	32	32
Number of records	266	365	364

Table 3-3: Summary of PM₁₀ concentrations measured at Peachgrove Road/ Claudelands in Hamilton from 2000 to 2014¹.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Monitoring Method	TEOM	BAM												
Monitoring Site	Peach-grove	Claude-lands												
"Good" 0-33% of guideline	79%	65%	71%	58%	72%	58%	67%	64%	70%	77%	66%	75%	65%	78%
"Acceptable" 33-66% of guideline	18%	34%	25%	37%	26%	37%	31%	34%	26%	23%	32%	23%	31%	21%
"Alert" 66-100% of guideline	2%	0.9%	3%	4%	2%	5%	2%	2%	3%	0%	2%	2%	1%	1%
"Action" >Guideline	1%	0%	0.9%	0.3%	0%	0.6%	0%	0%	0.8%	0%	0.3%	0%	3%	0%
Percentage of valid data	70%	93%	90%	94%	77%	100%	100%	100%	100%	99%	100%	100%	80%	69%
Annual average (µg/m ³)	13.5	14.7	14.5	16.4	14.0	16.5	14.7	15.3	14.4	13.1	14.4	13.4	13.7 ³	14.1 ³
Measured exceedances	3	0	3	1	0	2	0	0	3	0	1	0	8	0
99.7 %ile PM ₁₀ conc. (µg/m ³)	64	37	61	48	37	64	44	45	53	30	37	36	128	39
2 nd Highest PM ₁₀ conc. (µg/m ³)	60	37	60	48	36	65	45	46	52	30	37	37	127	37
Annual maximum (µg/m ³)	76	40	71	62	40	75	46	48	101	30	64	42	136	46
Number of records	256	338	328	344	281	363	364	364	363	361	364	364	291	252

1. Data from 2006 to 2013 inclusive is adjusted for gravimetric equivalency. Data from 2014 onwards is collected at the Claudelands site.
2. Note: data for 1998, 1999 and 2000 has been excluded from table due to formatting constraints.
3. Winter average rather than annual average due to limited datasets.

3.3 Concentrations of benzene, toluene and xylenes

In Hamilton, monitoring of benzene at the Peachgrove Road air monitoring site and at a high-density traffic area at Bridge Street has taken place since 2004. In 2005 an additional benzene sampling site was established at the intersection of Claudelands Road and Victoria Street (Claudelands Bridge). This is also a high density traffic area. Additional sites were established in 2006 in Tristram Street, Greenwood Street and at Hamilton Intermediate School.

Benzene concentrations measured at all locations in Hamilton during 2014 were within the Ministry for the Environment's 2010 annual guideline of $3.6 \mu\text{g}/\text{m}^3$ (Table 3.4). The guideline prior to 2010 was $10 \mu\text{g}/\text{m}^3$ (annual average). The highest annual concentration for 2014 was measured at the Greenwood Street monitoring site and was $2.5 \mu\text{g}/\text{m}^3$, a small decrease from the previous maximum of $2.7 \mu\text{g}/\text{m}^3$ measured at Greenwood Street in 2013 and 2012. (Figure 3.11). An improving or "levelling" trend is evident for annual average concentrations of benzene at all sites.

Large decreases in benzene concentrations were observed over the period 2004 to 2007. Prior to 2011, benzene concentrations had tapered relative to decreases observed from 2004 to 2007 (Figure 3.11). These earlier decreases were attributed to changes in fuel specifications and improved vehicle technology (Smith, 2007).

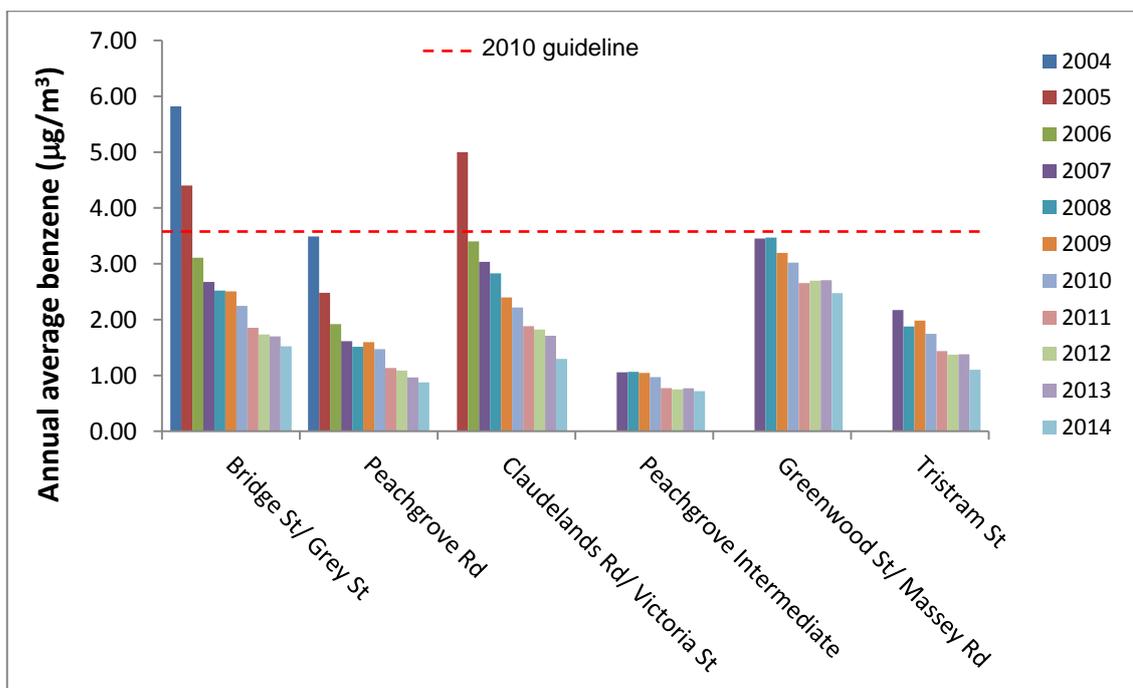


Figure 3-11: Annual average benzene measured at Hamilton sites (2004 to 2014).

Ethyl-benzene, 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 $190 \mu\text{g}/\text{m}^3$ and $950 \mu\text{g}/\text{m}^3$ for toluene and total xylenes respectively (MfE, 2000). The United States EPA Reference Concentration for ethyl-benzene is $1000 \mu\text{g}/\text{m}^3$ as an annual average. Concentrations of toluene, total xylenes and ethyl-benzene measured in Hamilton at all sites were significantly lower than the suggested MfE thresholds and USEPA Reference Concentration.

Table 3-4: Annual average concentrations of volatile organic compounds (VOCs) at Hamilton sites between 18 December 2013 to 18 December 2014.

VOC	Bridge St µg/m ³	Peachgrove Rd µg/m ³	Claudelands Rd µg/m ³	Peachgrove Intermediate µg/m ³	Greenwood St µg/m ³	Tristram St µg/m ³	Guideline ^a µg/m ³
Benzene	1.5	0.9	1.3	0.7	2.5	1.1	3.6 (10 ^a)
Ethyl-benzene	1.3	0.8	1.1	0.7	1.7	0.9	1000 ^b
Toluene	8.3	5.9	7.3	3.8	15.1	6.1	190 ^b
Total Xylenes	5.6	3.4	4.8	2.6	7.1	4.1	950 ^b

^a The historical guideline for benzene of 10 µg/m³ reduced to 3.6 µg/m³ in 2010.

^b There are currently no guideline values for ethyl-benzene, toluene and xylenes. Threshold values for toluene and total xylenes used here are from proposed amendments to the 1994 ambient air quality guidelines. For ethyl-benzene, the US EPA Reference Concentration has been used.

3.4 Concentrations of carbon monoxide

During 6 March 2014 to 10 June 2014, eight hourly average concentrations of carbon monoxide (CO) as measured at the Ohaupo Road monitoring station were well below the NESAQ standard for CO. The NESAQ standard for CO is 10 mg/m³ with one allowable exceedance per year (Refer to Figure 3.12). The eight-hour average concentrations of CO were less than 33% of the NES and national and regional ambient air quality guidelines and therefore fall within the good air quality indicator category (Refer to Table 3.5).

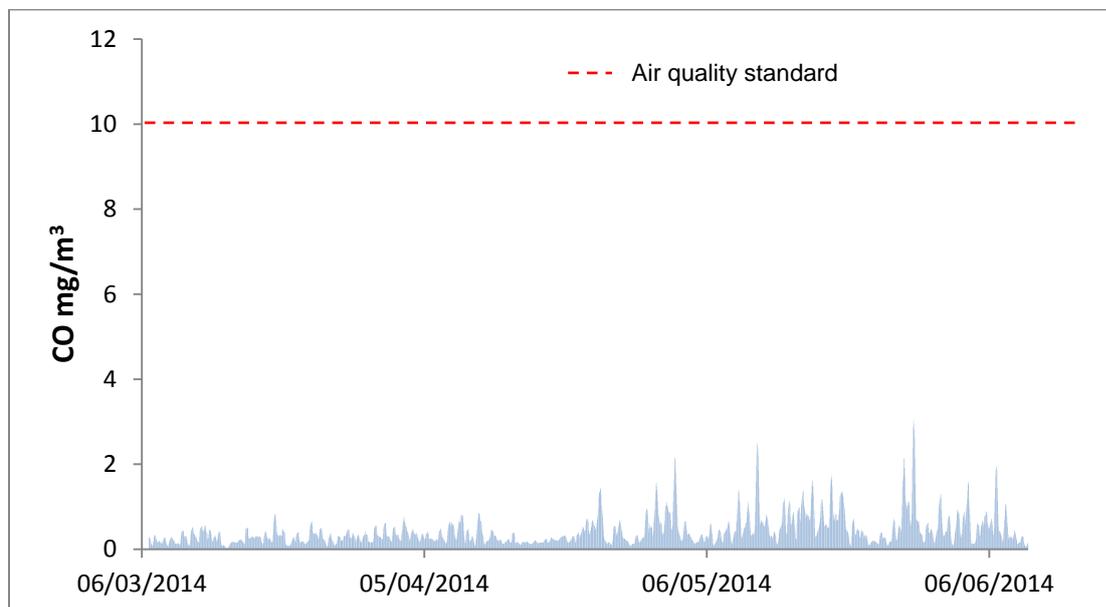


Figure 3-12: Eight hourly average CO concentrations measured during March 2014 to June 2014.

Table 3-5: Summary of 8-hour average CO concentrations measured during March 2014 to June 2014.

Indicator	2014
"Good" 0-33% of guideline	100%
"Acceptable" 33-66% of guideline	0%
"Alert" 66-100% of guideline	0%
"Action" >Guideline	0%
Percentage of valid data	100%
Annual average (mg/m ³)	0.4
Measured exceedances	0
99.7 %ile concentration (mg/m ³)	2.4
Annual maximum (mg/m ³)	3.0
Number of records	2291

3.5 Concentrations of nitrogen dioxide

During 10 June 2014 to 10 September 2014, one hourly average concentrations of nitrogen dioxide (NO₂) as measured at the Ohaupo Road monitoring station were well below the NESAQ standard for NO₂. The NESAQ standard for NO₂ is 200 µg/m³ with nine allowable exceedance per year (Refer to Figure 3.13). A maximum concentration of 91.1 µg/m³, which is less than 50% of the standard, was recorded on 3 July 2014 at 8 am. The one-hour concentrations of NO₂ were less than 66% of the NES and national and regional ambient air quality guidelines with the majority of data (99.1%) falling within the good air quality indicator category (Refer to Table 3.6).

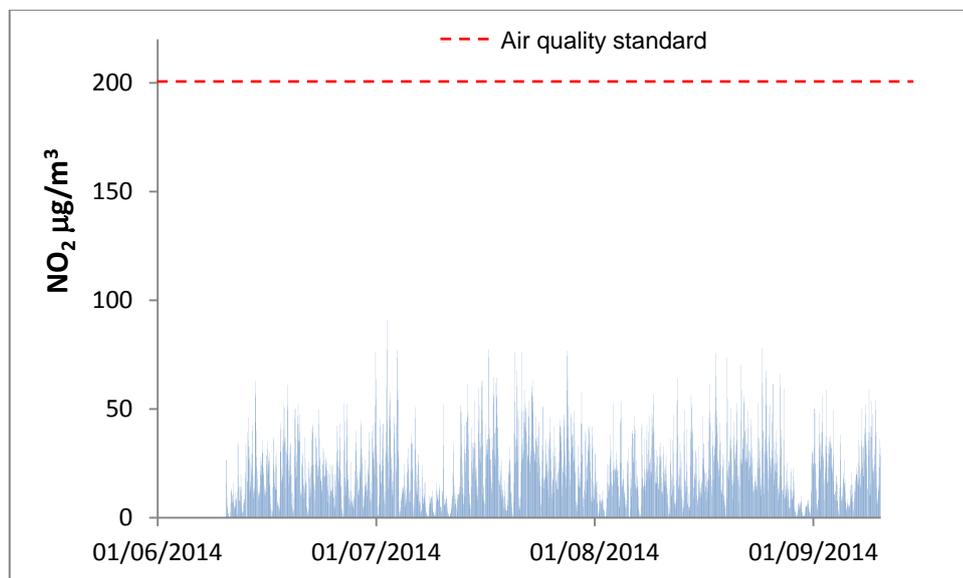


Figure 3-13: Hourly average NO₂ concentrations measured during June 2014 to September 2014.

Table 3-6: Summary of 1-hour average NO₂ concentrations measured during 2014.

Indicator	2014
"Good" 0-33% of guideline	99.1%
"Acceptable" 33-66% of guideline	0.8%
"Alert" 66-100% of guideline	0%
"Action" >Guideline	0%
Percentage of valid data	98%
Annual average (µg/m ³)	22.2
Measured exceedances	0
99.7 %ile PM ₁₀ concentration (µg/m ³)	76.5
Annual maximum (µg/m ³)	91.1
Number of records	2164

3.6 Comparison of meteorological conditions for 2014 to previous years

The frequency and extent of NES breaches from year to year depends largely on the prevalence of meteorological conditions conducive to elevated pollution, in particular low wind speeds, cooler temperatures and temperature inversions. Figure 3.14 and Figure 3.15 compare summary statistics for wind speed and temperature from 1998 to 2014. The significantly higher wind speed average of 8 m/s in 2009 indicates an anomaly with the data collected. Other Hamilton meteorological stations averaged around 3 m/s which is more consistent with that expected for the Peachgrove Rd data.

Collection of meteorological data over the May to August period in 2014 at Claudelands was sporadic and limited due to delays and problems with commissioning the meteorological equipment after the initial commissioning of the FH62 BAM in April. For this reason, the 2014 data is not sufficient to provide a statistical comparison with previous years.

An evaluation of meteorological conditions and PM₁₀ concentrations in Hamilton from 1998 to 2007 identified 24-hour average wind speed less than 0.74 m/s as the main meteorological characteristic of elevated PM₁₀ concentrations (Wilton, 2007). Figure 3.16 compares the number of days during the winter months when these meteorological conditions occurred from 2000 to 2014 and the number of days each year when PM₁₀ concentrations exceeded 50 µg/m³. Even when excluding the results for 2009 (refer anomalous data issue discussed above) there does not appear to be any clear evidence in recent years that elevated concentrations are linked to years when there is an increased number of days with low wind speeds over the winter season.

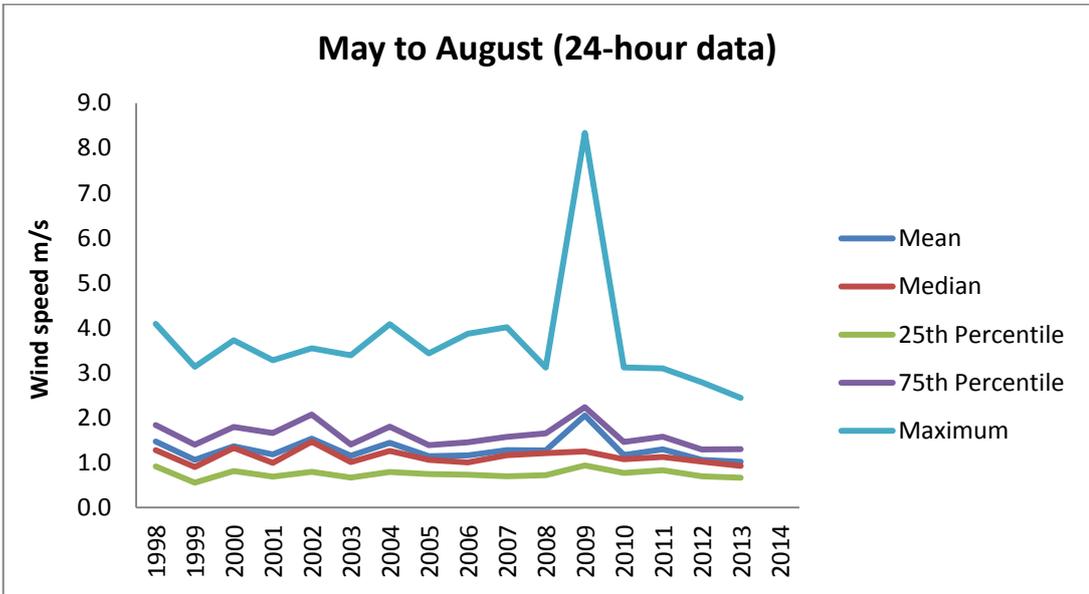


Figure 3-14: Summary wind speed data from 1998 to 2014 at the Peachgrove Road site (insufficient data available for 2014).

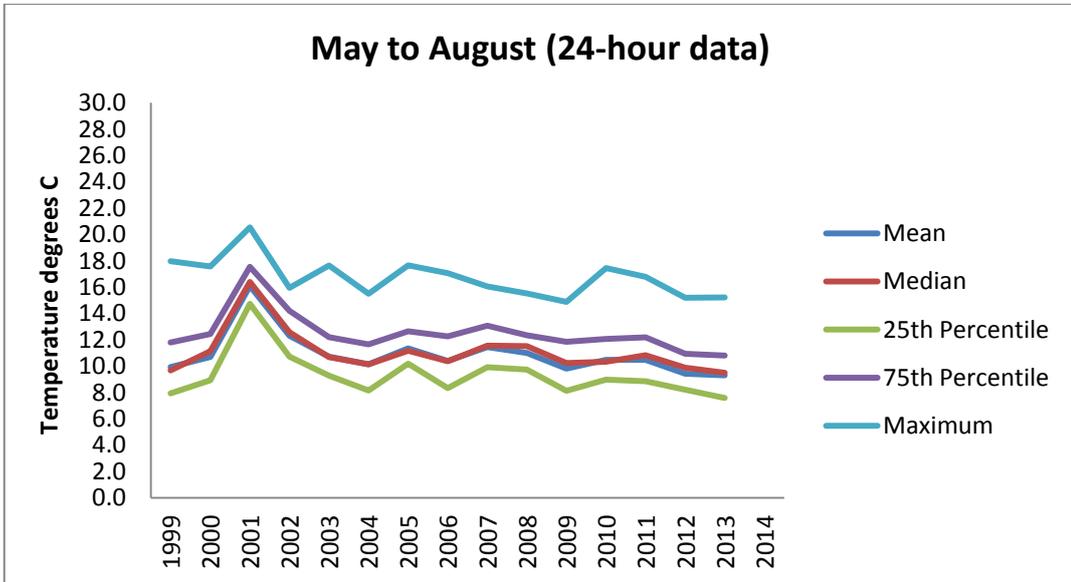


Figure 3-15: Summary temperature data from 1998 to 2014 at the Peachgrove Road site (insufficient data available for 2014).

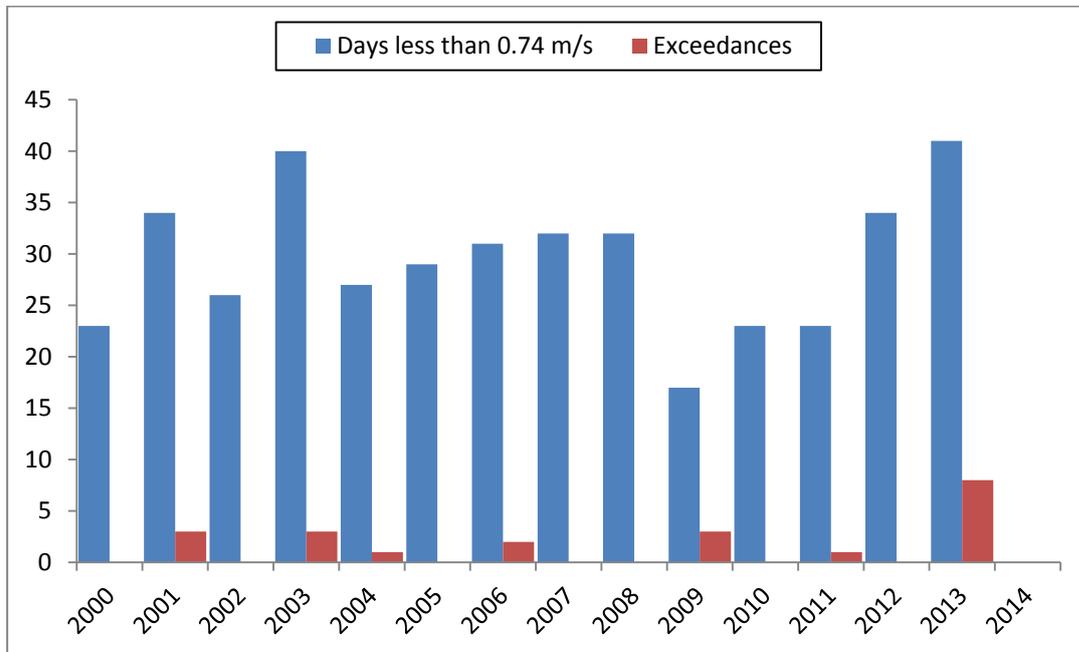


Figure 3-16: Number of days from May to August when the 24-hr average wind speed was less than 0.74 m/s and number of PM₁₀ exceedances per year (insufficient meteorological data available for 2014).

3.7 Daily variations on high pollution days

Meteorological conditions were available for only one of the five high pollution days recorded in 2014. Figure 3.17 shows the daily variations in PM₁₀ and PM_{2.5} concentrations and meteorological parameters on the 10 August 2014 when the daily average PM_{2.5} concentration exceeded 25 µg/m³ (PM_{2.5} = 26 µg/m³ and PM₁₀ = 29 µg/m³). The PM₁₀ and PM_{2.5} concentrations both peaked around 2 am with a very gradual drop off towards the middle of the day and a smaller peak at around 11 pm that evening.

