Management of PM$_{10}$ in Whangarei

An assessment of management options to achieve National Environmental Standards

Prepared for Northland Regional Council
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Executive Summary

For most of the year, the air quality in Whangarei is good. On occasion during the winter months concentrations of PM_{10} become elevated as a result of increased emissions and meteorological conditions which restrict dispersion.

The National Environmental Standard for air quality was introduced by the Ministry for the Environment in 2004 to manage air quality throughout New Zealand. The NES covers five key contaminants; carbon monoxide, nitrogen dioxide, ozone, sulphur dioxide and PM_{10}.The NES requires that PM_{10} concentrations do not exceed 50 μg m^{-3} (24-hour average) by 2013 with one allowable exceedence per year. The NES also requires that PM_{10} be monitored at the site that experiences the highest concentrations or has the greatest frequency of concentrations more than 50 μg m^{-3}.

The maximum PM_{10} concentration measured in Whangarei during winter is 52 μg m^{-3} (24-hour average) and was recorded during 2006 at the air quality monitoring site at Robert Street. This concentration has been used as the starting point to determine the required reductions in PM_{10} concentrations. Based on the 2006 data, a four percent reduction in PM_{10} concentrations is required to comply with the NES.

In response to the NES, the Northland Regional Council introduced regulations via the Regional Air Quality Plan to prohibit outdoor burning. This source was identified as contributing 9% of PM_{10} emissions during the winter months. These provisions became operative in 2008.

A home heating survey conducted for Whangarei in 2006 indicated a large proportion of solid fuel burners were installed before 1996. Because solid fuel burners have a limited useful life, it is likely that many will be replaced in the near future. Probable replacement methods include lower emitting NES compliant wood burners, electricity or gas. As a result of the improvement in PM_{10} associated with the replacement of old burners and the existing regulations prohibiting outdoor burning, it is unlikely that ambient PM_{10} concentration in the airshed will breach the NES.

To improve air further, Northland Regional Council could consider management options that would meet the Ministry for the Environment 'Acceptable' environmental performance indicator category for air quality of 33 μg m^{-3} (24-hour average) for PM_{10} (MfE, 2002). A 37% reduction in PM_{10} concentrations is required to meet this target.

It is possible that this target could be met by around 2016 (assuming 20 year natural attrition for burners) as a result of existing regulatory measures and natural attrition. Other management options that increase the certainty of achieving the 'Acceptable' category include a ban on open fires and the prohibition of multi fuel burners.

Dispersion modelling using TAPM generally under predicted PM_{10} concentrations on days when concentrations were highest at Whangarei. The cause of the discrepancy is unknown. An assessment of spatial variability suggests the highest PM_{10} concentrations occur around central to North West Whangarei. The current location of the Robert Street monitoring site is appropriately located around the area where maximum concentrations are predicted.

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1 Introduction

The standard of air quality in Whangarei is generally good and typically complies with the National Environmental Standard for Air Quality (NES) for PM_{10} of 50 µg m^{-3} (24-hour average), with one allowable exceedence per year. The NES requires that PM_{10} be monitored at the site that experiences the highest concentrations or has the greatest frequency of concentrations more than 50 µg m^{-3}.

In Whangarei PM_{10} concentrations are measured at a site in Robert Street. The maximum measured wintertime PM_{10} concentration of 52 µg m^{-3} (24-hour average) was recorded during June 2006. Air quality monitoring between 2007 and winter 2009 has not recorded any exceedences of 50 µg m^{-3} for PM_{10}.

Northland Regional Council developed the Regional Air Quality Plan to manage air quality in the Northland Region. The plan has been operative since 2003. In 2007 Plan Change 2: Backyard Burning was notified that proposed to prohibit outdoor burning in the Whangarei urban area. These regulations became operative in December 2008.

The Ministry for the Environment has also developed Environmental Performance Indicator categories for Air Quality (MfE, 2002) that provide guidance for Councils to manage air quality (Table 1.1). The maximum PM_{10} concentration to achieve the 'Acceptable' category for the environmental performance indicators is 33 µg m^{-3} (24-hour average).

This report identifies a number of management options to reduce PM_{10} concentrations and ensure compliance with the NES and the 'Acceptable' category for environmental performance indicators.