The PM₁₀ and PM_{2.5} profiles are very similar apart from a more pronounced drop off to zero for PM_{2.5} during the middle of the day compared with a more elevated concentration of around 11 µg/m³ for PM₁₀. The profiles are reasonably typical of those that are observed in situations where woodburner emissions dominate the emission sources. However, the more elevated concentration of PM₁₀ during the middle of the day indicates a greater component of the coarser particulate fraction during that part of the day which is consistent with a dust source.

The wind speed and air temperature were both reasonably low during the peak PM₁₀ and PM_{2.5} concentrations on the 10 August 2014 compared with the days prior to and subsequent to this day (average daily wind speed of 1.2 m/s and average daily temperature of 6.5 degrees) indicative of conditions expected during high pollution events.

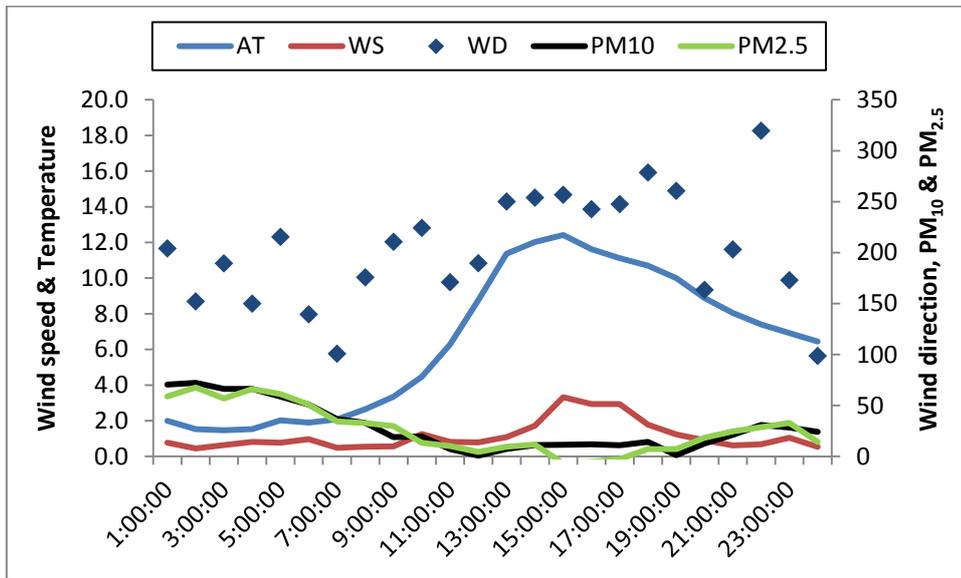


Figure 3-17: Daily variation in PM₁₀ and PM_{2.5} concentrations, wind speed, wind direction and temperature on 10 August 2014 when the daily average PM_{2.5} concentration exceeded 25 µg/m³.

3.8 Trend analysis

Over time, air quality may improve, get worse, or remain the same. Peak levels of PM₁₀ in any given airshed vary from winter to winter depending on meteorological conditions and human responses. For example, higher PM₁₀ and more exceedances might be expected if a winter has a greater number of days when the wind speed is low and there is vertical stability in the lower atmosphere. Over the short term this inter-annual variability will mask any genuine underlying trend toward better or worse air quality. A reasonably long monitoring record is needed to confirm or exclude the possibility of any underlying trend.

Seasonal Mann-Kendall test for monotonic trends (consistently increasing or decreasing trends) is the preferred approach for detecting underlying trends in variable environmental time-series data sets, and may suggest presence of an underlying trend which is not evident from visual inspection of the PM₁₀ record or summary statistics. This method generates probability (p) values that are used to assess the likelihood that the apparent relationship is genuine, or comes about fortuitously as a result of a random alignment of variables. The conventional threshold for deciding whether a relationship is likely to be genuine is at a probability value of $p = 0.05$ or lower, which corresponds to a 95% confidence level and greater. A negative MK-Stat indicates a decreasing trend.

As reported in the 2013 Air Quality Monitoring Report, Seasonal Mann Kendall test results for the Peachgrove Rd PM₁₀ data (MK-Stat of -2.05 and p-value of 0.04) provides possible evidence that PM₁₀ concentrations in Hamilton were decreasing over the period 2006 to 2013 (data corrections made for ignoring the impact of the eight exempted exceedances during 2013). The Claudelands site PM₁₀ data collected in 2014 has been excluded from this analysis as it is collected from a different site and cannot be included in the trend analysis for the Peachgrove Rd site. At least four year's data will be required before a trend analysis can be applied to data collected at the Claudelands site.

Based on this analysis and the current previous five year exceedance average (2010 to 2014) of 0.2 (2013 exceedances excluded), Hamilton could continue to meet the NES target of no more than one exceedance per 12 month period. But this will be dependent on meteorological conditions i.e. a particularly cold and calm winter could still result in more than one exceedance with in a 12 month period resulting in Hamilton being classified as a polluted airshed.

4 Tokoroa

4.1 Air Quality Monitoring in Tokoroa

In Tokoroa, monitoring for PM₁₀ has been carried out since 2001 at the Billah Street Reserve air quality monitoring site, located west of central Tokoroa. The monitoring site meets the requirements of the “Residential Neighbourhood” site classification as described in the *Good Practice Guideline for Air Quality Monitoring and Data Management 2009*, report (MfE, 2009).

In 1999, some air quality 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 in this air quality monitoring report due to uncertainties surrounding the monitoring method.

A MET ONE series 1020 BAM was used to monitor PM₁₀ from 2001 to September 2005 at the Billah Street site. In September 2005 the MET ONE instrument was replaced with a ThermoAndersen FH62 C14 BAM due to unacceptable data loss caused by frequent tape failure from the MET ONE. The FH62 BAM records data at ten minute intervals. Figure 4.1 shows the Tokoroa Airshed and the location of the air quality monitor in Tokoroa.



Figure 4-1: Tokoroa Airshed and air quality monitoring site.

4.2 PM₁₀ concentrations in Tokoroa

During 2014 there were 9 days when PM₁₀ concentrations exceeded 50 µg/m³. The dates and concentrations reached on these days are shown in Table 4.1. The maximum measured concentration was 69 µg/m³ and compares with a maximum of 59 µg/m³ and a total of 10 exceedances measured at the site during 2013. Daily PM₁₀ concentrations measured at Tokoroa during 2014 are shown in Figure 4.2.

Table 4-1: Dates and concentrations for exceedences of 50 µg/m³ in Tokoroa during 2014.

Date	PM ₁₀ µg/m ³	Rank	Date	PM ₁₀ µg/m ³	Rank
20/06/2014	69	1	28/05/2014	56	6
29/05/2014	67	2	15/06/2014	53	7
06/06/2014	62	3	18/05/2014	52	8
24/07/2014	58	4	17/05/2014	52	9
19/05/2014	56	5			

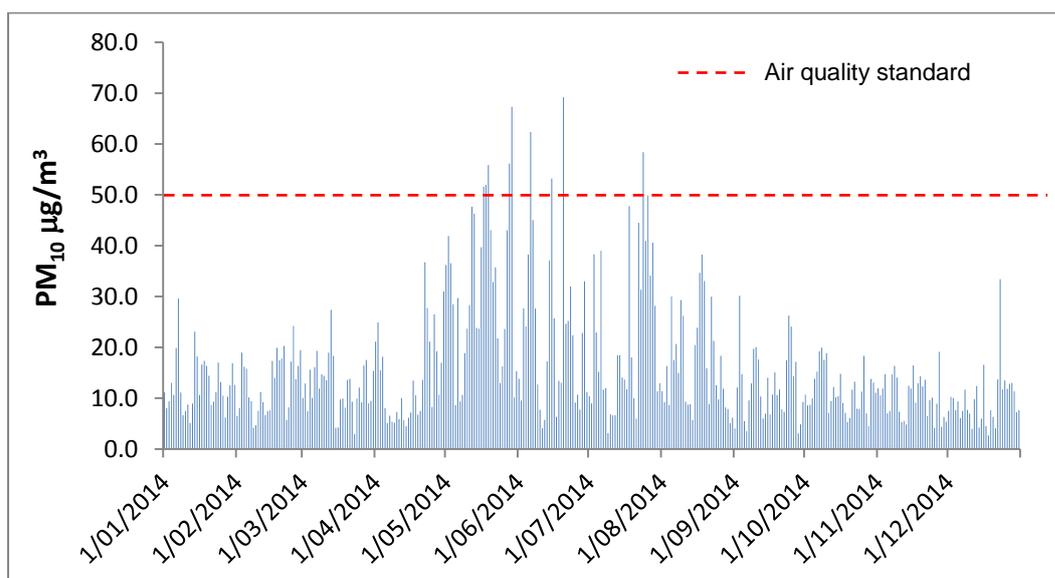


Figure 4-2: Daily average PM₁₀ concentrations measured in Tokoroa during 2014.

It is noted that the Met One BAM was changed to an FH62 BAM in September 2005, and a change in baseline readings was observed at that point (Smith, 2006). In 2007 and 2008 site-specific calibration against a gravimetric method was carried out. Comparison of results from the two co-located instruments suggest that:

- The previous BAM was recording an artificially high baseline reading, because the new instrument is accurate⁴ at low PM₁₀ concentrations, and
- The replacment BAM requires a significant upward correction across the mid and upper ranges, in the order of approximately 19% at a PM₁₀ concentration of 50 µg/m³. 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 report the approach taken has been to report only calibration-corrected data collected on the newer FH62 BAM during the monitoring years from 2006.

⁴ The newer BAM is more accurate when compared with the gravimetric reference method.

As a further check on this earlier gravimetric analysis, a sequential partisol was co-located with the FH62 BAM from May to October 2014. Analysis of the data indicates that the correction factor being applied is still valid with a correction being required in the order of approximately 19% at a PM₁₀ concentration of 50 µg/m³.

Figure 4.3 shows changes in PM₁₀ concentrations relative to air quality indicator categories at the Tokoroa site from 2006 to 2014 with typically around 3 to 6% of daily averages falling within the action category.

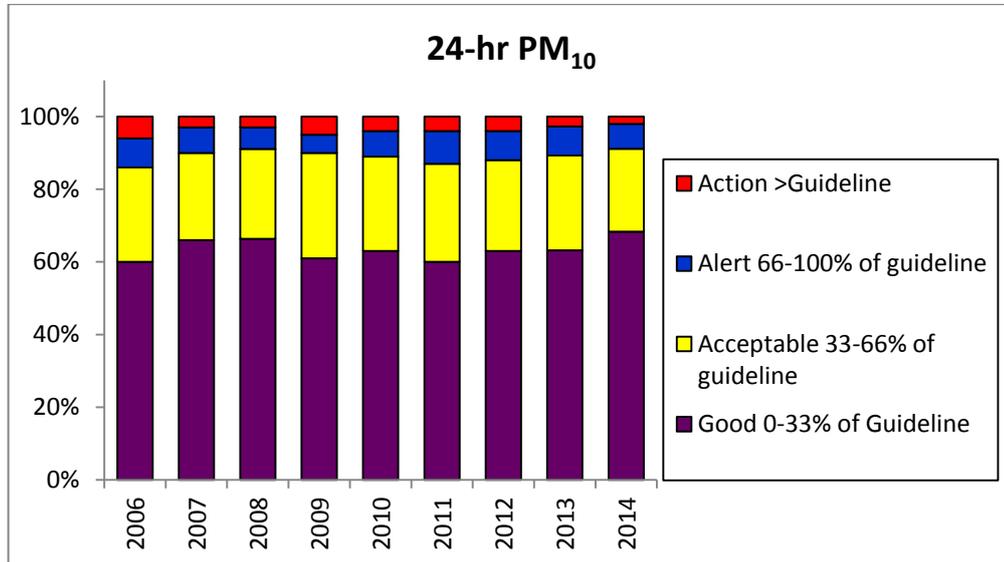


Figure 4-3: Comparison of PM₁₀ concentrations measured in Tokoroa from 2006 to 2014 to air quality indicator categories.

Figure 4.4 shows the seasonal variations in the distribution of PM₁₀ concentrations during 2014. There is a very evident seasonal pattern with regards winter versus summer daily averages with around three months of the year where the annual PM₁₀ standard is exceeded.

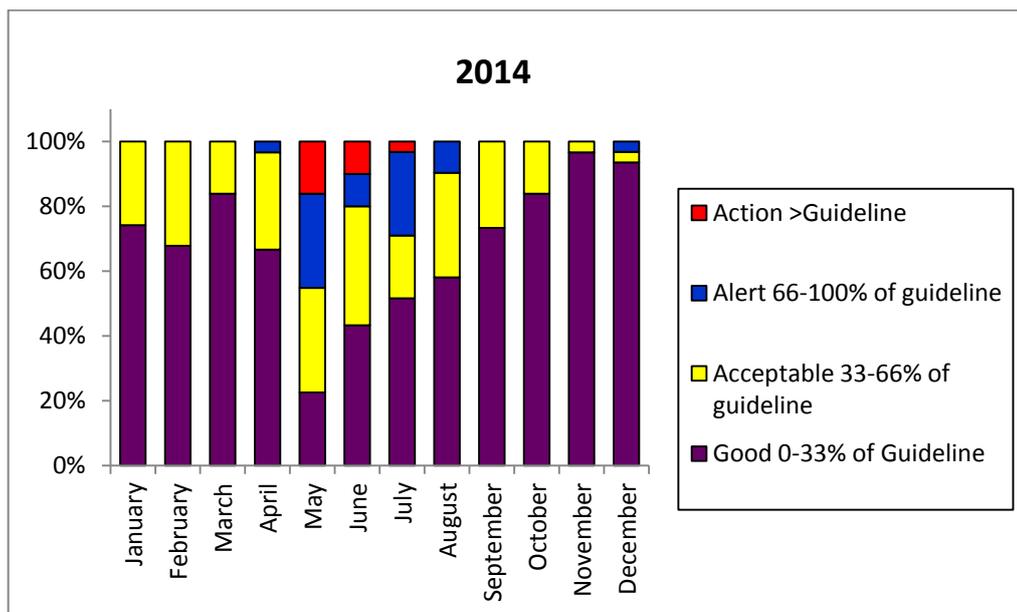


Figure 4-4: Comparison of daily PM₁₀ concentrations each month during 2014 to air quality indicator categories.

The number of days when $50 \mu\text{g}/\text{m}^3$ was exceeded, the maximum concentration and the 99.7 percentile concentration over the period 2006 to 2014 is presented in Figure 4.5. There is no indication of an improving trend with regards either the number of exceedances or the maximum and 2nd highest concentrations when a comparison is made with monitoring data collected since 2006.

The number of days when $50 \mu\text{g}/\text{m}^3$ was exceeded, the maximum concentration and the 2nd highest concentration over the period 2006 to 2014 is presented in Figure 4.5 along with the NES compliance targets for Tokoroa of no more than three exceedances after 1 September 2016 and no more than one exceedance after 1 September 2020 (green coloured bars positioned at 2017 and 2021 on graph as exceedances typically only occur during winter). The r^2 value of 0.19 indicates very poor evidence for a decreasing trend in the number of exceedances. Even if it is accepted that there is a downwards trend of the exceedance numbers, extrapolation of the exceedance trend line out to 2020 indicates that neither the 2016 or 2020 target will be met. A more robust trend analysis is provided in section 4.4.

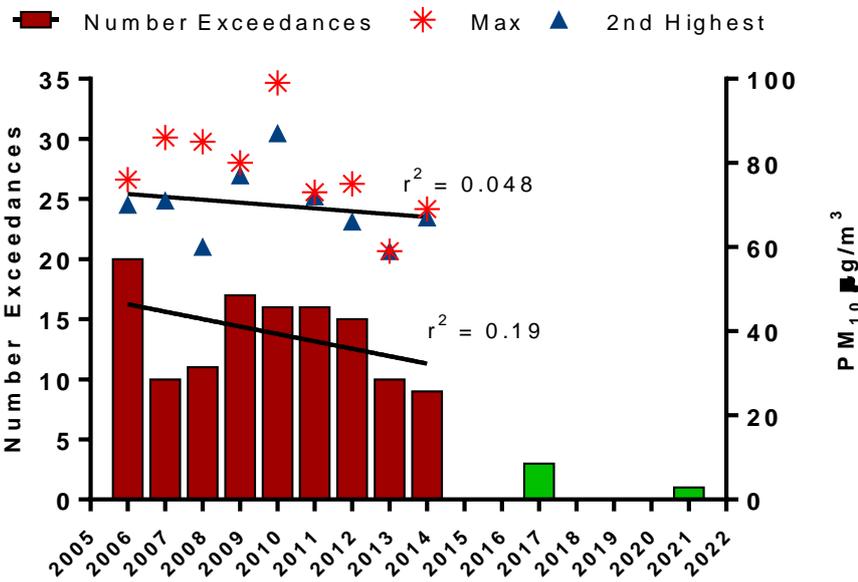


Figure 4-5: Number of days when $50 \mu\text{g}/\text{m}^3$ was exceeded compared with the maximum concentration and the 2nd highest concentration measured from 2006 to 2014.

The annual average PM_{10} concentration for Tokoroa for 2014 was $15.9 \mu\text{g}/\text{m}^3$ which is lower than annual average concentrations recorded over the last five years but similar to annual averages recorded for 2007 and 2008. The Ministry for the Environment specifies an annual average guideline for PM_{10} of $20 \mu\text{g}/\text{m}^3$ (MfE, 2002). Table 4.2 shows the summary statistics for PM_{10} monitoring results.

Table 4-2: Summary of PM₁₀ concentrations measured at the Tokoroa monitoring site from 2001 to 2014¹.

Indicator	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
"Good" 0-33% of guideline	12%	15%	25%	12%	28%	60%	66%	67%	61%	63%	60%	63%	63%	68%
"Acceptable" 33-66% of guideline	64%	71%	58%	54%	49%	26%	24%	25%	29%	26%	27%	25%	26%	23%
"Alert" 66-100% of guideline	17%	9%	13%	23%	13%	8%	7%	6%	5%	7%	9%	8%	8%	7%
"Action" >Guideline	8%	4%	4%	11%	9%	6%	3%	3%	5%	4%	4%	4%	3%	2%
Percentage of valid data	47%	97%	55	96	88%	99%	99%	99%	100%	99%	99%	100%	100%	100%
Annual average (µg/m ³)	26.6	24.0	24.1	31.0	25.3	18.6	16.3	16.5	17.5	18.0	18.0	17.2	16.8	15.9
Measured exceedances	13	14	8	38	33	20	10	11	17	16	16	15	10	9
99.7 %ile PM10 conc. (µg/m ³)	70	66	59	92	83	70	70	60	77	87	72	66	58	67
2 nd Highest PM10 con. (µg/m ³)	66	66	57	92	83	70	71	60	77	87	72	66	55	67
Annual maximum (µg/m ³)	75	70	62	97	89	76	86	85	80	99	73	75	59	69
Number of records	173	353	199	349	321	360	360	360	364	360	362	366	364	365

1. Data post 2005 is adjusted for gravimetric equivalency.

4.3 Daily variations in PM₁₀ and meteorology on high pollution days

Figure 4.6 compares summary statistics for wind speed and temperature from 2006 to 2014. The data summary indicates a decreasing trend in wintertime wind speed data up to 2012 with a subsequent increase in windspeed in 2013 and 2014, particularly with respect to the maximum wind speed. The maximum, mean and median wintertime air temperature shows a small decrease over the period 2008 to 2009 followed by a small increase over the period 2010 to 2011.

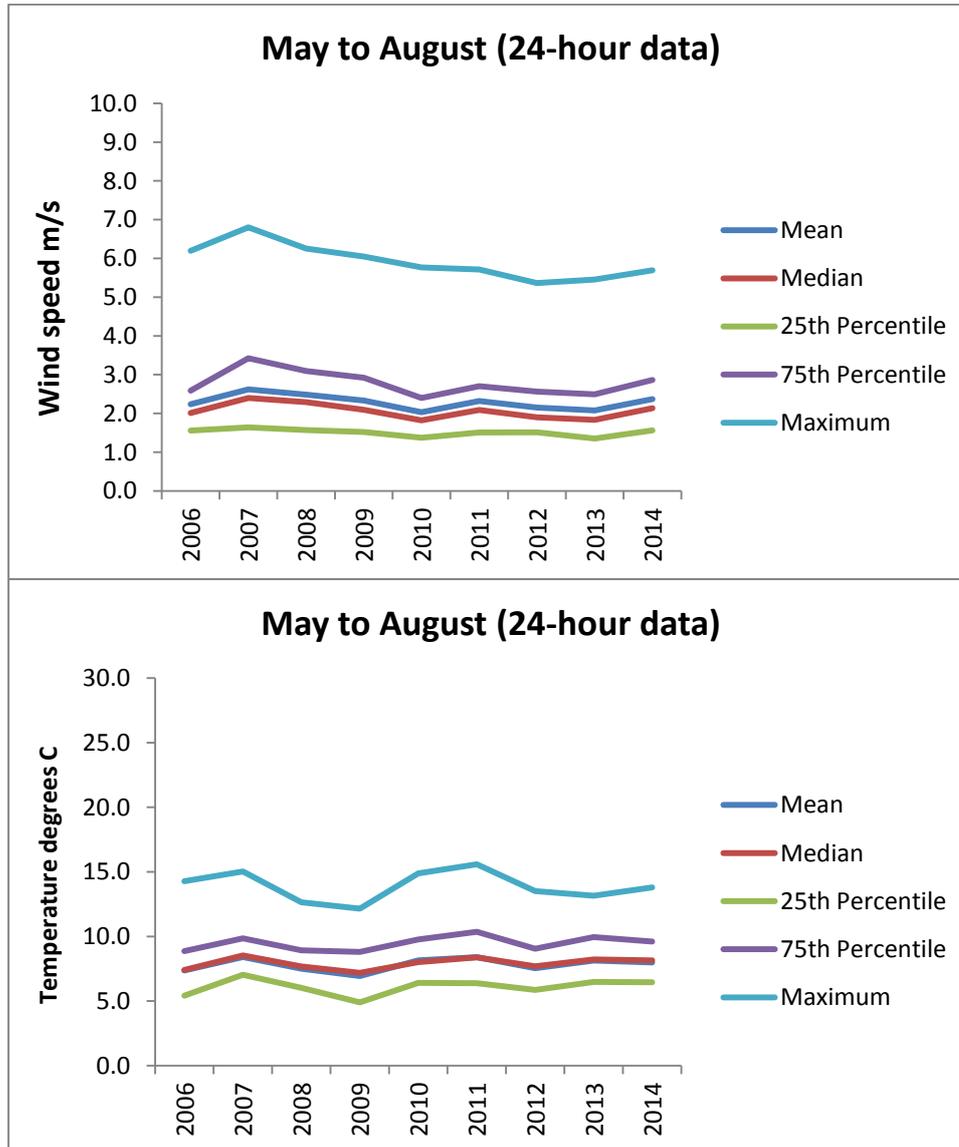


Figure 4-6: Summary wind speed and temperature data from 2006 to 2014 in Tokoroa.

Figure 4.7 shows the variations in meteorological conditions and hourly average PM₁₀ concentrations on the 9 days when the 24-hour average for PM₁₀ measured at Tokoroa exceeded 50 µg/m³.

Generally, PM₁₀ concentrations showed typical diurnal variations with a decrease in concentrations from midnight to 7am, a small peak around 9am and a more substantial increase in concentrations from 5pm. The one exception to this occurred on 6 June (large spike around 10 am) possibly caused by lime dosing at the adjacent water treatment plant. However, co-located source apportionment analysis undertaken by GNS on that day using a partisol filter indicates only a 3% contribution from lime dosing

(Ancelet and Davy, 2015). High concentrations typically occurred when the wind speeds and air temperature are low and the wind direction is from the south east.

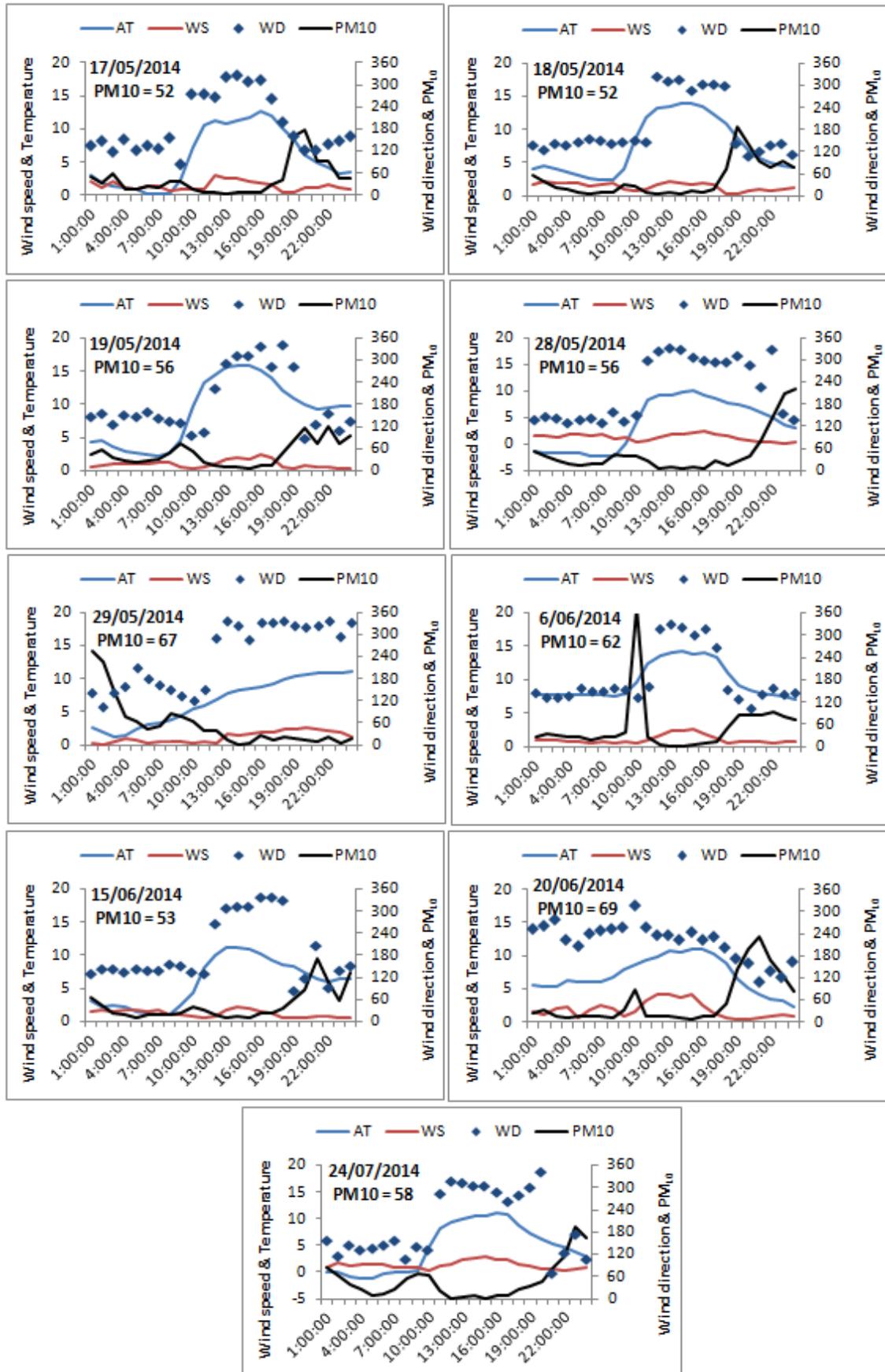


Figure 4-7: Hourly average PM₁₀, wind speed, wind direction and temperature on days when PM₁₀ concentrations exceeded the NES in Tokoroa.

4.4 Trend Analysis

Over time, air quality may improve, get worse, or remain the same. Peak levels of PM₁₀ in any given airshed vary from winter to winter depending on meteorological conditions and human responses. For example, higher PM₁₀ and more exceedances might be expected if a winter has a greater number of days when the wind speed is low and there is vertical stability in the lower atmosphere. Over the short term this inter-annual variability will mask any genuine underlying trend toward better or worse air quality. A reasonably long monitoring record is needed to confirm or exclude the possibility of any underlying trend.

Seasonal Mann-Kendall test for monotonic trends (consistently increasing or decreasing trends) is the preferred approach for detecting underlying trends in variable environmental time-series data sets, and may suggest presence of an underlying trend which is not evident from visual inspection of the PM₁₀ record or summary statistics. This method generates probability (p) values that are used to assess the likelihood that the apparent relationship is genuine, or comes about fortuitously as a result of a random alignment of variables. The conventional threshold for deciding whether a relationship is likely to be genuine is at a probability value of $p = 0.05$ or lower, which corresponds to a 95% confidence level and greater. A negative MK-Stat indicates a decreasing trend.

While the Seasonal Mann Kendall test results (MK-Stat of -1.2 and a p-value of 0.23) do not provide evidence that PM₁₀ concentrations in Tokoroa have been getting either better or worse over the period 2006 to 2014, a comparison with the previous analyses for the periods 2006 to 2013 and 2006 to 2012 indicates that the MK-Stat is increasing in negativity and that the p-value is decreasing towards $p = 0.05$. If the 2015 winter season provides similar data to 2013 and 2014, then inclusion of this data may start to influence these two statistics sufficiently to provide evidence of an improving trend.

Additional analysis has also been undertaken using methodologies developed by Environet Ltd which account for the impacts of varying meteorology in Tokoroa (Wilton, 2013a). Meteorological conditions conducive to high pollution in Tokoroa include days which have both low windspeeds and low temperatures over a specific period of the day, namely:

- Days with more than 15 hours when the hourly average wind speed was less than 2 metres per second; and
- Days where the average temperature from 8 pm to midnight is less than 5.36 degrees Celsius.

In summary, if these criteria are met then these are the days you would expect the majority of exceedances to occur. Figure 4.8 provides a summary of the year-to-year variation of the proportion of high pollution potential days which resulted in exceedances in Tokoroa. Figure 4.9 provides a summary of the year-to-year variation of the absolute number of high pollution potential days compared with the number of exceedance days.

If PM₁₀ concentrations were decreasing, a consistent reduction in the proportion of high pollution potential days that resulted in breaches would be evident. In 2006 exceedances occurred on around 70% of days when meteorological conditions conducive to elevated PM₁₀ occurred. This reduced to around 40% in 2007 and 2008, then stabilised around 50% from 2009 to 2012 before dropping again to around 20 to 25% in 2013 and 2014. This analysis indicates that there may have been a reduction in PM₁₀ emissions between 2006 and 2007 in Tokoroa. There has been an even more dramatic decrease since 2012 of the percentage of days with exceedances while the absolute number of high pollution potential days has remained comparatively high and similar to previous years where the total number of days with exceedances has been higher (refer to Figure 4.9). This analysis provides some stronger evidence that there

has been a reduction in PM₁₀ emissions since 2012. Alternatively, it may be possible that there has been an increase in exceedances occurring under atypical meteorological conditions.

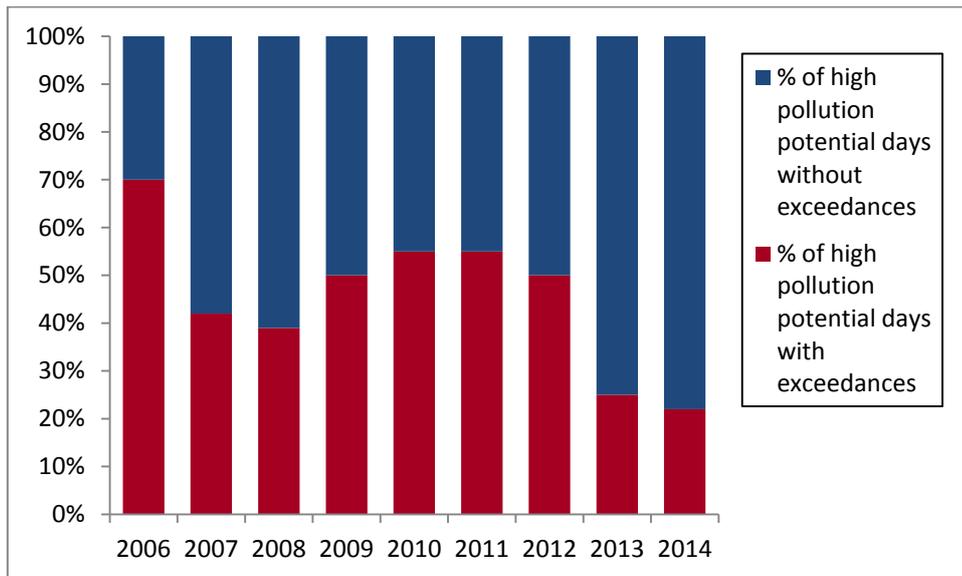


Figure 4-8: Year-to-year variation of the proportion of high pollution potential days which resulted in exceedances.

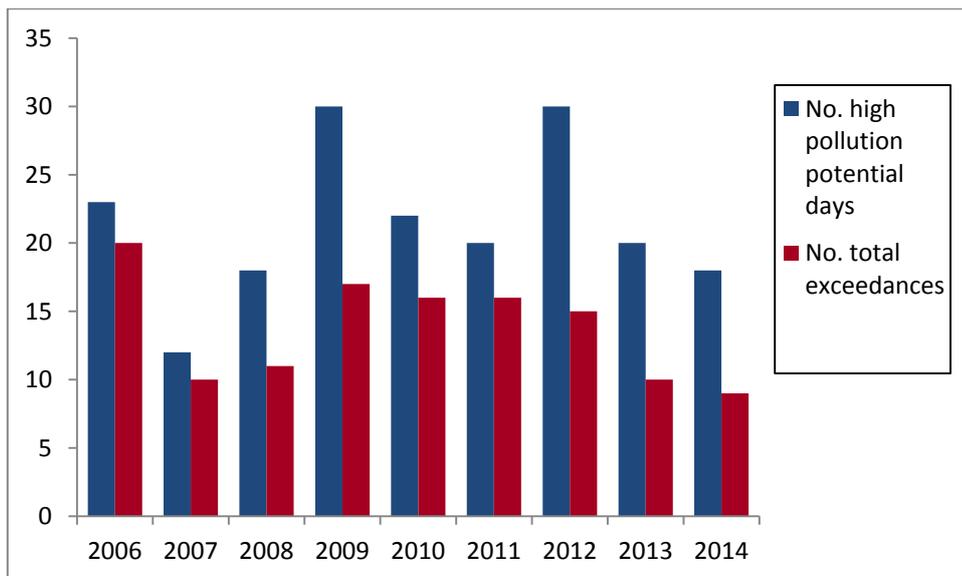


Figure 4-9: Year-to-year variation of the absolute number of high pollution potential days compared with the total number of exceedance days.

The analysis tool developed by Environet Ltd also provides the ability to minimise the impact of varying meteorology. This methodology is referred to as normalising the PM₁₀ concentrations so that the influence of varying meteorology is minimised. The graph of normalised PM₁₀ concentrations presented in Figure 4.10 provides no evidence that PM₁₀ concentrations have decreased.

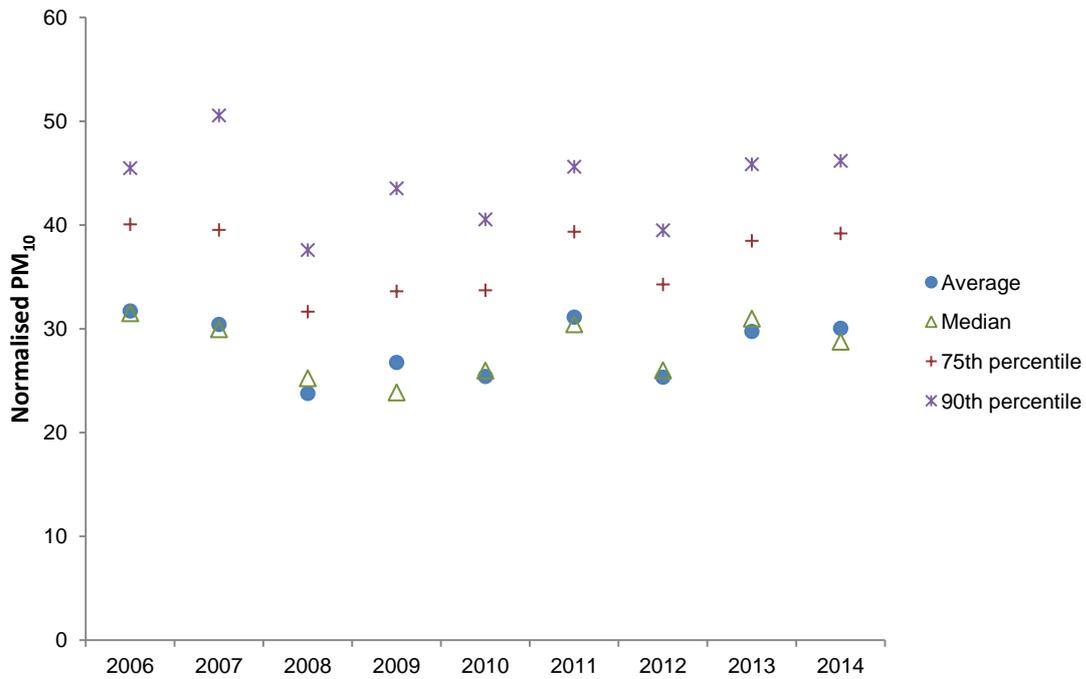


Figure 4-10: Average, 75th percentile, 90th percentile and median PM₁₀ concentrations for the days when the impacts of meteorological variability have been minimised.

Another way of comparing changes in air quality over time is to compare the 5 year exceedance average from year to year (refer to Figure 4.11) in order to remove some of the variation that occurs from year to year. The 5 year exceedance average has only varied by a small amount over the period 2006 to 2014 ranging from 13.2 for 2010 to 2014 to 15 for the period 2008 to 2012.

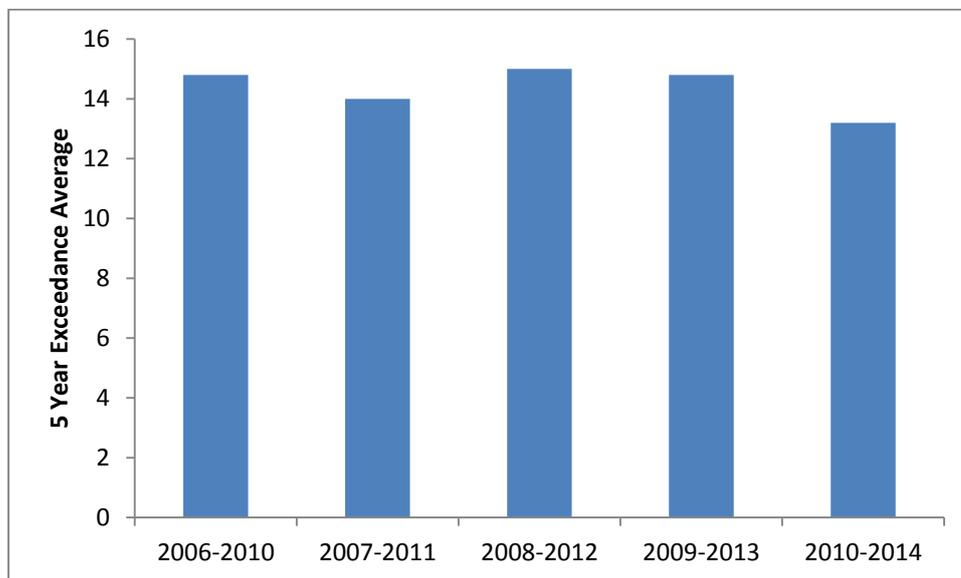


Figure 4-11: Comparison of the five year exceedance averages for the period 2006 to 2014.

Based on these analyses and the current five year exceedance average of 13.2, it is not expected that Tokoroa will meet the interim NES 2016 target of no more than three exceedances without significant emission reductions. It has been estimated that an emission reduction of around 24% is required to meet the 2016 target and around 43%

to meet the 2020 target (Wilton, 2011). These required emission reductions are based on the estimated emissions as of mid 2007.

5 Taupo

5.1 Air quality monitoring in Taupo

The air quality monitoring site for Taupo is located at Gillies Avenue Reserve in central Taupo and was established in November 2000. The site meets the requirements of the “Residential Neighbourhood” site classification as described in the ‘*Good Practice Guideline for Air Quality Monitoring and Data Management 2009*’ report (MfE, 2009).

A FH62 C14 BAM has measured PM₁₀ concentrations since March 2007. Gravimetric sampling using a Rupprecht and Patashnick Partisol Model 2000 PM₁₀ sampler also took place at the Gillies Avenue Site during 2007 and 2008. Figure 5.1 shows the Taupo Airshed and the location of the monitoring site at Gillies Avenue in Taupo.

Prior to 2005, PM₁₀ was monitored in Taupo on a one day in three basis at the Gillies Avenue Reserve site using a Rupprecht and Patashnick Partisol Model 2000 PM₁₀ sampler. In January 2006 a FH62 C14 BAM continuous PM₁₀ monitoring station along with meteorological instrumentation was established at Taupo Primary School. The meteorological instruments measured wind speed, wind direction, air temperature, and relative humidity. The site meets the requirements of the “Residential Neighbourhood” site classification (MfE, 2000).

Operation of the Gillies Avenue Reserve Partisol Model 2000 PM₁₀ sampler continued throughout 2006 to March 2007 to evaluate the spatial variation of PM₁₀ concentrations between Gillies Avenue and Taupo Primary School.

The maximum recorded 24-hour PM₁₀ concentration at the Taupo Primary School site in 2006 was 25 µg/m³ whereas the maximum recorded 24-hour PM₁₀ concentration at the Gillies Avenue Reserve site (based on one day in three Partisol monitoring) was 89 µg/m³. 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. The 2006 data reported in this report use the partisol sampling results for Gillies Avenue. On 17 March 2007 the FH62 C14 BAM and meteorological instrumentation was moved from Taupo Primary School to the Gillies Avenue Reserve site.

Gravimetric sampling using the Partisol Model 2000 PM₁₀ sampler also took place at the Gillies Avenue Site during 2008. The sampling regime 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.



Figure 5-1: Taupo Airshed and air quality monitoring site.

5.2 PM₁₀ concentrations in Taupo

Average daily PM₁₀ concentrations measured at the Taupo Gillies Ave site during 2014 are shown in Figure 5.2. There were no PM₁₀ exceedances of 50 µg/m³ (24-hour average) measured at this site during 2014. A maximum 24 hour average concentration of 45 µg/m³ was measured on 23 June. This compares with two exceedances (65 µg/m³ and 62 µg/m³) recorded during 2013, one exceedance (53 µg/m³) recorded during 2012 and one exceedance (51 µg/m³) in 2011.

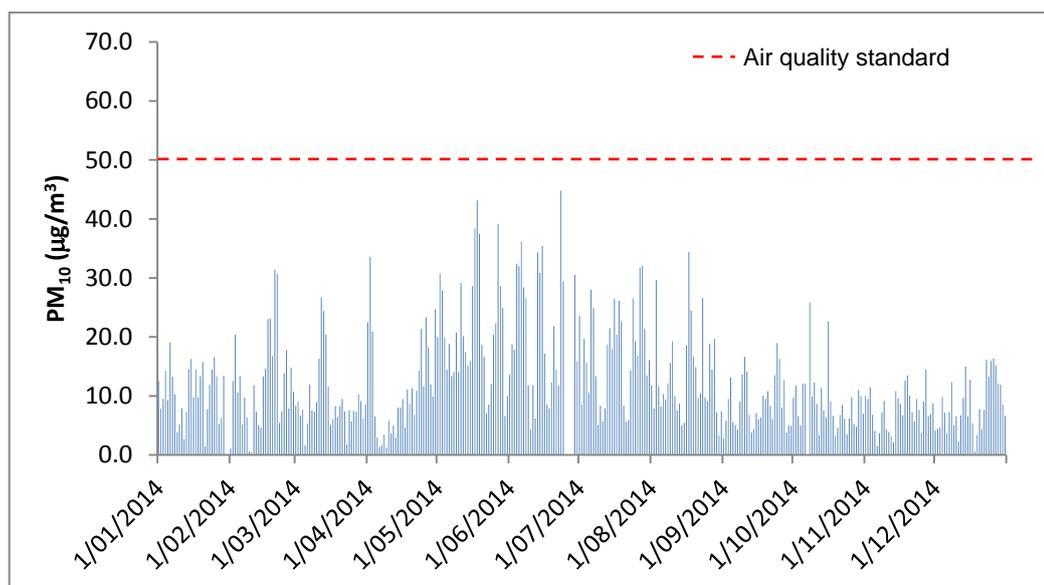


Figure 5-2: Daily average PM₁₀ concentrations measured at Taupo during 2014.