Table 1.1: Environmental Performance Indicator categories for air quality (MfE, 2002).

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

The report also identifies, through air shed modelling the meteorological conditions in Whangarei, and the likely location of the highest concentration of PM_{10}.

1.1 Whangarei Airshed

The Whangarei Airshed includes the following census area units: Tikipunga East, Tikipunga West, Kamo East, Otangarei, Whau Valley, Kensington, Western Hills, Regent, Mairtown, Riverside, Vinetown, Woodhill, Horahora, Maunu, Morningside, Raumaunga West, Raumaunga East, Port-Limeburners, Whangarei Central, Parahaki, Inlet-Port Whangarei and Onerahi. In addition, the areas of Kamo West, Sherwood Rise, Abbey Caves, Springs Flat, Three Mile bush and, Otaika-Portland are partially within the airshed (Figure 1.1).

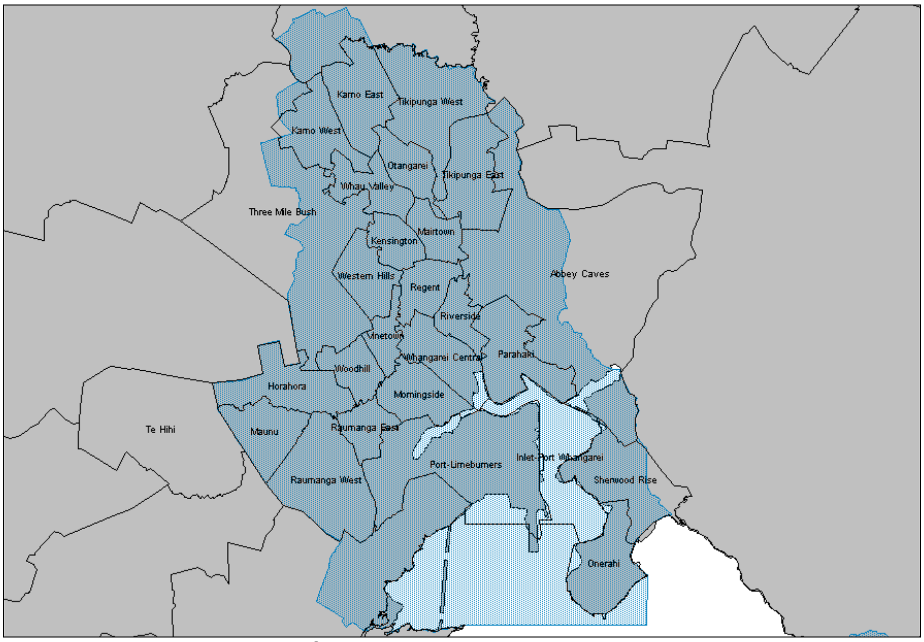

Figure 1.1: Airshed boundary for Whangarei (blue shading).

2 Air quality monitoring

Air quality monitoring for CO, SO_2 and PM_{10} has taken place in Whangarei. Monitoring for carbon monoxide at a site on Bank Street in Whangarei during 1996 indicated that concentrations exceeded 10 μg m^{-3} (eight hour average) on three occasions. In addition, there was one exceedence of the value of 30 milligrams (per cubic metre, one hour average). Sulphur dioxide concentrations were monitored at Whangarei Heads from 2003 to 2007. Results show that SO_2 concentrations have remained below the New Zealand ambient air quality guideline of 120 μg m^{-3}.

Particulate matter (PM_{10}) is measured at a site on Walter Street and at a site on Robert Street (Figure 2.1). A high volume sampler that measures PM_{10} concentrations intermittently is located at the Walter Street site. A Beta Attenuation Monitor (BAM) measures PM_{10} concentrations at 10 minute intervals at the Robert Street site, and this site is compliant with the air quality monitoring requirements for the NES.