The changes in PM₁₀ concentrations relative to air quality indicator categories at the Taupo site from 2006 to 2014 are shown in Figure 5.3. Data are adjusted for gravimetric equivalency only since 2007 so comparison of trends with pre 2006 data

are limited⁵. There has been a gradual increase in the proportion of PM₁₀ concentrations in the 'good' category since 2007. Figure 5.4 shows the seasonal variations in the distribution of PM₁₀ concentrations for 2014.

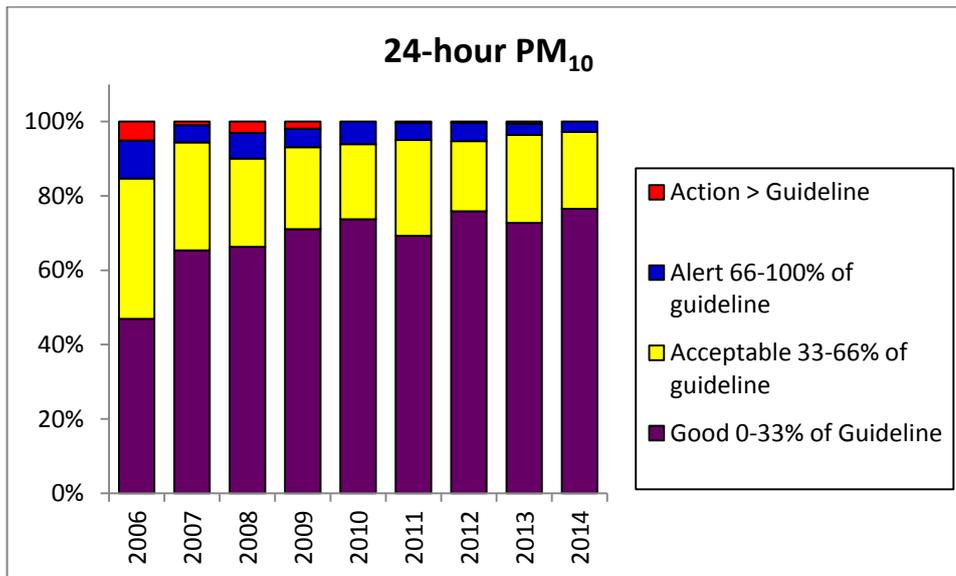


Figure 5-3: Comparison of PM₁₀ concentrations measured at the Taupo site from 2006 to 2014 to air quality indicator categories.

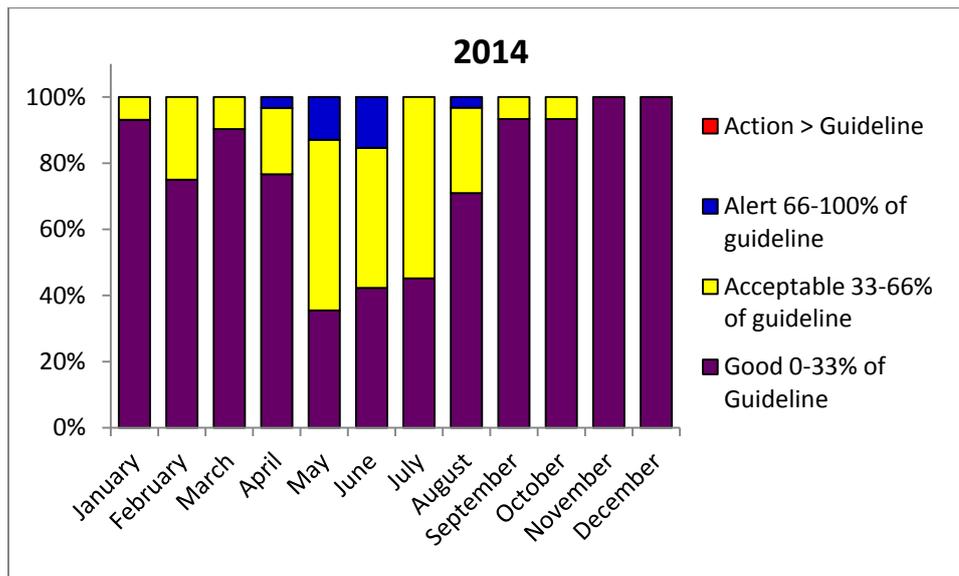


Figure 5-4: Comparison of daily PM₁₀ concentrations each month during 2014 to air quality indicator categories.

Figure 5.5 shows the number of days when 50 µg/m³ was exceeded, the maximum concentration and the 2nd highest concentration for 2006 to 2014. The trend line slope for exceedances per year is negative with an R² value of 0.59. The trend line slope for 2nd highest concentrations per year is also negative with an R² value of 0.56. This suggests that air quality has been improving over the period 2006 to 2014 and that compliance with the NES after 2016 is possible if emissions continue to reduce. Further discussion of this is provided in the trend analysis presented in Section 5.4 of this report.

⁵ For 2006 the gravimetric partisol data from Gillies Ave were used in preference to the BAM primary school data.

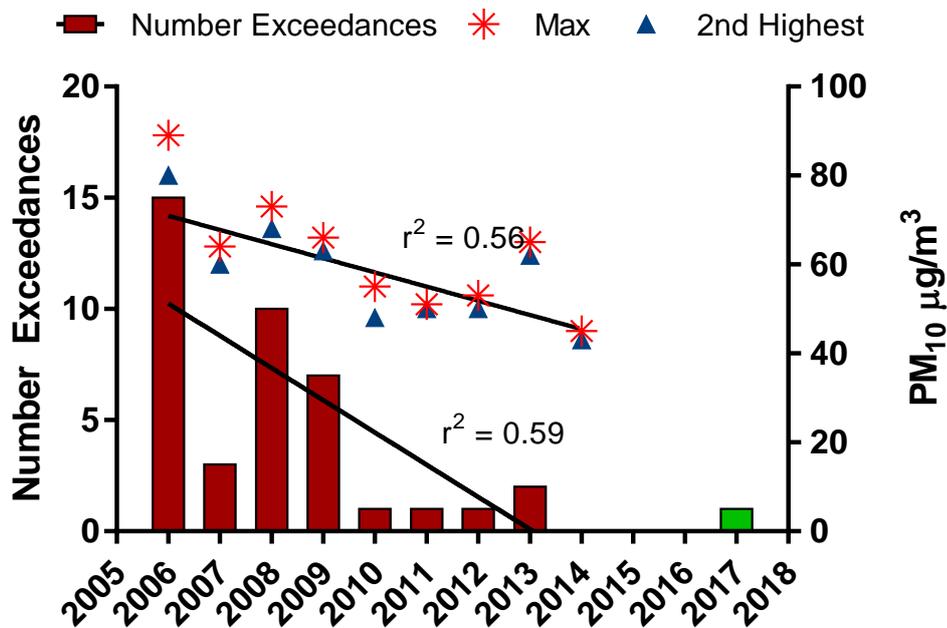


Figure 5-5: Number of days when $50 \mu\text{g}/\text{m}^3$ was exceeded compared with the maximum concentration and the 2nd highest concentration measured from 2006 to 2014.

The annual average PM_{10} concentration for 2014 of $12.4 \mu\text{g}/\text{m}^3$ is the lowest annual average measured at the Taupo site from 2006 to 2014 (refer to Figure 5.6). The Ministry for the Environment specifies an annual average guideline for PM_{10} of $20 \mu\text{g}/\text{m}^3$ (MfE, 2002). The trend line slope for annual averages is negative with an R^2 value of 0.74 indicative of an improving trend.

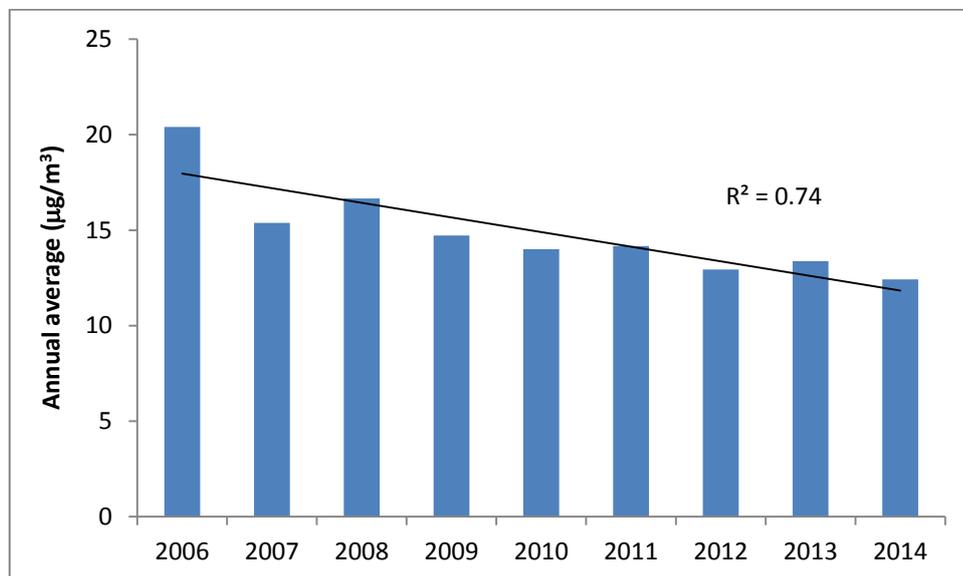


Figure 5-6: Comparison of annual averages measured at the Taupo site from 2006 to 2014.

Summary statistics for PM_{10} monitoring results for the period 2001 to 2014 are shown in Table 5.1.

Table 5-1: Summary of PM₁₀ concentrations measured at the Taupo monitoring site from 2001 to 2014¹.

Indicator	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
"Good" 0-33% of guideline	43%	59%	52%	55%	56%	47%	65%	66%	71%	73%	69%	76%	73%	77%
"Acceptable" 33-66% of guideline	36%	33%	32%	30%	36%	38%	29%	24%	22%	20%	26%	19%	24%	21%
"Alert" 66-100% of guideline	18%	7%	12%	12%	7%	10%	5%	7%	5%	6%	5%	5%	3%	3%
"Action" >Guideline	2%	1%	4%	2%	1%	5%	1%	3%	2%	0%	0%	0%	1%	0%
Percentage of valid data	12%	21%	29%	29%	30%	27%	83%	99%	99%	100%	99%	99%	99%	98%
Annual average ² (µg/m ³)	19.7	15.9	18.5	17.8	15.8	20.4	15.4	16.7	14.7	14.0	14.2	12.9	13.4	12.4
Measured exceedances	1	3	12	6	3	15	3	10	7	1	1	1	2	0
99.7 %ile PM ₁₀ conc. (µg/m ³)	55	51	62	62	50	86	60	67	62	47	49	50	60	43
Annual maximum (µg/m ³)	57	54	62	65	52	89	64	73	66	55	51	53	65	45
Number of records	44	76	106	105	111	98	303	362	363	364	361	362	363	358
2 nd Highest						80	60	68	63	48	50	50	62	43

1. 2007 - 2008 data have been updated from that reported in the 2007 and 2008 reports based on a more recent (2009) adjustment factor. 2006 data were gravimetric at Gillies Ave. Data post 2006 has been adjusted for gravimetric equivalency. Note the 2008 monitoring report used a different equation and reported six exceedances of 50 µg m⁻³ for 2007 compared with three exceedances reported here.
2. To avoid seasonal bias in missing data, annual averages for gravimetric data collected prior to 2007 have been calculated based on the average of the individual seasonal averages (i.e. Jan to Apr, May to Aug, Sep to Dec). Annual average calculations from 2007 onwards have been based on averaging of all data (it makes no difference which method is used because there is very little missing data).

5.3 Daily variations in PM₁₀ and meteorology on high pollution days

Figure 5.7 shows variations in PM₁₀ concentrations and meteorological data on 23 June when the maximum 24-hour average PM₁₀ of 45 µg/m³ was measured at Taupo.

The pattern in hourly PM₁₀ concentrations for 23 June (Figure 5.7) is reasonably typical of high pollution episodes in urban areas of New Zealand. In particular there is a small morning peak in concentrations around 9am followed by a decrease for the majority of the daytime then an increase in concentrations around 5 pm.

In Taupo, high PM₁₀ concentrations typically occur when the wind is from an easterly or south easterly direction and wind speeds are low. During the daytime the wind shifts to westerly, returning to east/south east during the evening (Wilton & Baynes, 2010) consistent with the pattern observed on 23 June 2014.

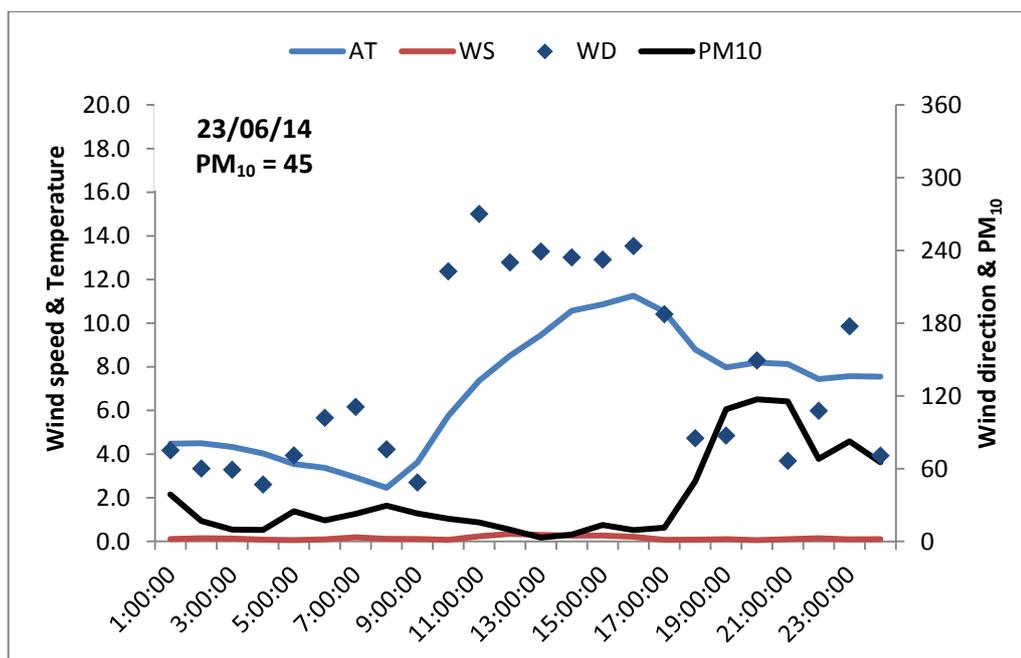


Figure 5-7: Hourly average PM₁₀, wind speed, wind direction and temperature on the 23 of June when the highest 24-hour average PM₁₀ concentration of 45 µg/m³ was recorded at Taupo.

5.4 Trend analysis

Over time, air quality may improve, get worse, or remain the same. Peak levels of PM₁₀ in any given airshed vary from winter to winter depending on meteorological conditions and human responses. For example, if a winter has a greater number of days when the wind speed is low and there is vertical stability in the lower atmosphere then there is likely to be a greater frequency of elevated PM₁₀ concentrations. Over the short term this inter-annual variability will mask any genuine underlying trend toward better or worse air quality. A reasonably long monitoring record is needed to confirm or exclude the possibility of any underlying trend.

Seasonal Mann-Kendall test for monotonic trends (consistently increasing or decreasing trends) is the preferred approach for detecting underlying trends in variable environmental time-series data sets, and may suggest presence of an underlying trend which is not evident from visual inspection of the PM₁₀ record or summary statistics. This method generates probability (p) values that are used to assess the likelihood that

the apparent relationship is genuine, or comes about fortuitously as a result of a random alignment of variables. The conventional threshold for deciding whether a relationship is likely to be genuine is at a probability value of $p = 0.05$ or lower, which corresponds to a 95% confidence level and greater. A negative MK-Stat indicates a decreasing trend.

Seasonal Mann Kendall test results (MK-Stat of -2.6 and p-value of 0.01) provides evidence that PM_{10} concentrations in Taupo have been decreasing over the period 2006 to 2014.

Additional analysis has also been undertaken using methodologies developed by Environet Ltd which account for the impacts of varying meteorology in Taupo (Wilton, 2013b). Meteorological conditions conducive to high pollution in Taupo include days which have both low windspeeds and low temperatures over a specific period of the day, namely:

- Days with more than 16 hours when the hourly average wind speed was less than 1 metres per second; and
- Days where the average temperature between 5 pm to midnight is less than 7.7 degrees Celsius.

In summary, if both of these criteria are met then these are the days you would expect exceedances to occur. Figure 5.8 provides a summary of the year-to-year variation of the proportion of high pollution potential days which resulted in exceedances in Taupo. Figure 5.9 provides a summary of the year-to-year variation of the absolute number of high pollution potential days compared with the number of exceedance days.

In 2007 exceedances occurred on around 21% of days when meteorological conditions conducive to elevated PM_{10} occurred. This increased to around 28% in 2008 and 25% in 2009, then dropped significantly to around 4 to 6% from 2010 to 2012 before increasing to around 12% in 2013 and then down to 0% in 2014. This decrease in the percentage of days with exceedances on high pollution potential days since 2009 indicates that there has been a reduction in PM_{10} emissions between 2009 and 2010 in Taupo.

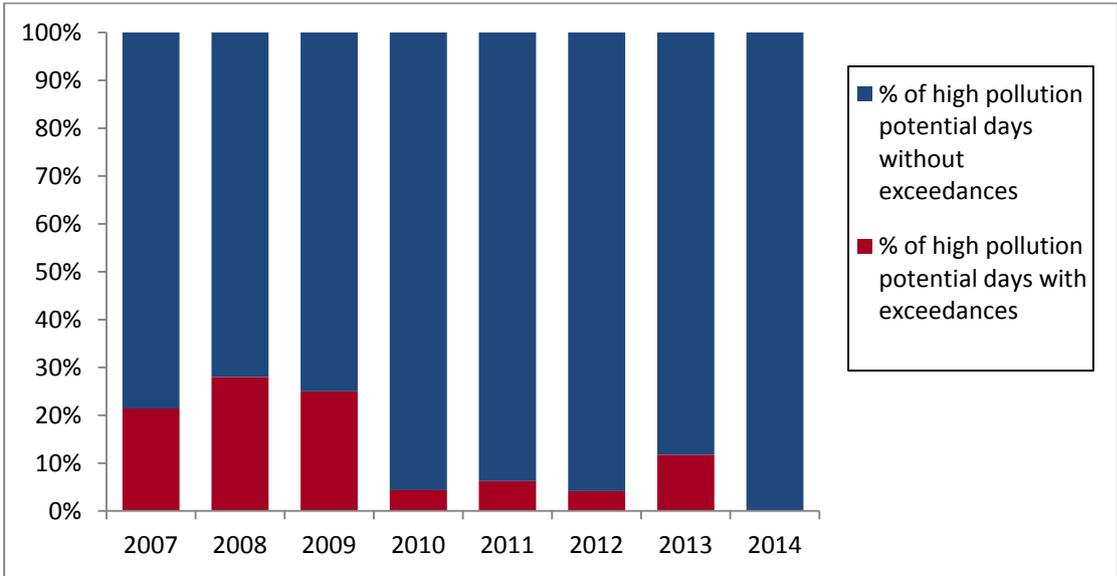


Figure 5-8: Year-to-year variation of the proportion of high potential pollution days which resulted in exceedances.

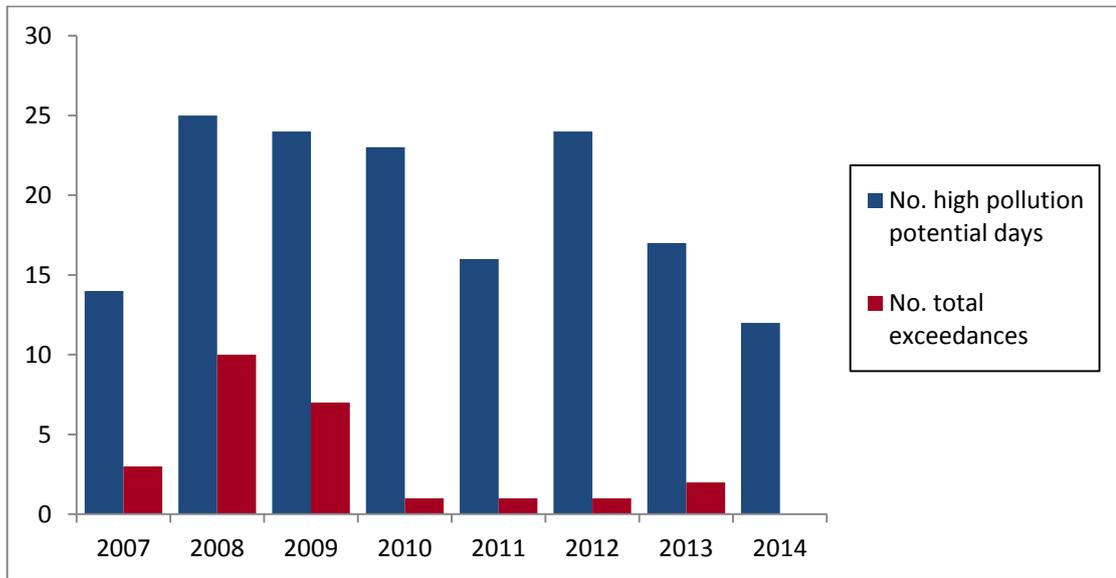


Figure 5-9: Year-to-year variation of the absolute number of high pollution potential days compared with the total number of exceedance days.

The analysis tool developed by Environet Ltd also provides the ability to minimise the impact of varying meteorology. This methodology is referred to as normalising the PM₁₀ concentrations so that the influence of varying meteorology is removed. The graph of normalised PM₁₀ concentrations presented in Figure 5.10 provides some evidence that PM₁₀ concentrations have been decreasing since 2009 (especially when considering the reduction in average and median PM₁₀ concentrations).

Management measures to further reductions of PM₁₀ by around 20% are recommended for on-going NES compliance (Wilton, 2014).