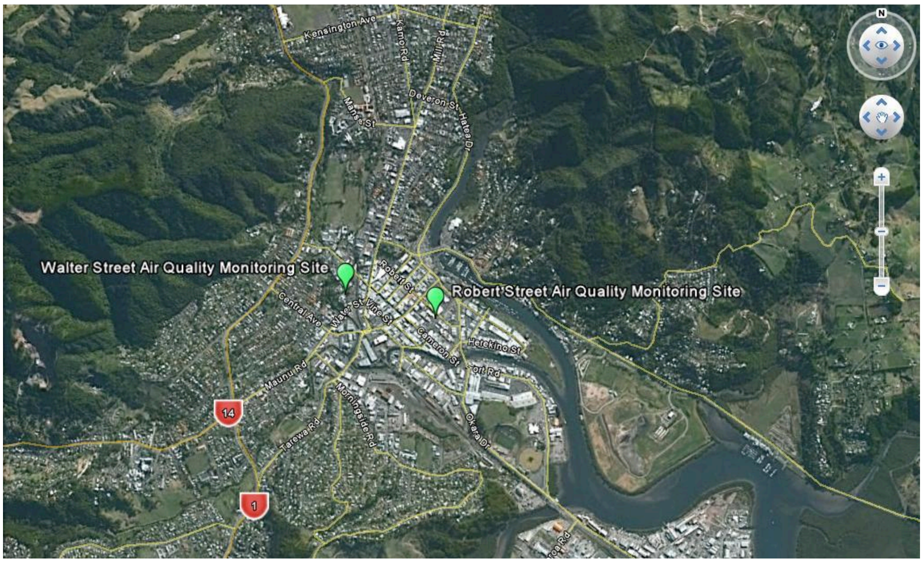

Figure 2.1: Current air quality monitoring sites at Whangarei.

Figure 2.2 shows the daily average PM_{10} concentrations from March to December 2006 at the Robert Street site. Figure 2.3 shows the daily average PM_{10} concentrations during 2007. There were no exceedences of the NES during 2007, although it is noted that only 54% of data was available during this year.

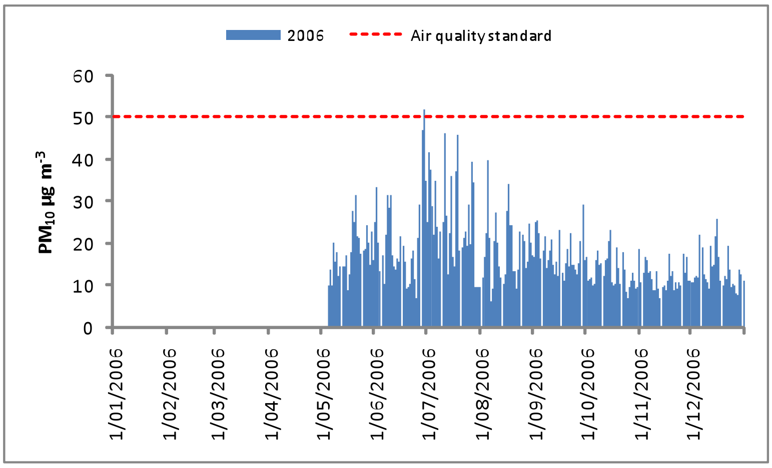

Figure 2.2: Daily average PM_{10} concentrations for 2006 at the Robert Street site.

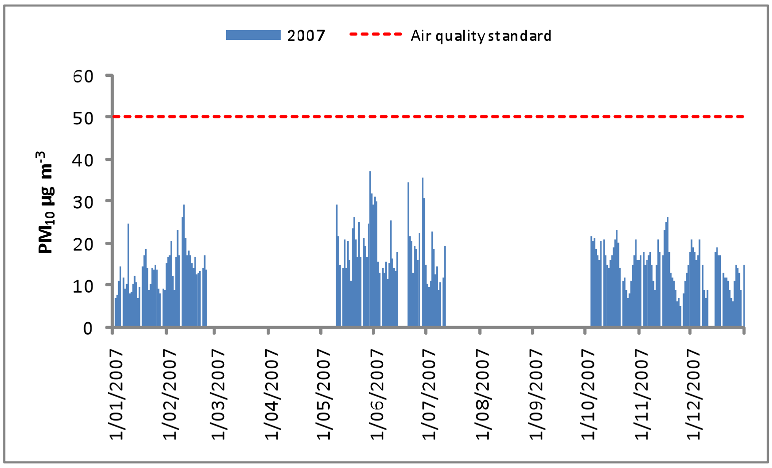

Figure 2.3: Daily average PM_{10} concentrations for 2007 at the Robert Street site.

Figure 2.4 shows daily average PM_{10} concentrations during 2008. The maximum concentration was 35 µg m^{-3}. Daily average PM_{10} concentrations during 2009 are shown in Figure 2.5. Only 23% of data is available for 2009. The maximum recorded concentration of 94 µg m^{-3} was recorded on 25 September. This concentration, which coincides with the Australian bush fires and resulted in exceedences of 50 µg m^{-3} at numerous air quality monitoring sites in New Zealand, is not considered further in this report.

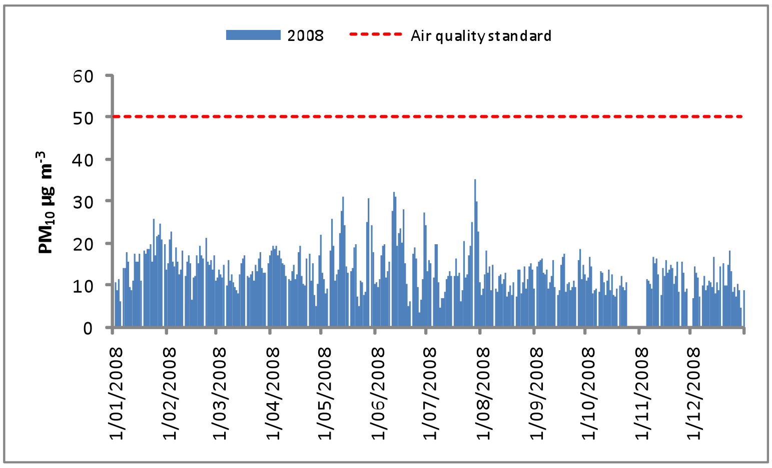

Figure 2.4: Daily average PM_{10} concentrations for 2008 at the Robert Street site.

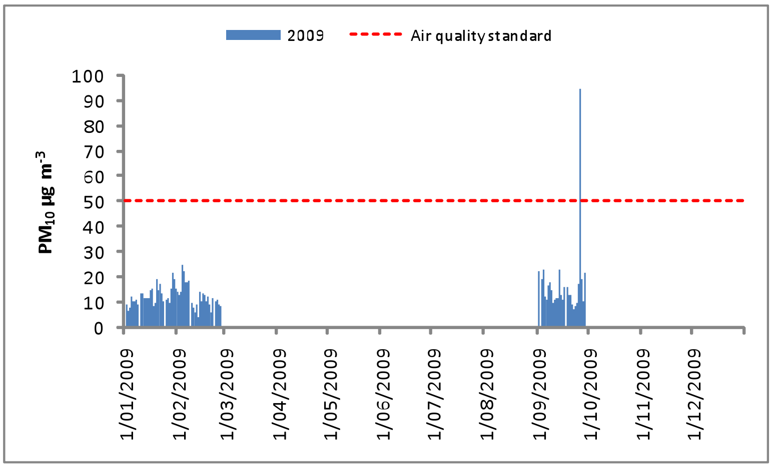

Figure 2.5: Daily average PM_{10} concentrations for 2009 at the Robert Street site.

Concentrations of PM_{10} measured from 2006 to 2009 were compared to the MfE air quality indicator categories described in Table 1.1. The majority of the PM_{10} concentrations measured were less than 66% of the air quality guideline, within the “acceptable” and “good” air quality categories. In 2006 around 6% of data were within the “alert” (66-100% of the guideline) category (Figure 2.6).

Monthly variations in the distribution of PM_{10} concentrations for 2006 are shown in Figure 2.7. Figure 2.8 shows the monthly variations in PM_{10} concentrations for 2008. Monthly variation data for 2007 and 2009 are not included due to the limited data available for these times periods.

Emily 17/3/10 12:26 PM
Comment: Paul – the distribution of concentrations is interesting. Any reason why the shift in % good data from August onwards – baseline shift in instrumentation?