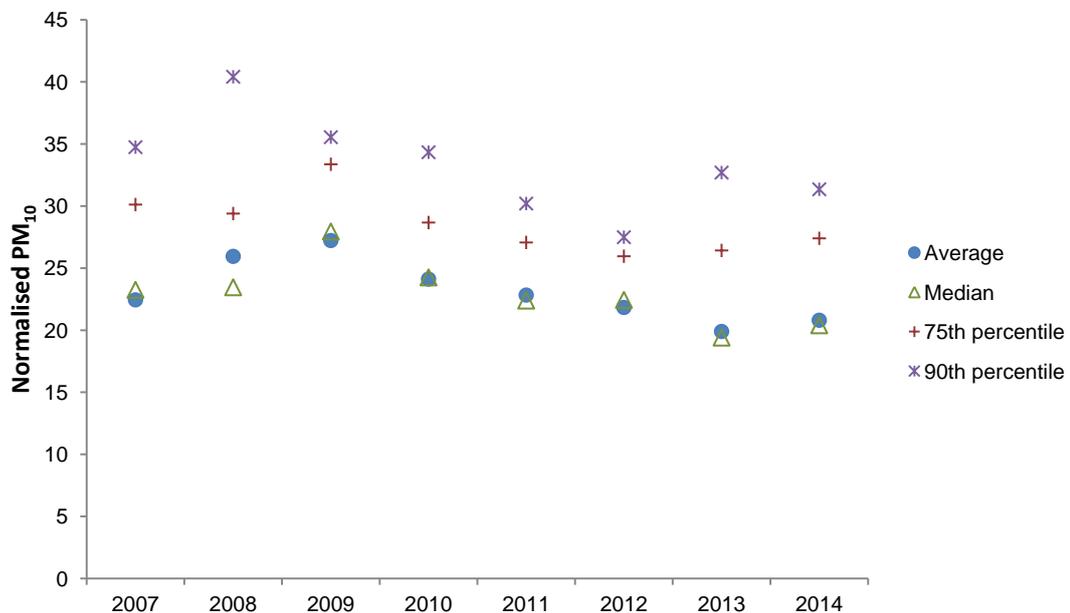


Figure 5-10: Average, 75th percentile, 90th percentile and median PM₁₀ concentrations for the days when the impacts of meteorological variability have been minimised.

Another way of comparing changes in air quality over time is to compare the 5 year exceedance average from year to year (refer to Figure 5.11) in order to remove some of the variation that occurs from year to year. There has been a consistent downwards

trend in the 5 year exceedance average over the period 2006 to 2014 ranging from 7.2 for 2006 to 2010 to 1 for the period 2010 to 2014.

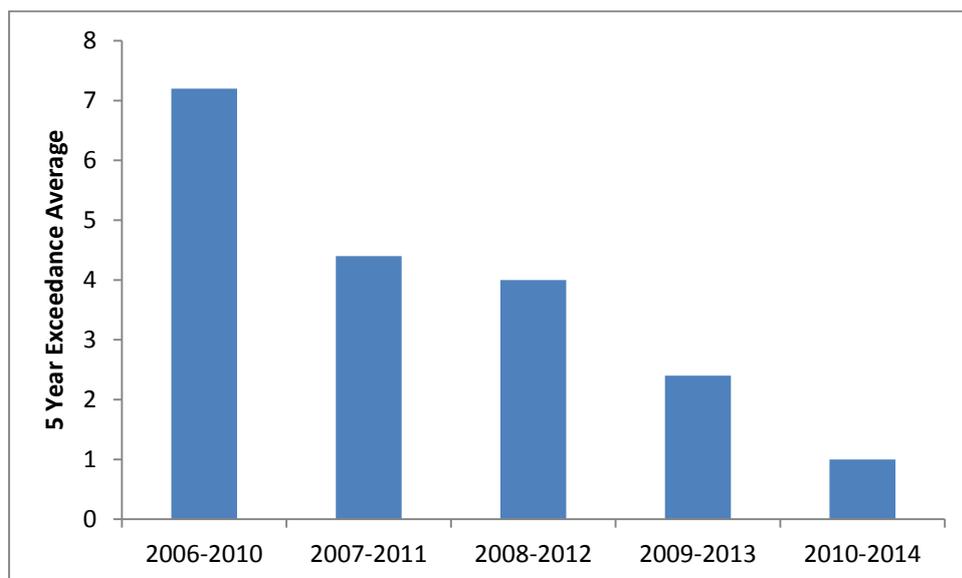


Figure 5-11: Comparison of the five year exceedance averages for the period 2006 to 2014.

Based on these analyses and the current previous five year exceedance average of 1, it is likely that Taupo will meet the NES 2016 target of no more than one exceedance per 12 month period. But this will still be dependent on meteorological conditions i.e. a particularly cold and calm winter could still result in more than one exceedance with in a 12 month period. Further reductions in emissions would provide a “safeguard” against future impacts of changes in meteorology.

6 Te Kuiti

6.1 Air quality monitoring in Te Kuiti

The Te Kuiti air quality monitoring site is located at the Te Kuiti City Council Offices off Queen Street. This site has been used continuously since 2003 to monitor PM₁₀ and was also used for short term monitoring in 1998 to monitor PM₁₀. Results of the 1998 monitoring are not included in this air quality monitoring report due to the short term duration of the monitoring and uncertainties surrounding the data.

Wilton, (2002) provides further descriptions of the air quality monitoring site, including a map and site layout in the ‘*Air Quality Monitoring Report – Waikato Region*’ report. The site meets the requirements of the “Residential Neighbourhood” site classification as described in the ‘*Good Practice Guideline for Air Quality Monitoring and Data Management 2009*’ report (MfE, 2009).

A ThermoAndersen FH62 C14 BAM is used at this site. Data are recorded at 10 minute intervals. Figure 6.1 shows the Te Kuiti Airshed and the location of the monitoring station in Te Kuiti.

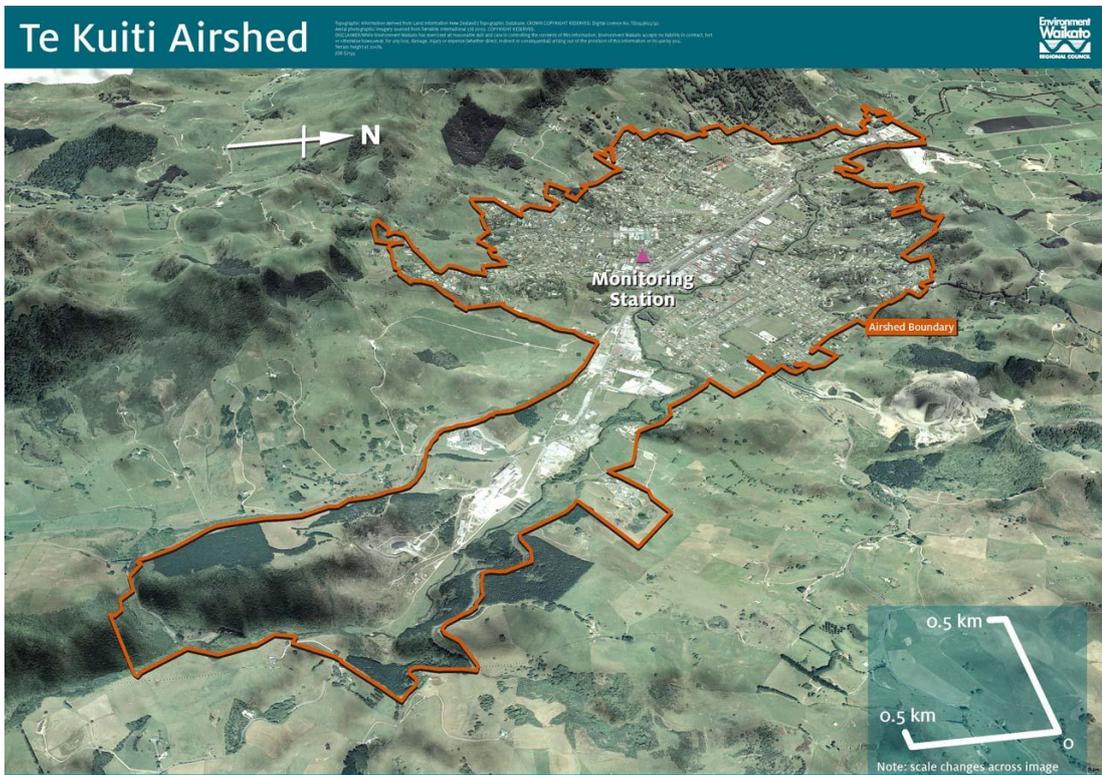


Figure 6-1: Te Kuiti Airshed and air quality monitoring site.

6.2 PM₁₀ concentrations in Te Kuiti

Figure 6.2 shows daily average PM₁₀ concentrations measured in Te Kuiti during 2014. There were no PM₁₀ exceedances of 50 µg/m³ (24-hour average) measured at this site during 2014. The maximum concentration in Te Kuiti was 48 µg/m³ (24-hour average) recorded on 25 July. No exceedances of 50 µg/m³ were recorded during 2013. This compares with one exceedance (61 µg/m³) recorded during 2012 and one exceedance (51 µg/m³) in 2011. Prior to this, the number of exceedances ranged between three to four per year.

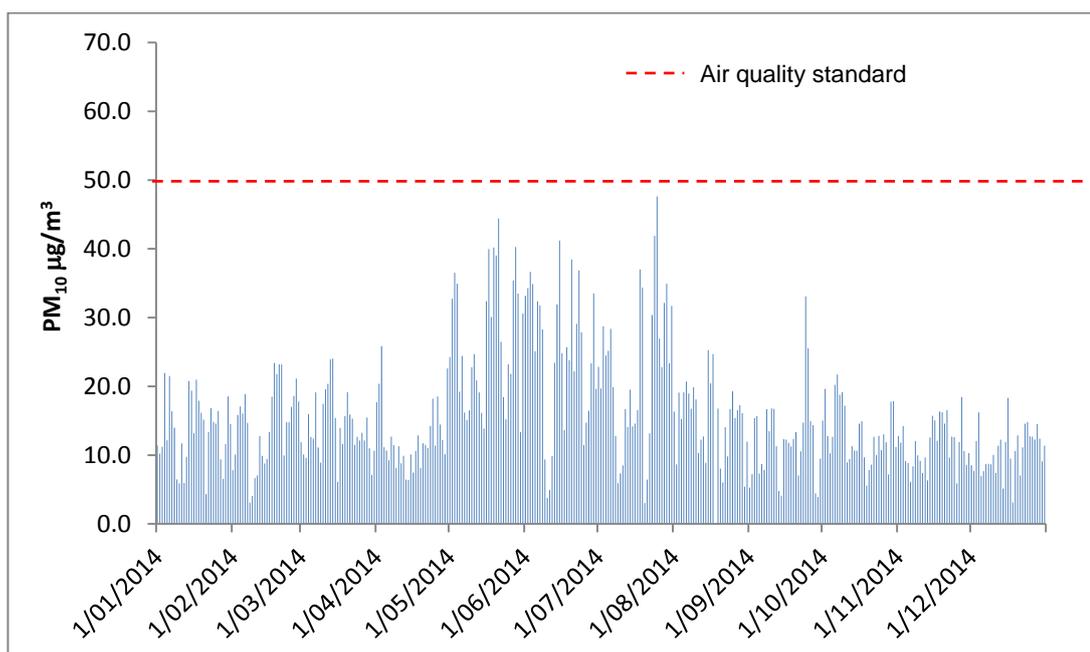


Figure 6-2: Daily average PM₁₀ concentrations measured at the Te Kuiti site during 2014.

The changes in PM₁₀ concentrations relative to air quality indicator categories at the Te Kuiti site from 2003 to 2014 are shown in Figure 6.3. There has been a gradual increase in the proportion of PM₁₀ concentrations in the 'good' category since 2003. Figure 6.4 shows the seasonal variations in the distribution of PM₁₀ concentrations for 2014.

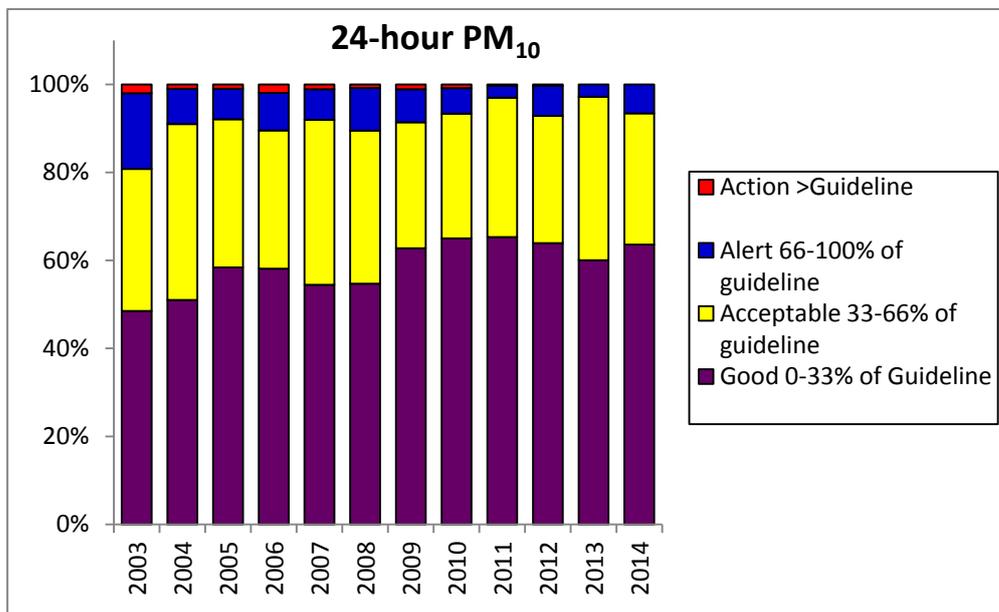


Figure 6-3: Comparison of PM₁₀ concentrations measured at the Te Kuiti site from 2003 to 2013 to air quality indicator categories.

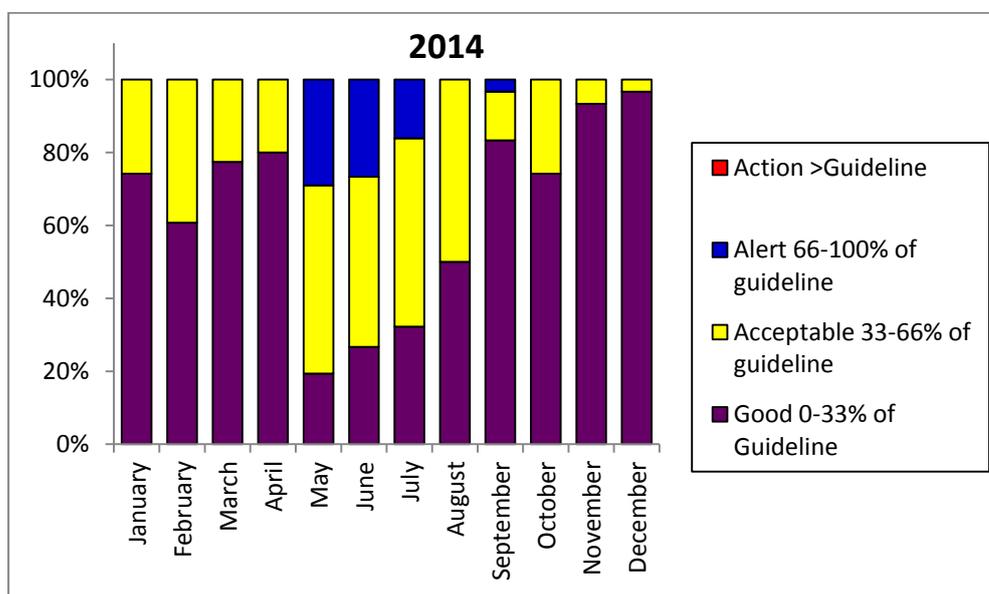


Figure 6-4: Comparison of daily PM₁₀ concentrations each month during 2014 to air quality indicator categories.

Figure 6.5 shows the number of days when 50 µg/m³ was exceeded, the maximum concentration and the 2nd highest concentration from 2003 to 2014. The trend line slope for exceedances per year is negative with an R² value of 0.58. The trend line slope for 2nd highest concentrations per year is also negative with an R² value of 0.53. These indicators suggest that air quality has improved over the period 2003 to 2014. This is further supported by the trend analysis presented in Section 6.4 of this report.

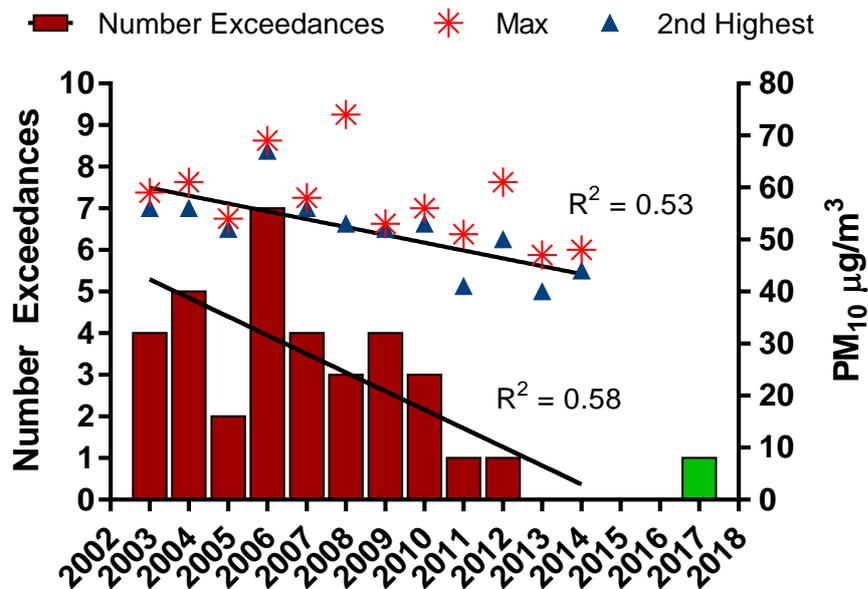


Figure 6-5: Number of days when $50 \mu\text{g}/\text{m}^3$ was exceeded compared with the maximum concentration and the 2nd Highest concentration measured from 2003 to 2014.

Summary statistics for PM_{10} monitoring data from the Te Kuiti site from 2003 to 2014 are shown in Table 6.1. In 2014 the annual average PM_{10} concentration in Te Kuiti was $15.9 \mu\text{g}/\text{m}^3$ which is consistent with the last four to five years and lower than the typical average of approximately $18 \mu\text{g}/\text{m}^3$ prior to 2009. The Ministry for the Environment specifies an annual average guideline for PM_{10} of $20 \mu\text{g}/\text{m}^3$ (MfE, 2002). An annual average PM_{10} concentration is not specified in the NES. The summary also shows that since 2009 a greater proportion of PM_{10} data falls within the good indicator category (0 to 33% of guideline) compared with the period prior to 2009. This provides further evidence of improvements in PM_{10} concentrations in Te Kuiti since around 2009.

Table 6-1: Summary of PM₁₀ concentrations measured at the Te Kuiti monitoring site from 2003 to 2014.

Indicator	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Good 0-33% of Guideline	48%	51%	59%	58%	54%	55%	63%	65%	65%	64%	60%	64%
Acceptable 33-66% of guideline	32%	40%	34%	31%	38%	35%	29%	28%	32%	29%	37%	30%
Alert 66-100% of guideline	17%	8%	7%	9%	7%	9%	8%	6%	3%	7%	3%	6%
Action >Guideline	2%	1%	1%	2%	1%	1%	1%	1%	0%	0%	0%	0%
Percentage of valid data	63%	95%	92%	100%	99%	99%	99%	99%	100%	99%	98%	100%
Annual average ($\mu\text{g}/\text{m}^3$)	18.0	18.0	17.0	17.7	17.8	18.2	16.8	16.1	15.1	16.4	16.3	15.9
Number exceedances	4	5	2	7	4	3	4	3	1	1	0	0
99.7 %ile concentration ($\mu\text{g}/\text{m}^3$)	56	56	52	67	55	52	52	53	41	50	40	44
Annual maximum ($\mu\text{g}/\text{m}^3$)	59	61	54	69	58	74	53	56	51	61	47	48
Number records	229	346	337	363	360	362	360	360	363	363	358	364
2 nd Highest concentration ($\mu\text{g}/\text{m}^3$)	56	56	52	67	56	53	52	53	41	50	40	44

6.3 Daily variations in PM₁₀ and meteorology on high pollution days

Figure 6.6 shows hourly variations in PM₁₀ concentrations and meteorological variables on 25 July when the 24-hour average PM₁₀ concentration reached a maximum of 48 µg/m³. The hourly PM₁₀ profile is fairly typical of an urban PM₁₀ pollution event with an elevated broad peak extending from the previous night and slowly reducing over the early hours of the morning followed by around 9 to 10 am, a drop off to around zero during the middle of the day and then a gradual increase again from about 5 pm. The wind speed and temperature are low during the period of peak PM₁₀ concentration. During the middle of the day wind speed and temperature become elevated, coinciding with a decrease in PM₁₀ concentrations.

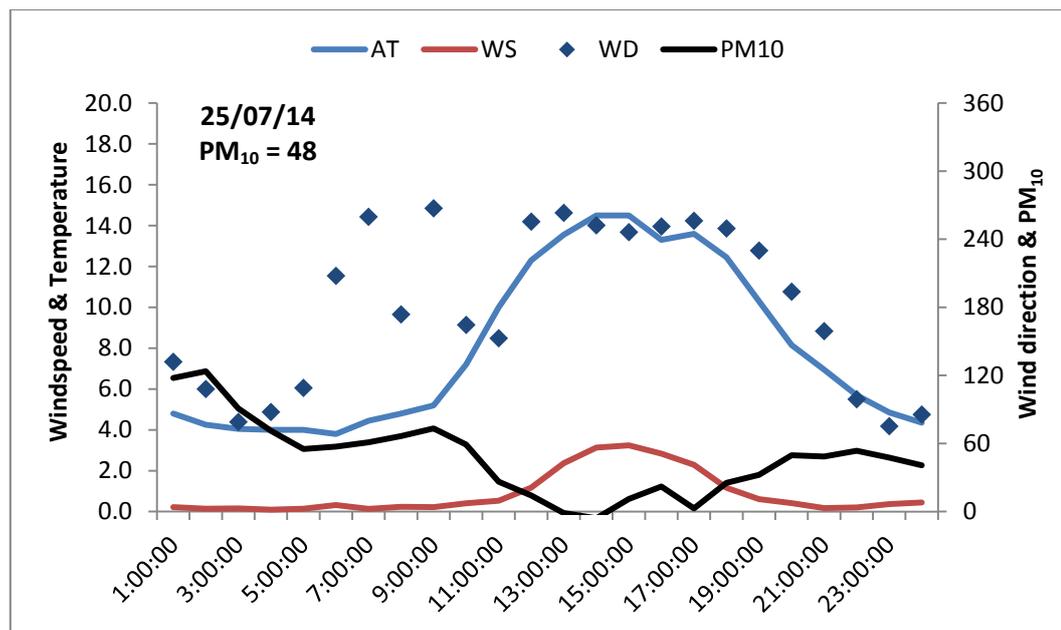


Figure 6-6: Hourly average PM₁₀, wind speed, wind direction, and temperature on 25 July when the highest 24-hour average PM₁₀ concentration of 48 µg/m³ was recorded at Te Kuiti.