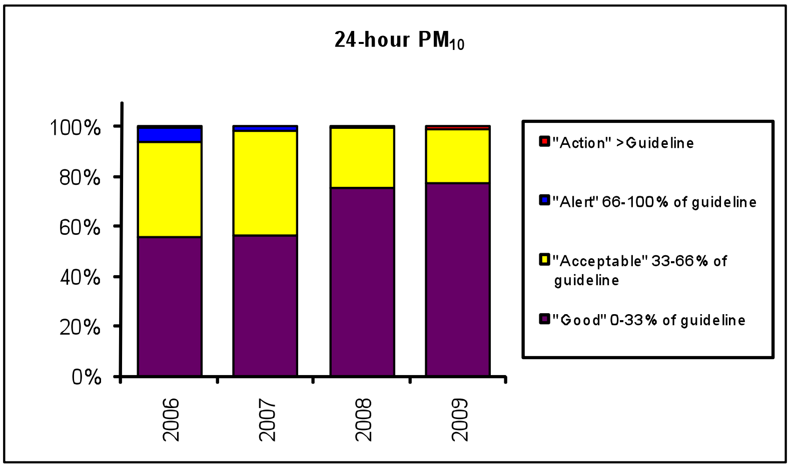

Figure 2.6: Comparison of PM_{10} concentrations measured at Robert Street in Whangarei from 2006 to 2009 to MfE air quality indicator categories.

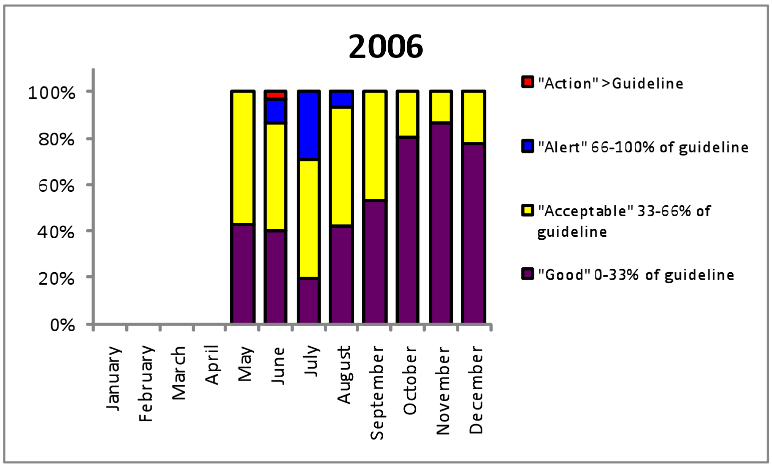

Figure 2.7: Comparison of daily PM_{10} concentrations at Robert Street in Whangarei for each month during 2006 to MfE air quality indicator categories.

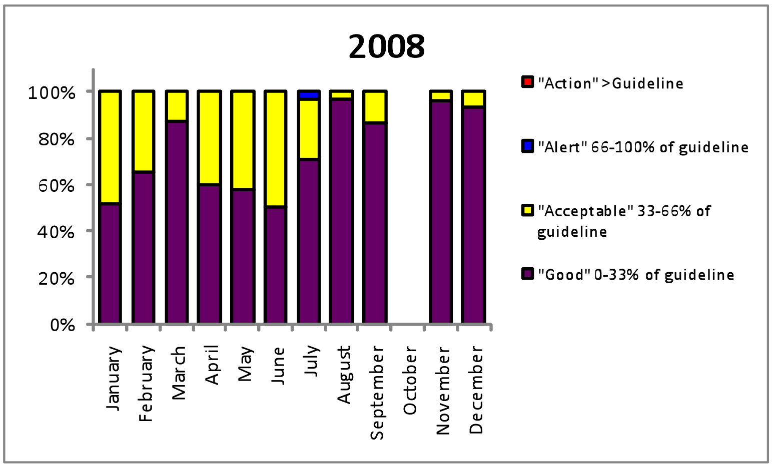

Figure 2.8: Comparison of daily PM_{10} concentrations at Robert Street in Whangarei for each month during 2008 to MfE air quality indicator categories.

Summary statistics for PM_{10} monitoring results are shown in Table 2.1.

Table 2.1: Summary of PM_{10} concentrations measured at Robert Street in Whangarei from 2006 to 2009.