6.4 Trend analysis

Over time, air quality may improve, get worse, or remain the same. Peak levels of PM₁₀ in any given airshed vary from winter to winter depending on meteorological conditions and human responses. For example, higher PM₁₀ and more exceedances might be expected if a winter has a greater number of days when the wind speed is low and there is vertical stability in the lower atmosphere. Over the short term inter-annual variability will mask any genuine underlying trend toward better or worse air quality. A reasonably long monitoring record is needed to confirm or exclude the possibility of any underlying trend.

Seasonal Mann-Kendall test for monotonic trends (consistently increasing or decreasing trends) is the preferred approach for detecting underlying trends in variable environmental time-series data sets, and may suggest presence of an underlying trend which is not evident from visual inspection of the PM₁₀ record or summary statistics. This method generates probability (p) values that are used to assess the likelihood that the apparent relationship is genuine, or comes about fortuitously as a result of a random alignment of variables. The conventional threshold for deciding whether a relationship is likely to be genuine is at a probability value of $p = 0.05$ or lower, which

corresponds to a 95% confidence level and greater. A negative MK-Stat indicates a decreasing trend.

Seasonal Mann Kendall test results (MK-Stat of -2.7 and p-value of 0.007) provides strong evidence that PM₁₀ concentrations in Te Kuiti have been decreasing over the period 2005 to 2014.

Another way of comparing changes in air quality over time is to compare the 5 year exceedance average from year to year (refer to Figure 6.7) in order to remove some of the variation that occurs from year to year. There has been a consistent downwards trend in the 5 year exceedance average over the period 2006 to 2014 ranging from 4.2 for 2006 to 2010 to 1 for the period 2010 to 2014.

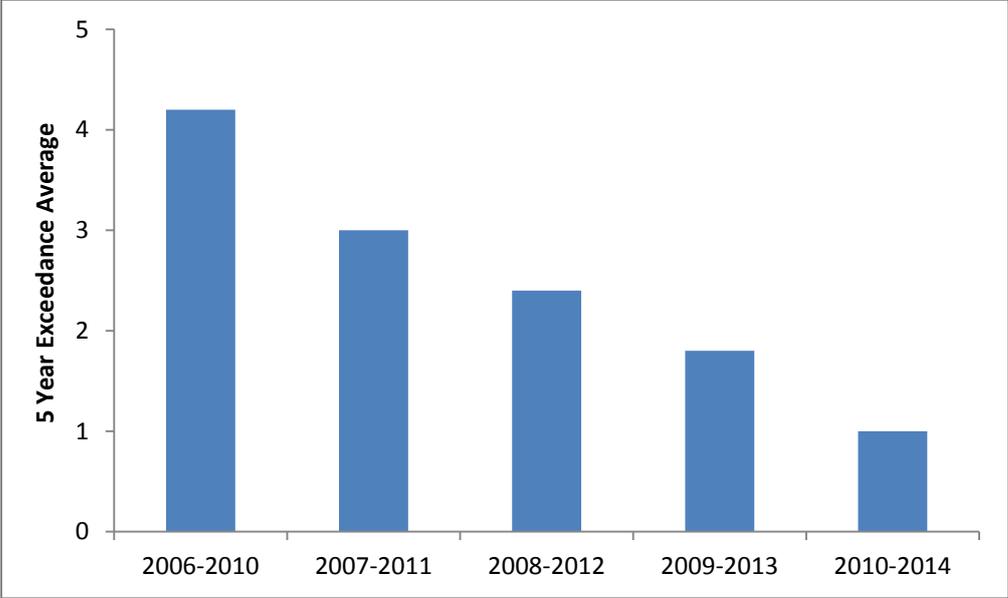


Figure 6-7: Comparison of the five year exceedance averages for the period 2006 to 2014.

Based on these analyses and the current previous five year exceedance average of 1, it is likely that Te Kuiti will meet the NES 2016 target of no more than one exceedance per 12 month period. But this will be dependent on meteorological conditions i.e. a particularly cold and calm winter could still result in more than one exceedance with in a 12 month period.

7 Putaruru

7.1 Air quality monitoring in Putaruru

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

A monitoring site was established at the Bowling Club on Arapuni Street in Putaruru, in July 2006 (refer to Figure 7.1). The map reference for the site is NZMS260 T15:533-457. Daily concentrations of PM₁₀ have been measured since the site was established. Data is adjusted for gravimetric equivalency.

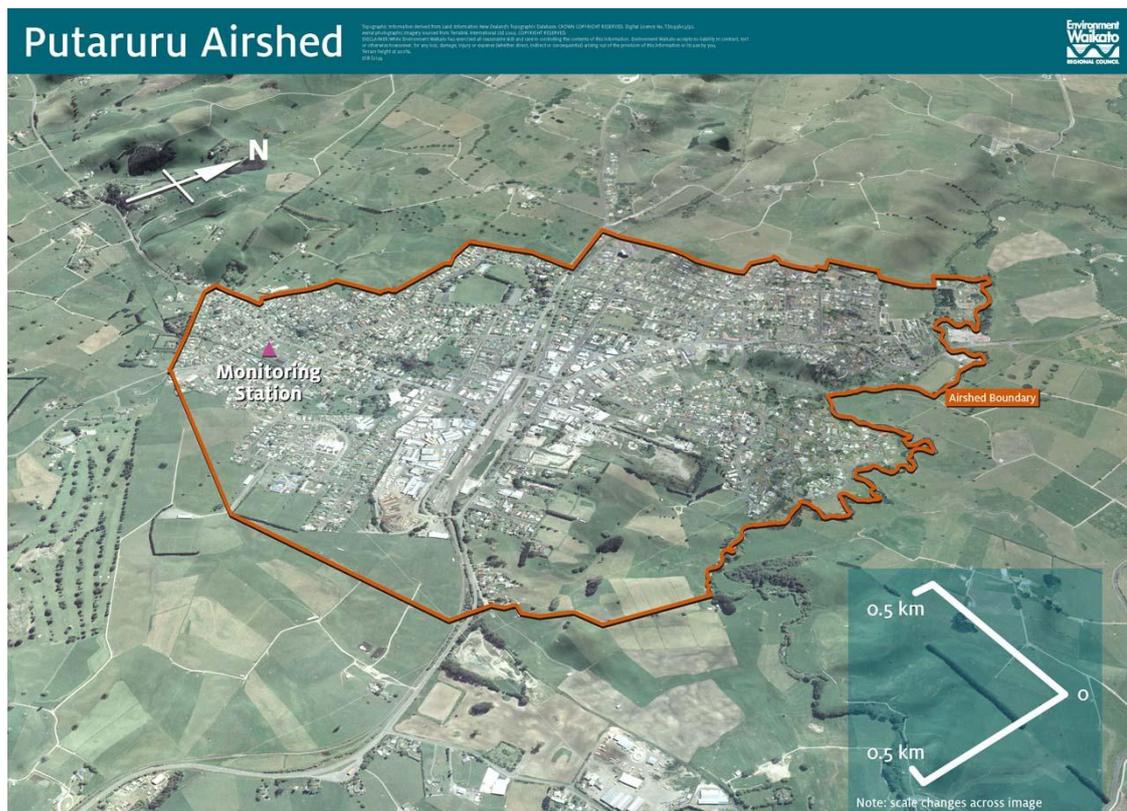


Figure 7-1: Putaruru Airshed and air quality monitoring site.

A ThermoAndersen FH62 C14 BAM is used at this site. Data is recorded at ten minute intervals (refer to Figure 7.2).



Figure 7-2: Putaruru air quality monitor.

7.2 PM₁₀ concentrations in Putaruru

Daily average PM₁₀ concentrations measured at Putaruru during 2014 are shown in Figure 7.3. Two exceedances of 50 µg/m³ (24-hour average) were recorded during 2014 and measured 73 µg/m³ on 13 March and 55 µg/m³ on 8 April. This compares with a maximum 24 hour average concentration of 46 µg/m³ during 2013 and 38 µg/m³ during 2012. Both exceedances in 2014 occurred well outside the typical wintertime season with hourly profiles inconsistent with the typical diurnal pattern indicative of a home heating source. In both cases the wind direction at the time was from the south southeast indicating a source from either the adjacent bowling green or paddock.

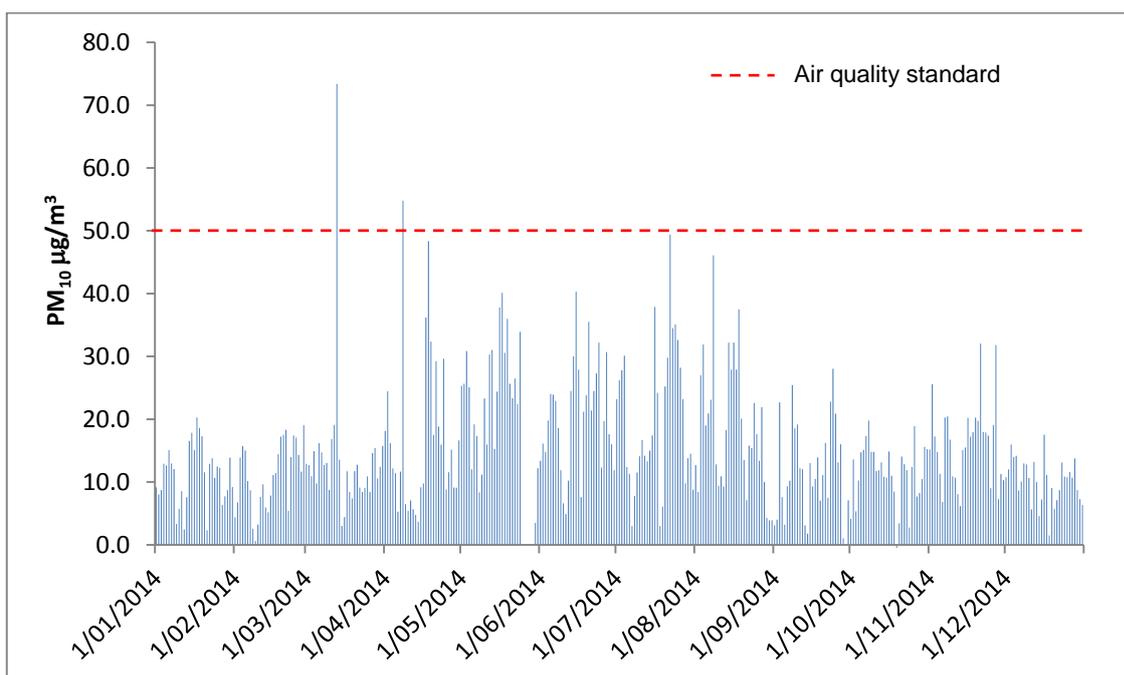


Figure 7-3: Daily average PM₁₀ concentrations measured at the Putaruru site during 2014.

Figure 7.4 compares PM₁₀ concentrations measured at Putaruru from 2006 to 2014 to the MfE (2000) air quality indicator categories.

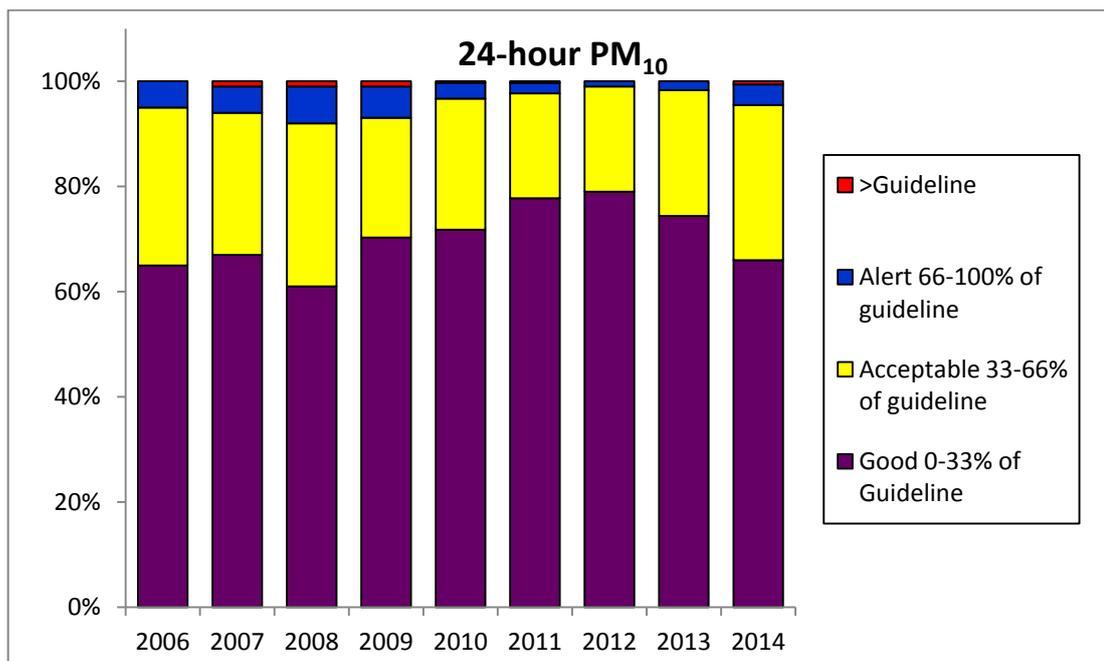


Figure 7-4: Comparison of PM₁₀ concentrations measured at the Putaruru site from 2006 to 2014 to air quality indicator categories.

Figure 7.5 shows seasonal variations in the distribution of PM₁₀ concentrations for 2014. The occurrence of exceedances in the March to April period is unusual and inconsistent with the expectation of exceedances coinciding with the May to August period when a large proportion of the data falls outside the good category and instead falls within the acceptable to alert category.

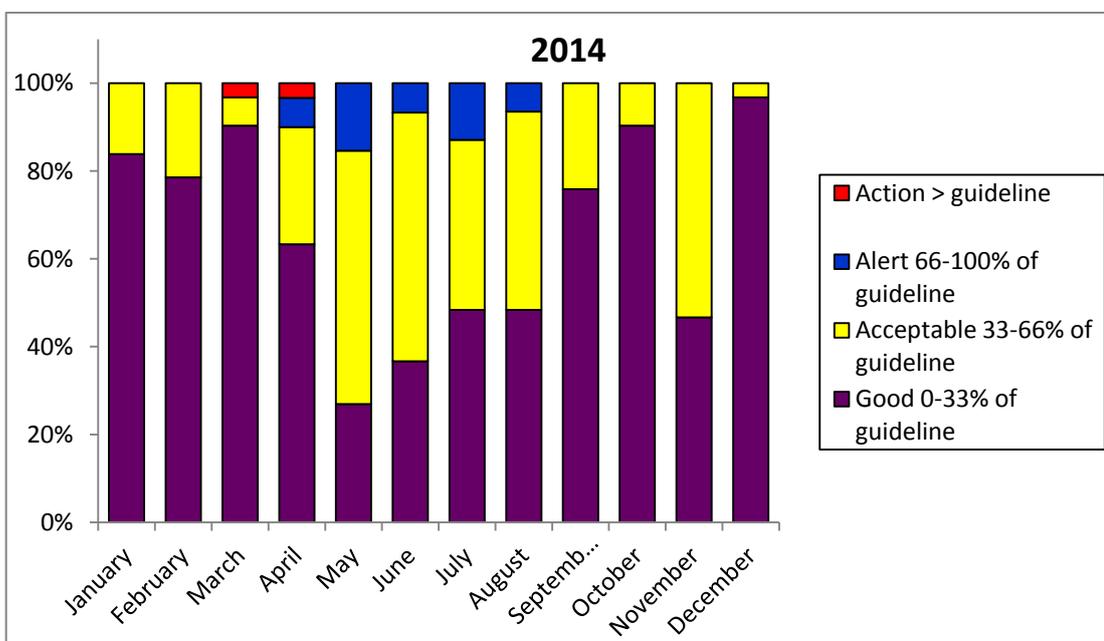


Figure 7-5: Comparison of daily PM₁₀ concentrations for 2014 to air quality indicator categories.

Figure 7.6 shows the number of days when 50 µg/m³ was exceeded, the maximum concentration and the 2nd highest concentration from 2007 to 2014. The 2006 data has

been excluded from the comparison as monitoring only began half way through the winter season. The trend line slope for exceedances per year is negative with an R^2 value of 0.5. The trend line slope for the 2nd highest concentrations per year is also negative with an R^2 value of 0.31. The greatest number of exceedances and the highest PM₁₀ concentrations occurred during 2008. However it is worth noting that in 2008, two of the four recorded exceedances were in summer (February) and came about as a result of dust created by roadworks during the unusual drought conditions. The two exceedances that occurred in March and April of 2014 are also considered unusual and not typical of the normal wintertime woodburner emission related exceedances.

Data suggests that the NES target for PM₁₀ may be met and that air quality has been improving over the period 2007 to 2014. However, further evaluation into non-winter sources of PM₁₀ giving rise to a breach of the NES observed in 2014 is required as this source may compromise future attainment of the standard for PM₁₀. Further discussion of this is provided in the trend analysis presented in Section 7.3 of this report.

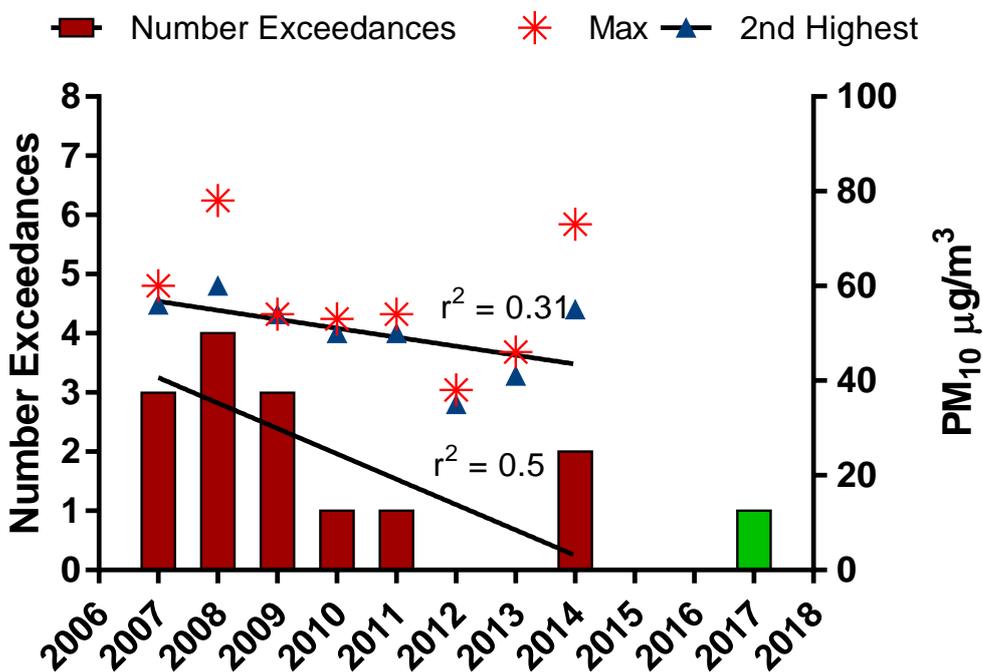


Figure 7-6: Number of days when 50 µg/m³ was exceeded compared with the maximum concentration and the 2nd highest concentration measured from 2007 to 2014.

The annual average PM₁₀ concentration for Putaruru for 2014 was 15.3 µg/m³ which is higher than the annual average of around 13 µg/m³ for the previous 5 years. The Ministry for the Environment specifies an annual average guideline for PM₁₀ of 20 µg/m³ (MfE, 2002). Summary statistics for PM₁₀ monitoring results are shown in Table 7.1.

Table 7-1: Summary of PM₁₀ concentrations measured at the Putaruru monitoring site from 2006 to 2013.

Indicator	2006	2007	2008	2009	2010	2011	2012	2013	2014
Good 0-33% of Guideline	65%	67%	61%	71%	72%	78%	79%	74%	66%
Acceptable 33-66% of guideline	30%	27%	31%	23%	25%	20%	20%	24%	30%
Alert 66-100% of guideline	5%	5%	7%	6%	3%	2%	1%	2%	4%
Action > Guideline	0%	1%	1%	1%	0.3%	0.3%	0%	0%	1%
Percentage of valid data	46%	100%	100%	100%	100%	95%	99%	99%	98%
Annual average ($\mu\text{g}/\text{m}^3$)	n/a	15.1	17.2	13.6	14.2	12.5	11.8	13.2	15.3
Number exceedances	0	3	4	3	1	1	0	0	2
99.7 %ile ($\mu\text{g}/\text{m}^3$)	41	56	59	53	50	50	35	41	54
Annual maximum ($\mu\text{g}/\text{m}^3$)	42	60	78	54	53	54	38	46	73
Number records	166	365	364	364	363	346	361	360	359
2 nd Highest ($\mu\text{g}/\text{m}^3$)	40	56	60	54	50	50	35	41	55

7.3 Trend analysis

Over time, air quality may improve, get worse, or remain the same. Peak levels of PM₁₀ in any given airshed vary from winter to winter depending on meteorological conditions and human responses. For example, higher PM₁₀ and more exceedances might be expected if a winter has a greater number of days when the wind speed is low and there is vertical stability in the lower atmosphere. Over the short term this inter-annual variability will mask any genuine underlying trend toward better or worse air quality. A reasonably long monitoring record is needed to confirm or exclude the possibility of any underlying trend.