	2006	2007	2008	2009
"Good" 0-33% of guideline	55%	56%	75%	77%
"Acceptable" 33-66% of guideline	38%	42%	25%	21%
"Alert" 66-100% of guideline	6%	2%	0%	0%
"Action" >Guideline	0.4%	0%	0%	1%
Percentage of valid data	66%	54%	96%	23%
Annual average ($\mu g\ m^{-3}$)	16	16	14	
Measured exceedences	1	0	0	1
Annual maximum ($\mu g\ m^{-3}$)	52	37	35	94
Number of records	242	197	351	84

3 Sources of PM_{10} emissions

3.1 Whangarei Emission Inventory – 2006

An emission inventory was completed for Whangarei in 2006 (Wilton, 2007). The inventory included emissions from domestic home heating, motor vehicles, outdoor burning and industry. The contribution of natural sources such as sea spray and soil were not included as these sources cannot be identified in a robust manner using an inventory approach. Emissions to air of PM_{10}, CO, SOx, NOx, VOC, CO_2 and $PM_{2.5}$ were quantified.

The inventory showed that the main methods of home heating in Whangarei were electricity (44%), gas (35%) and wood burners (33%). Many households used more than one method to heat the main living area of their home.

Domestic heating was found to be the main source of PM_{10} emissions during winter months (Figure 3.1). Industry contributed 11% of PM_{10} emissions, outdoor burning contributed 9% and transport contributed 6% of PM_{10} emissions.

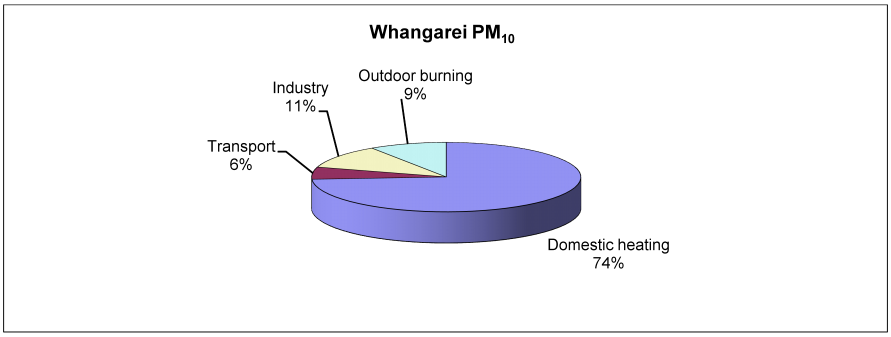

Figure.3.1: Sources of PM_{10} emissions in the urban areas of Whangarei in winter 2006.

3.2 Spatial distribution of PM_{10} emissions

Figure 3.2 shows the spatial distribution of PM_{10} emissions in and around Whangarei expressed as kg/day PM_{10} emissions per meshblock. It is worth noting that some of the meshblocks with the highest emissions (around 11-12 kg/day) are large and the emission density (and consequently impacts) in these blocks will be lower than the smaller meshblocks with emissions in the 8-12 kg/day range.