Seasonal Mann-Kendall test for monotonic trends (consistently increasing or decreasing trends) is the preferred approach for detecting underlying trends in variable environmental time-series data sets, and may suggest presence of an underlying trend which is not evident from visual inspection of the PM₁₀ record or summary statistics. This method generates probability (p) values that are used to assess the likelihood that the apparent relationship is genuine, or comes about fortuitously as a result of a random alignment of variables. The conventional threshold for deciding whether a relationship is likely to be genuine is at a probability value of $p = 0.05$ or lower, which corresponds to a 95% confidence level and greater. A negative MK-Stat indicates a decreasing trend.

Seasonal Mann Kendall test results (MK-Stat of -1.6 and p-value of 0.11) do not provide evidence that PM₁₀ concentrations in Putaruru have been getting either better or worse over the period 2007 to 2014. The previous assessment for the period 2007 to 2013 did provide evidence of an improving trend (MK-Stat of -1.98 and p-value of 0.048).

The monthly averages for April, May and August in 2014 were higher than in 2013 and also indicates a reversal of the downwards trend for monthly averages in previous years (refer to Figure 7.7). The annual average is also higher (refer to Figure 7.8). A possible reason for this is insects getting in to the air intake of the BAM and depositing on the filters and causing short term spikes in the data. While these spikes were removed where possible when insects were identified, it is possible that they have had some impact on the monthly averages.

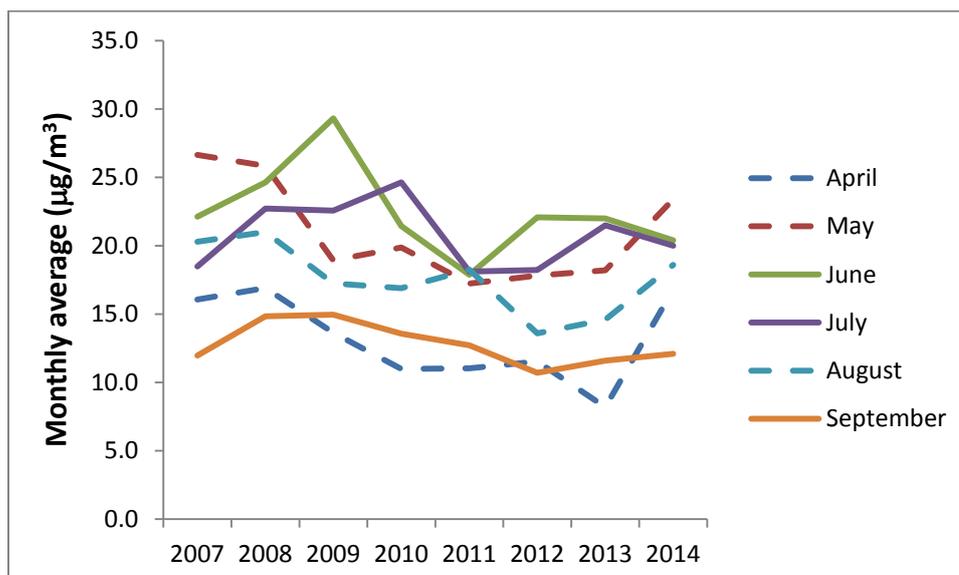


Figure 7-7: Comparison of the monthly averages (April to September) for the period 2007 to 2014.

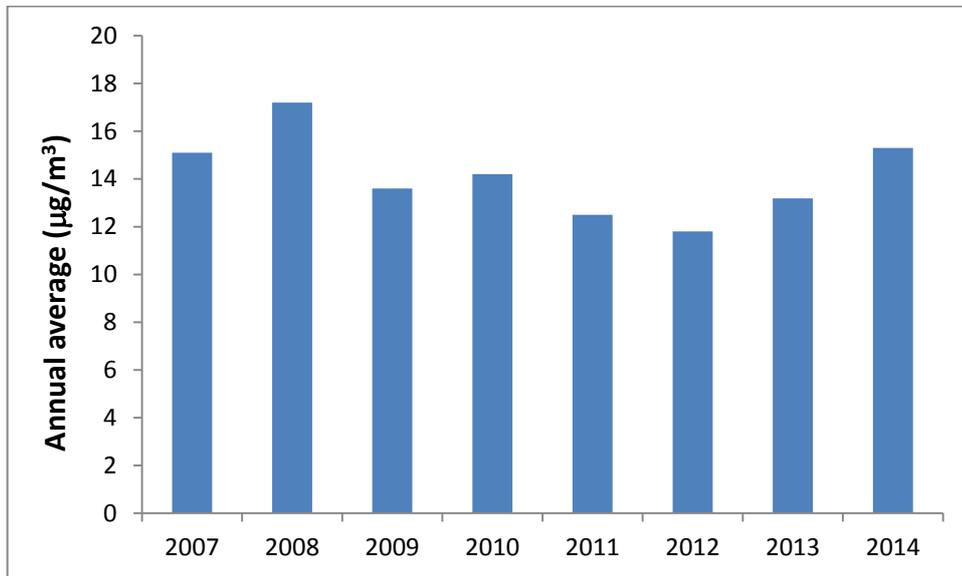


Figure 7-8: Comparison of the annual averages for the period 2007 to 2014.

Another way of comparing changes in air quality over time is to compare the 5 year exceedance average from year to year (refer to Figure 7.9) in order to remove some of the variation that occurs from year to year. There has been a consistent downwards trend in the 5 year exceedance average over the period 2006 to 2014 ranging from 2.8 for 2006 to 2010 to 0.8 for the period 2010 to 2014.

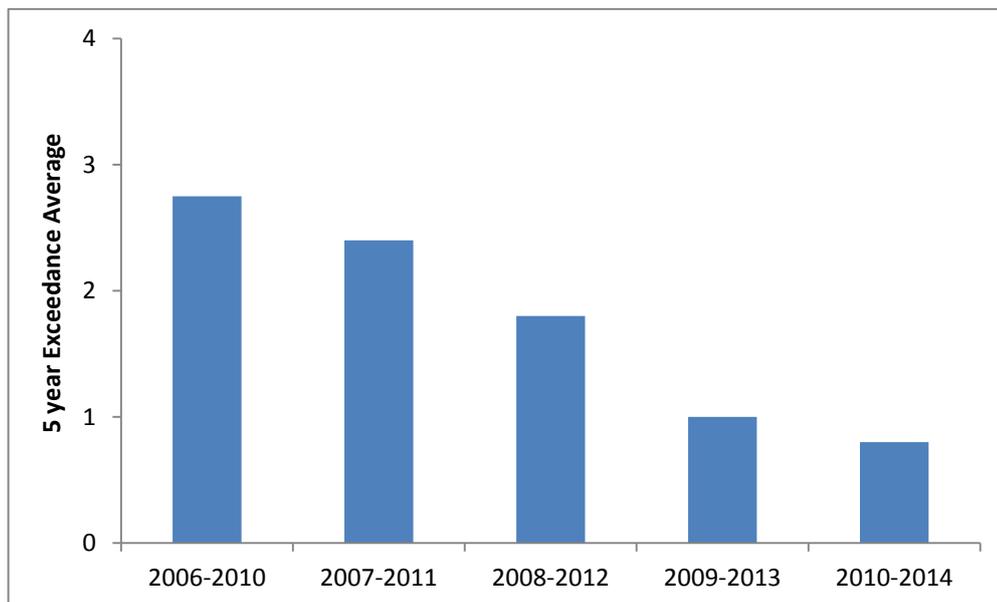


Figure 7-9: Comparison of the five year exceedance averages for the period 2006 to 2014.

While the overall indication is that exceedance numbers are tracking downwards, the non-winter exceedances that occurred in 2014 indicate the presence of an unidentified and localised source of PM₁₀ that could result in further exceedances in future.

8 Turangi

8.1 Air quality monitoring in Turangi

Turangi is located on the banks of the Tongariro River near the southern end of Lake Taupo and is 50 kilometres south west of Taupo. Turangi has a population of around 3500 and is the second largest population centre in the Taupo District. It is near the edge of the Kaimanawa Ranges.

A monitoring site was established at 16 Ohuanga Road, Turangi (refer to Figure 8.1) on 11 March 2009. Daily and hourly average PM₁₀ concentrations are measured at the site using a FH 62 BAM.



Figure 8-1: Turangi Airshed and air quality monitoring site.

8.2 PM₁₀ concentrations in Turangi

The maximum PM₁₀ concentration in Turangi was 40 µg m⁻³ (24-hour average) and was recorded on 27th of February which is well outside the typical wintertime season. The hourly profile indicates two large peaks occurring over the period 9 am to 4 pm. The second highest concentration was 33 µg/m³ which was recorded on 19 July and is consistent with the 2013 maximum of 33 µg/m³ recorded on 13th July and is also similar to maximum concentrations recorded in previous years. Daily average PM₁₀ concentrations measured at the Turangi site during 2014 are shown in Figure 8.2.

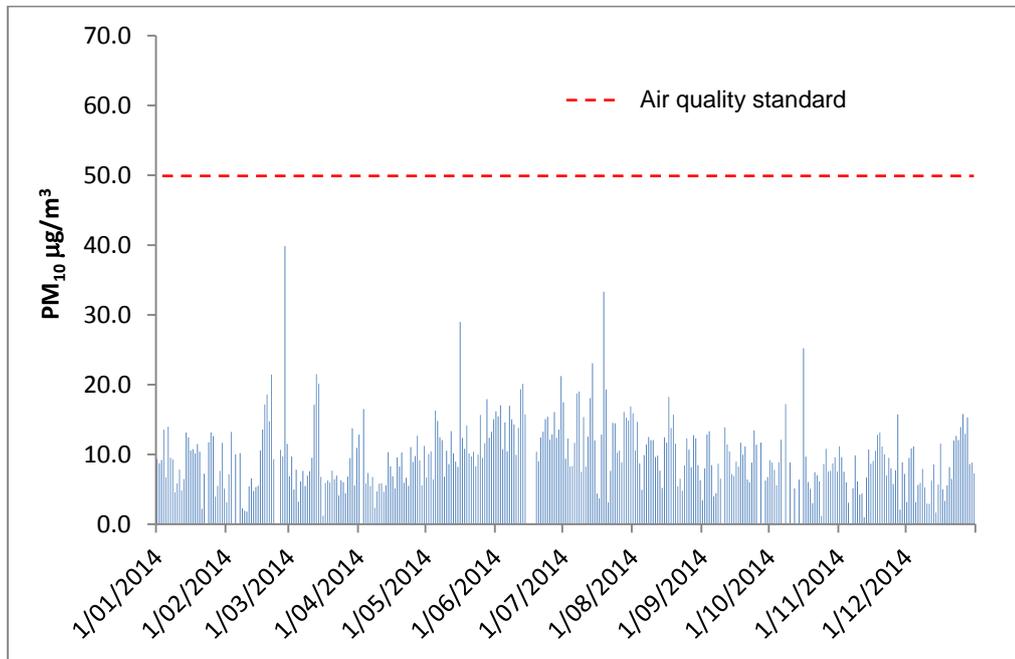


Figure 8-2: Daily average PM₁₀ concentrations measured at the Turangi site for 2014.

Figure 8.3 shows concentrations of PM₁₀ relative to air quality indicator categories at Turangi from 2009 to 2014. In 2014, 89% of days experienced PM₁₀ concentrations within the ‘good’ category. On all other days PM₁₀ was within the “acceptable” category apart from 0.6% of days falling within the “alert” category.

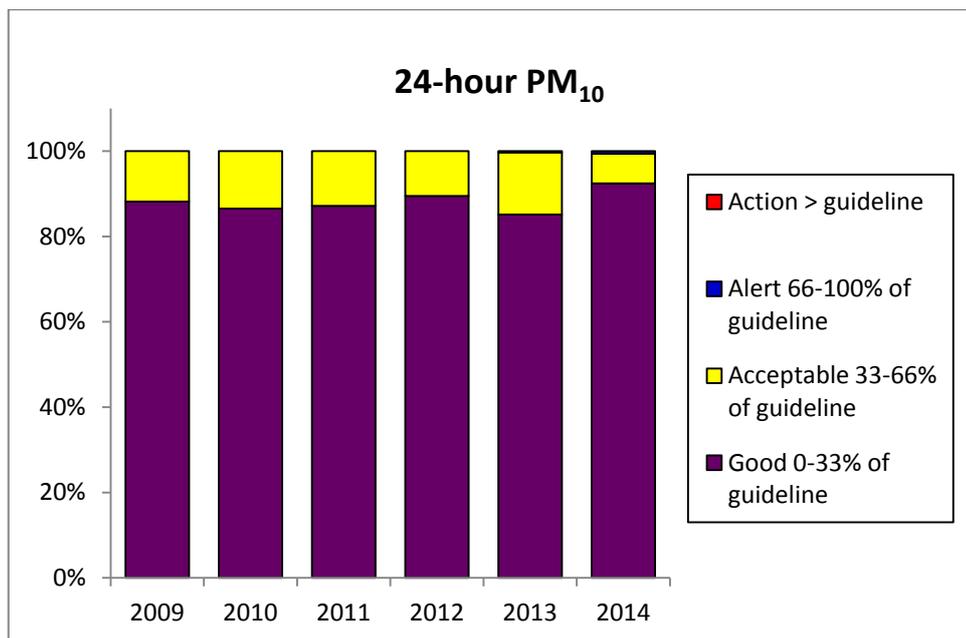


Figure 8-3: Comparison of PM₁₀ concentrations measured at the Turangi site from 2009 to 2014 to air quality indicator categories.

Seasonal variations in the distribution of PM₁₀ concentrations for 2014 are shown in Figure 8.4.

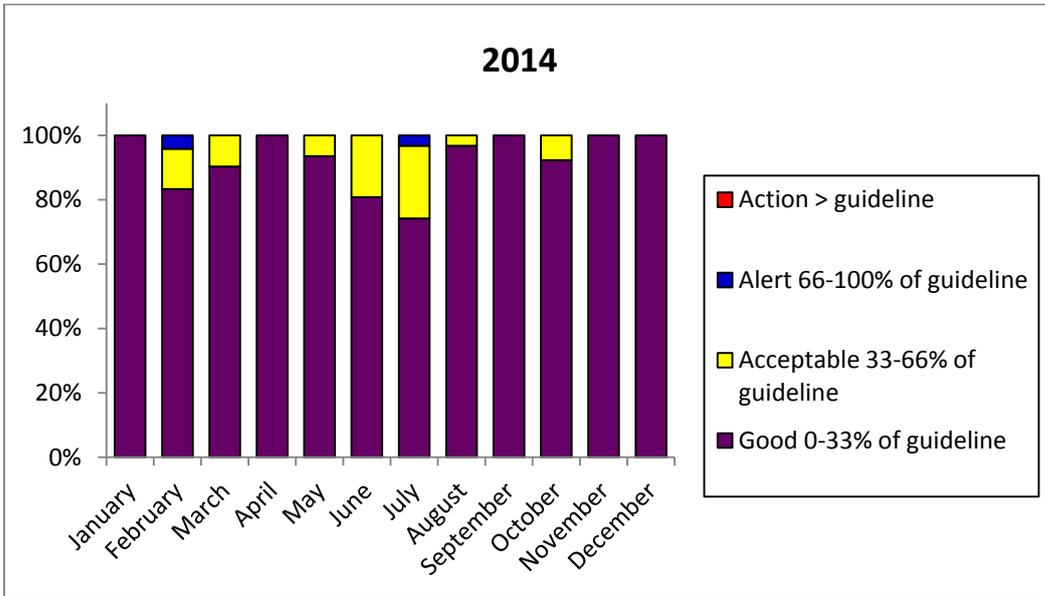


Figure 8-4: Comparison of daily PM₁₀ concentrations each month for 2014 to air quality indicator categories.

Figure 8.5 shows there were no exceedances of 50 µg/m³ from 2009 to 2014. It also shows the maximum concentration and the second highest concentration for each year which has remained consistently around 30 µg/m³ apart from the maximum of 40 µg/m³ for 2014 which was recorded during summer and is not likely to be caused by woodburner emissions based on the time of the year and an analysis of the hourly profile.

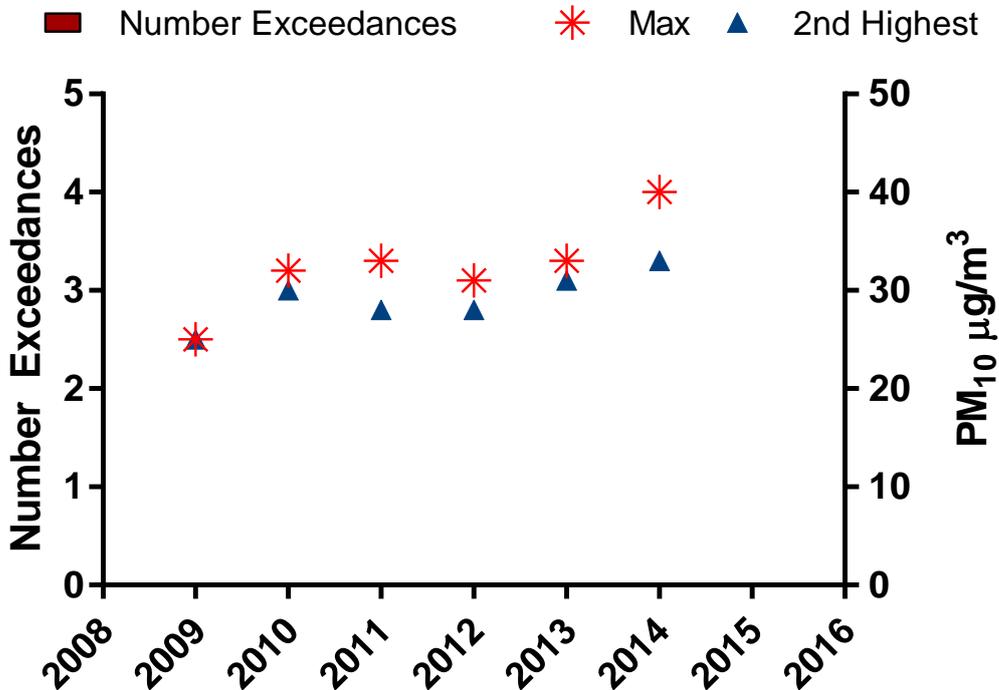


Figure 8-5: Number of days when 50 µg/m³ was exceeded compared with the maximum concentration and the 2nd highest concentration measured from 2009 to 2014.

The annual average PM₁₀ concentration for Turangi for 2014 is 9.9 µg/m³ which is consistent with previous annual averages of around 10 µg/m³. The Ministry for the Environment specifies an annual average guideline for PM₁₀ of 20 µg/m³ (MfE, 2002). Table 8.1 shows summary statistics for PM₁₀ monitoring results from 2009 to 2014.

Table 8-1: Summary of PM₁₀ concentrations measured at the Turangi monitoring site from 2009 to 2014.

Indicator	2009	2010	2011	2012	2013	2014
Good 0-33% of guideline	88%	87%	87%	90%	85%	89%
Acceptable 33-66% of guideline	12%	13%	13%	10%	15%	7%
Alert 66-100% of guideline	0%	0%	0%	0%	0%	1%
Action > guideline	0%	0%	0%	0%	0%	0%
Percentage of Valid data	79%	84%	85%	99%	100%	95%
Annual Average (µg/m ³)	9.8	10.8	10.2	10.0	10.8	9.9
Measured exceedances	0	0	0	0	0	0
99.7 %ile concentration	25	30	28	28	31	33
Annual Maximum (µg/m ³)	25	32	33	31	33	40
Number of records	288	305	312	362	363	346
2 nd Highest (µg/m ³)	25	30	28	28	31	33

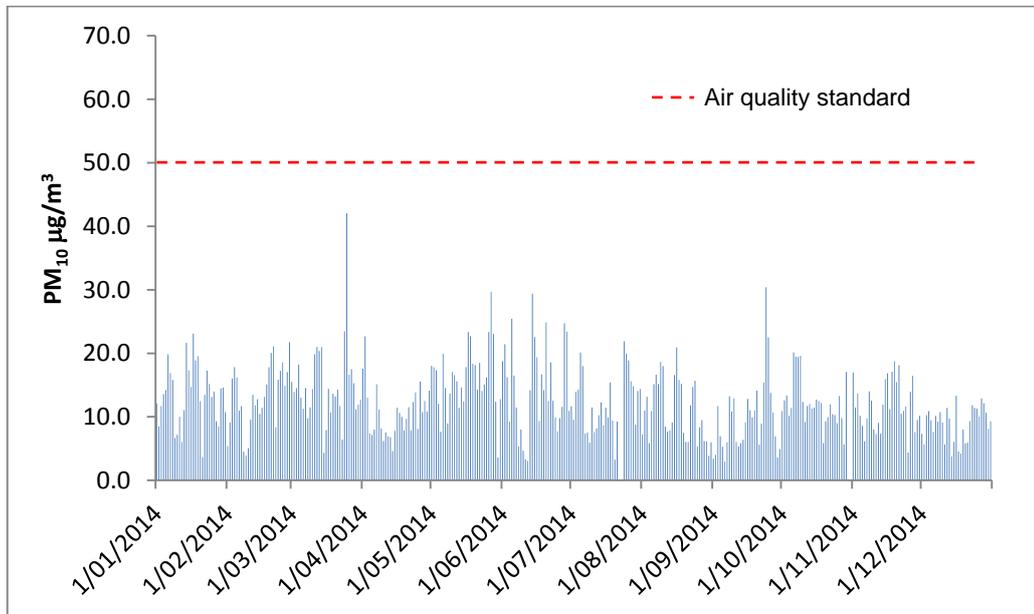


Figure 9-2: Daily average PM₁₀ concentrations measured at Cambridge during 2014.

Figure 9.3 shows concentrations of PM₁₀ relative to air quality indicator categories at Cambridge for 2013 and 2014. In 2014, 79% of days experienced PM₁₀ concentrations within the 'good' category. On all other days, but one which fell within the "alert" category, PM₁₀ was within the "acceptable" category.

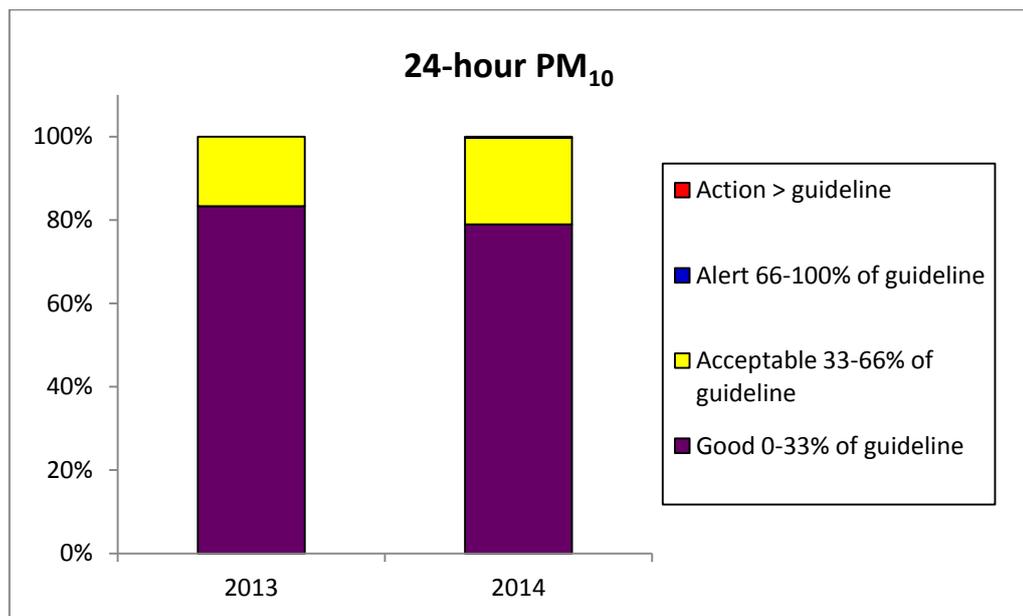


Figure 9-3: Comparison of PM₁₀ concentrations measured at the Cambridge site from 2013 to 2014 to air quality indicator categories.

Seasonal variations in the distribution of PM₁₀ concentrations for 2014 are shown in Figure 9.4.

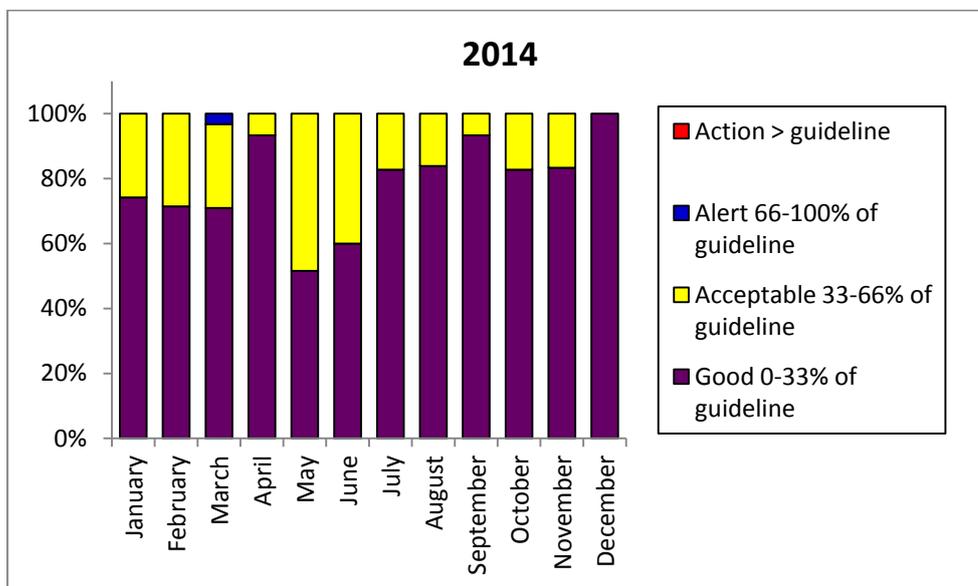


Figure 9-4: Comparison of daily PM₁₀ concentrations each month during 2014 to air quality indicator categories.

The annual average PM₁₀ concentration for 2014 of 12.4 µg/m³ is similar to the annual average for 2013 and is at the low end of the range of annual averages determined for airsheds in the Waikato region. The Ministry for the Environment specifies an annual average guideline for PM₁₀ of 20 µg/m³ (MfE, 2002). Summary statistics for PM₁₀ monitoring results for 2014 are shown in Table 9.1.

Table 9-1: Summary of PM₁₀ concentrations measured at the Cambridge monitoring site during 2013 and 2014.

Indicator	2013	2014
Good 0-33% of guideline	83%	79%
Acceptable 33-66% of guideline	17%	21%
Alert 66-100% of guideline	0%	0.3%
Action > guideline	0%	0%
Percentage of valid data	59%	99%
Annual average (µg/m ³)	11.8	12.4
Measured exceedances	0	0
99.7 %ile PM ₁₀ conc. (µg/m ³)	26	30
Annual maximum (µg/m ³)	28	42
Number of records	216	361
2 nd highest conc. (µg/m ³)	26	30

10 Te Awamutu-Kihikihi

10.1 Air quality monitoring in Te Awamutu-Kihikihi

Te Awamutu is located approximately 30 km south of Hamilton with a population of approximately 12,000. The air quality monitoring site for Te Awamutu is located at Albert Park on Albert Park Drive and was established in June 2013. The site meets the requirements of the “Residential Neighbourhood” site classification as described in the ‘*Good Practice Guideline for Air Quality Monitoring and Data Management 2009*’ report (MfE, 2009).

A FH62 C14 BAM has measured PM₁₀ concentrations since June 2013. Figure 10.1 shows the Te Awamutu-Kihikihi Airshed and the location of the monitoring site at Albert Park Drive in Te Awamutu.

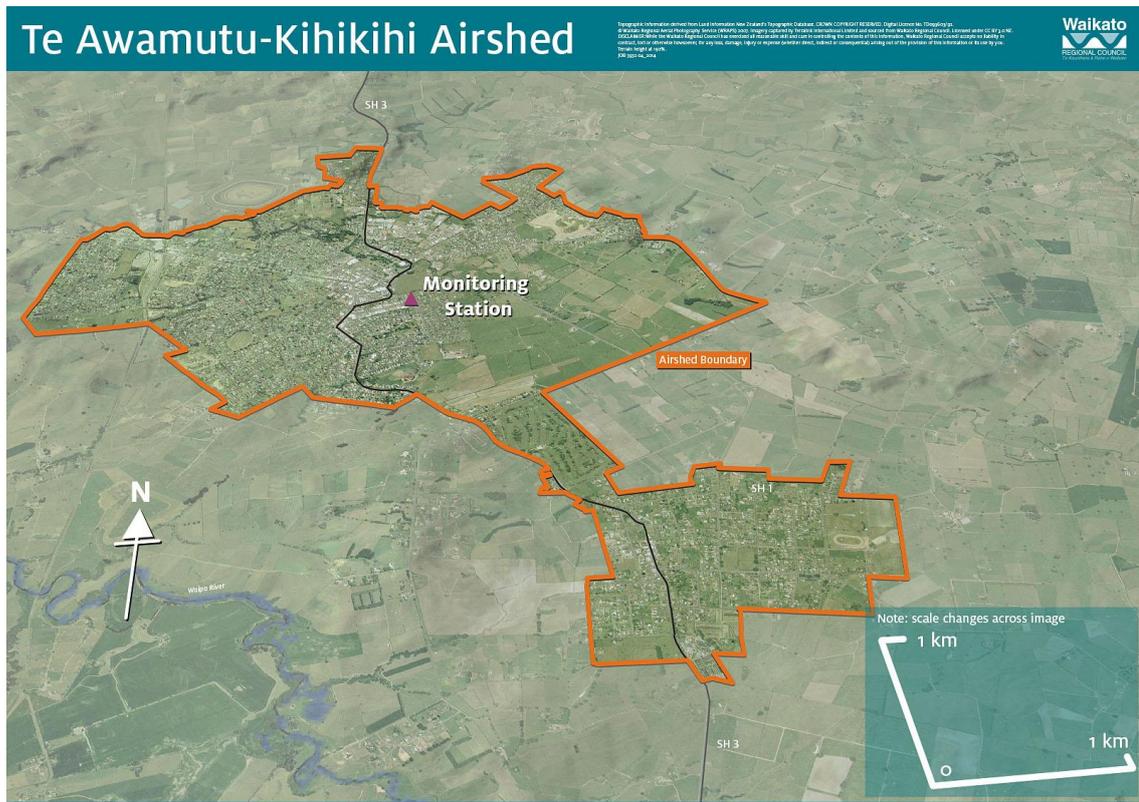


Figure 10-1: Te Awamutu-Kihikihi Airshed and air quality monitoring site.

10.2 PM₁₀ concentrations in Te Awamutu-Kihikihi

Daily average PM₁₀ concentrations measured at the Albert Park site during 2014 are shown in Figure 10.2. The maximum concentration in Te Awamutu was 32 µg/m³ (24-hour average) recorded on 17 July. No exceedances of 50 µg/m³ were recorded during 2013.

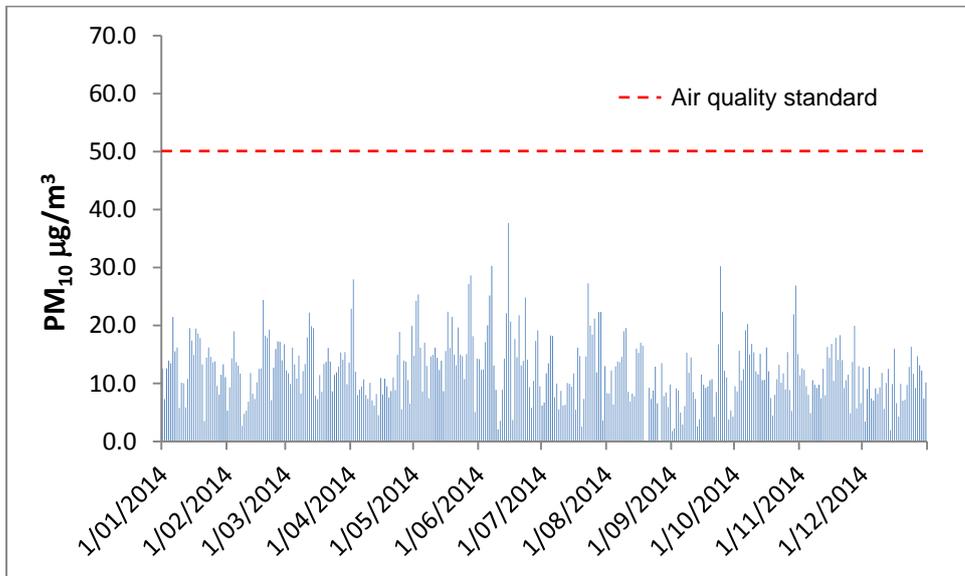


Figure 10-2: Daily average PM₁₀ concentrations measured at Te Awamutu during 2014.

Figure 10.3 shows concentrations of PM₁₀ relative to air quality indicator categories at Te Awamutu for 2013 and 2014. In 2014, 82% of days experienced PM₁₀ concentrations within the ‘good’ category. On all other days, but one which fell within the “alert” category, PM₁₀ was within the “acceptable” category.

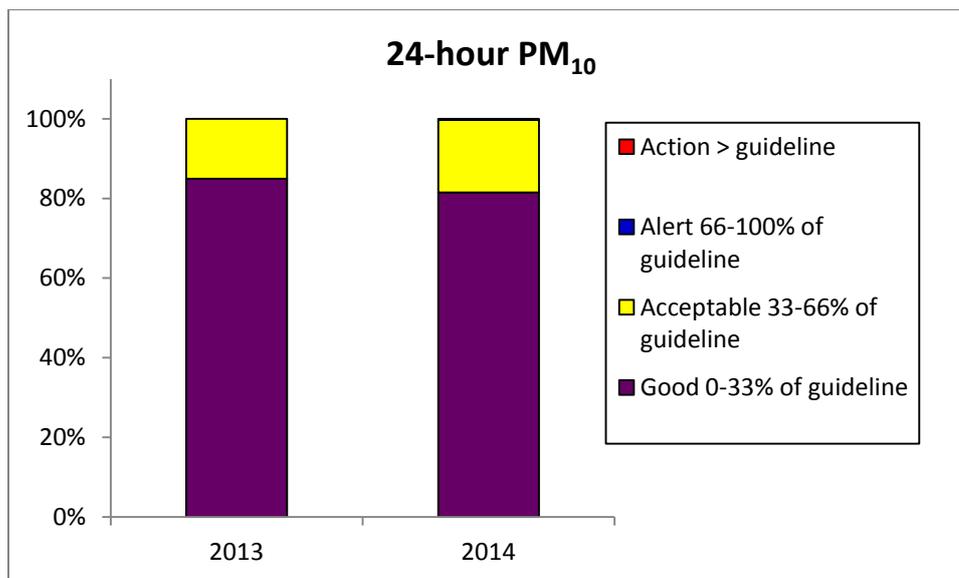


Figure 10-3: Comparison of PM₁₀ concentrations measured at the Te Awamutu site from 2013 to 2014 to air quality indicator categories.

Seasonal variations in the distribution of PM₁₀ concentrations for 2014 are shown in Figure 10.4.

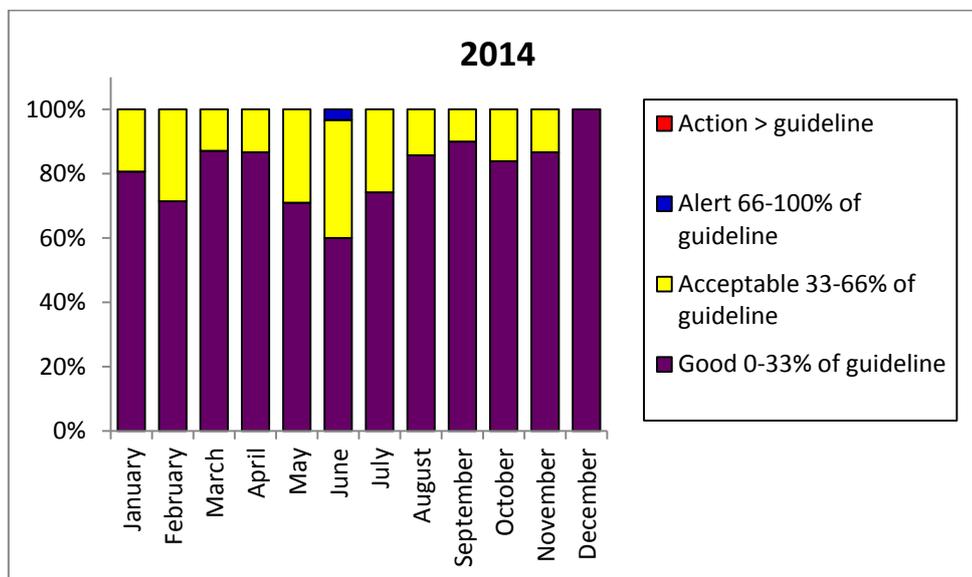


Figure 10-4: Comparison of daily PM₁₀ concentrations each month during 2014 to air quality indicator categories.

The annual average PM₁₀ concentration for 2014 of 12.3 µg/m³ is similar to the annual average for 2013 and is at the low end of the range of annual averages determined for airsheds in the Waikato region. The Ministry for the Environment specifies an annual average guideline for PM₁₀ of 20 µg/m³ (MfE, 2002). Summary statistics for PM₁₀ monitoring results for 2014 are shown in Table 10.1.

Table 10-1: Summary of PM₁₀ concentrations measured at the Te Awamutu monitoring site during 2013 and 2014.

Indicator	2013	2014
Good 0-33% of guideline	85%	82%
Acceptable 33-66% of guideline	15%	18%
Alert 66-100% of guideline	0%	0.3%
Action > guideline	0%	0%
Percentage of valid data	51%	99%
Annual average (µg/m ³)	11.8	12.3
Measured exceedances	0	0
99.7 %ile PM ₁₀ conc. (µg/m ³)	28	30
Annual maximum (µg/m ³)	32	38
Number of records	186	362
2 nd highest conc. (µg/m ³)	25	30

11 Summary

During 2014 concentrations of PM₁₀ were measured at air quality monitoring sites in Hamilton, Tokoroa, Taupo, Te Kuiti, Putaruru, Turangi, Cambridge and Te Awamutu-Kihikihi. PM_{2.5}, oxides of nitrogen, carbon monoxide, benzene, toluene, xylenes and ethylbenzene were also measured in Hamilton.

More than one exceedance of 50 µg/m³ as a 24-hour PM₁₀ average within a rolling 12-month period constitutes a breach of the NESAQ. The standard for PM₁₀ was breached in Tokoroa and Putaruru in 2014. There were no breaches in any of the other airsheds. There were also no exceedances of the annual average guideline of 20 µg/m³ for PM₁₀ in any of the airsheds. The maximum measured PM₁₀ concentrations, number of exceedances of 50 µg/m³ and the annual average PM₁₀ concentrations in all airsheds are shown in Table 11.1.

Table 11-1: Summary of PM₁₀ monitoring results for 2014.

Site	Maximum measured concentration (µg/m ³)	Measured exceedances	Number of NES breaches	Annual Average (µg/m ³)
Hamilton (Claudelands)	46	0	0	14.1
Hamilton (Ohaupo Rd)	32	0	0	13.4
Tokoroa	69	9	9 ¹	15.9
Taupo	45	0	0	12.4
Te Kuiti	48	0	0	15.9
Putaruru	73	2	1	15.3
Turangi	40	0	0	9.9
Cambridge	42	0	0	12.4
Te Awamutu-Kihikihi	38	0	0	12.3

1. The first exceedance of the calendar year was a breach based on less than 12 months since the last exceedance for 2013.

Refer to Table 11.2 for a summary of trend and five year exceedance average for the four polluted airsheds and Hamilton airshed, which has had exceedances in the past and therefore has the potential to be classified as polluted should there be more than two exceedances within any 12 month period. A statistical analysis of seasonal PM₁₀ data collected in Hamilton, Te Kuiti and Taupo indicates that concentrations have decreased over the previous six or more year period. No statistically significant change has been identified for Tokoroa and the previous decreasing trend identified for Putaruru is no longer significant based on inclusion of the 2014 data. A trend analysis of Turangi, Cambridge and Te Awamutu-Kihikihi is unnecessary because there have been no exceedances and a visual assessment of the data does not indicate any potential for increasing concentrations based on data collected to date.

Table 11-2: Five year exceedance average and trend analysis for the five worst airsheds.

Airshed	Five year exceedance average (2010 to 2014)	Trend
Hamilton	0.4	Decrease ¹
Tokoroa	13.2	No change
Taupo	1	Decrease
Te Kuiti	1	Decrease
Putaruru	0.8	No change

1. Based on data collected up to 2013 from Peachgrove Rd only.

A comparison of the changes in the five year exceedance average for the four polluted airsheds and Hamilton airshed is provided in Figure 11.1 which indicates that the exceedance averages have been decreasing.

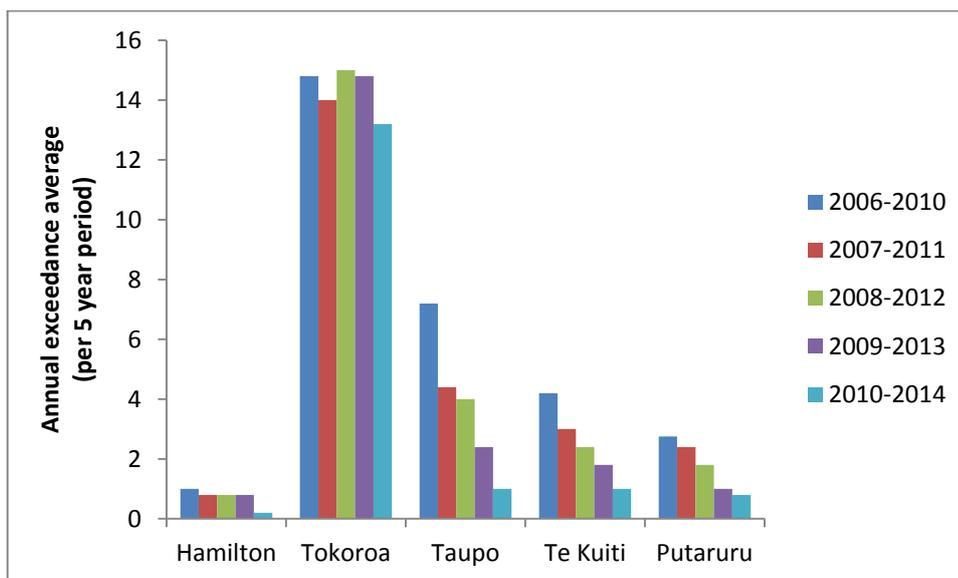


Figure 11-1: Comparison of changes in the annual exceedance averages (per 5 year period) for Hamilton, Tokoroa, Taupo, Te Kuiti and Putaruru.

In Hamilton, PM_{2.5} concentrations exceeded the World Health Organisation (WHO) guideline of 25 µg/m³ (24-hour average) on five days during 2014 and coincided with the five days when PM₁₀ was most elevated.

The highest annual average concentration for benzene of 2.5 µg/m³ was measured in Hamilton at the Greenwood Street monitoring site and is lower than the Ministry for the Environment’s annual guideline. An improving or “levelling” trend is evident for annual average concentrations of benzene at all sites. Concentrations of toluene, xylene and ethylbenzene were also well within acceptable levels.

Both carbon monoxide and nitrogen dioxide as measured in Hamilton at the Ohaupo Road monitoring station were well below the NES standards for CO and NO₂. The 8-hour concentrations of CO were less than 33% of the NES and NZ and regional ambient air quality guidelines and therefore fall within the good air quality indicator category. The 1-hour concentrations of NO₂ were less than 66% of the NES and NZ and regional ambient air quality guidelines and therefore fall within the acceptable air quality indicator category.

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Appendices

The appendices to this report are the Excel spreadsheets of raw data and indicator calculations and are compiled in separate Waikato Regional Council documents which may be obtained on request from the Waikato Regional Council.

Description	Document Reference Number
Hamilton BTEX	1269117
Hamilton CO	1058703
Hamilton NOx	2899408
Hamilton (Peachgrove Rd) PM ₁₀	2241995
Hamilton (Ohaupo Rd) PM ₁₀	2866561
Hamilton Meteorology	1058711
Taupo PM ₁₀	2289178
Taupo Normalisation	3024937
Taupo Meteorology	1218406
Tokoroa PM ₁₀	2165753
Tokoroa Normalisation	2896020
Tokoroa Meteorology	1058722
Te Kuiti PM ₁₀	1058720
Te Kuiti Meteorology	1058717
Cambridge PM ₁₀	2824886
Te Awamutu PM ₁₀	2824899
Putaruru PM ₁₀	1219164
Turangi PM ₁₀	1620622