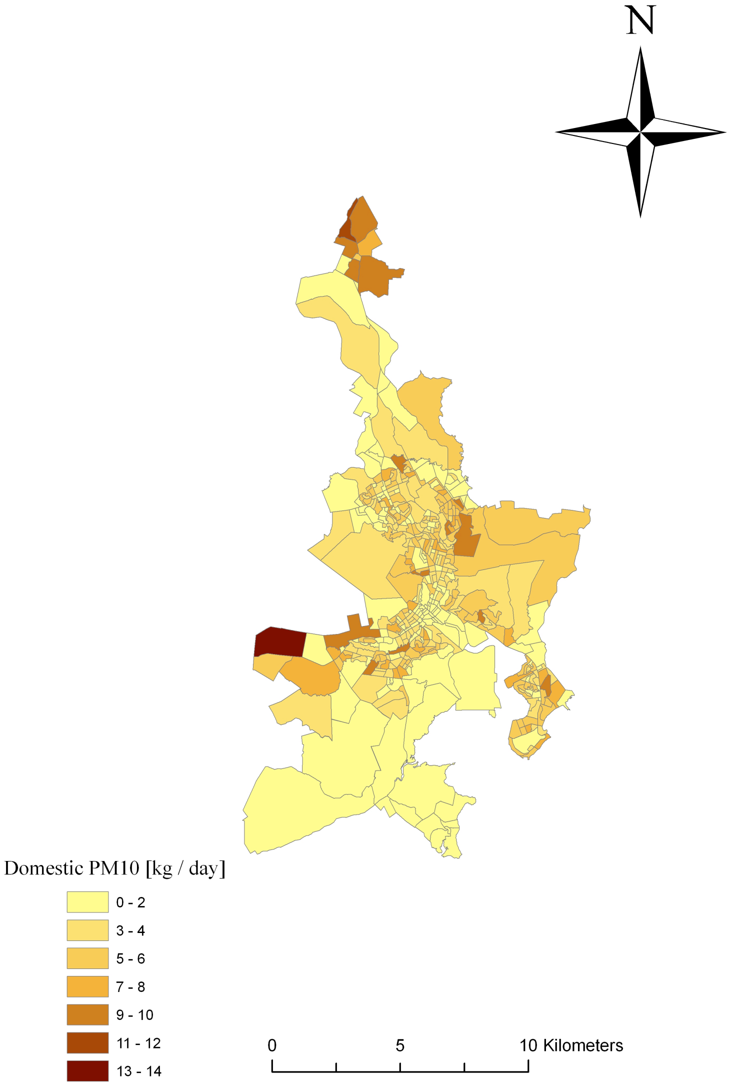

Figure 3.2: Spatial distribution of domestic PM_{10} emissions for Whangarei.

4 Reductions required in PM_{10} concentrations

A number of methods have been proposed for setting the reductions required in PM_{10} concentrations to meet the NES and for determining compliance with the "straight line path" (SLiP) in managing air quality.

Existing monitoring data can be used to estimate the reductions required in PM_{10} concentrations to meet the NES. In our view, this is the most robust method, particularly in locations where many years of monitoring results are available. The more data that are available, the higher the probability that the data captures the worst-case meteorological conditions that give rise to elevated PM_{10} concentrations. For Whangarei there is sufficient monitoring data from which to evaluate the starting point for the SLiP.

For Whangarei, it is recommended that a value of 52 µg m^{-3} is used as the starting point for the SLiP. This is based on the highest recorded PM_{10} concentration using the BAM. It is noted that this is a precautionary starting point as concentrations in Whangarei do not normally exceed 50 µg m^{-3} on more than one occasion per year.

Equation 4.1 shows the calculation to determine the required reduction in PM_{10} concentrations to meet an air quality target of 50 µgm^{-3} (24-hour average).

$$R = 100(1 - \frac{t}{c}) \qquad \text{Equation 4.1}$$

where

R = the percentage reduction

t = the air quality target (e.g., 50 µgm^{-3})

c = the concentration identified as representing the starting point of the SLiP

Based on Equation 4.1 the required reduction to meet the NES in Whangarei is 4%. Using the same approach, a 37% reduction in PM_{10} concentrations is required to meet the 'Acceptable' category for the MfE Environmental Performance Indicators for Air Quality.

5 Airshed modelling

5. Whangarei Air Shed Modelling

5.1 Model setup

The Air Pollution Model (TAPM) version 3.0.7 was used to predict air pollution concentrations for the Whangarei district for the period 25 June to 27 July 2006. TAPM is a three dimensional, incompressible, non-hydrostatic, primitive equations model, which uses a terrain following coordinate system (Hurley, 2002).

The model was configured with five nested grids – the outer grid spacing was 30 km and covered the upper North Island from approximately Lake Taupo. The remaining grid spacings were 10, 3, 1 and 0.5 km respectively. The 1 km grid is shown in Figure 5.1 – each individual square is 1 x 1 km. General model options consisted of 25 grid points and vertical levels, all other parameters remained default. Meteorological model options were also left as default, except for non-hydrostatic pressure, which was left on. Pollution input options are shown in Figure 5.1. One tracer, with no chemistry was selected for input across the area source (the grey square in Figure 5.1). A background tracer concentration of 9 µg m^{-3} was added post simulation. For this exercise, the four different emissions types (domestic, industrial, wood burning and traffic emissions) were totalled. This total was used as the sole tracer in TAPM.

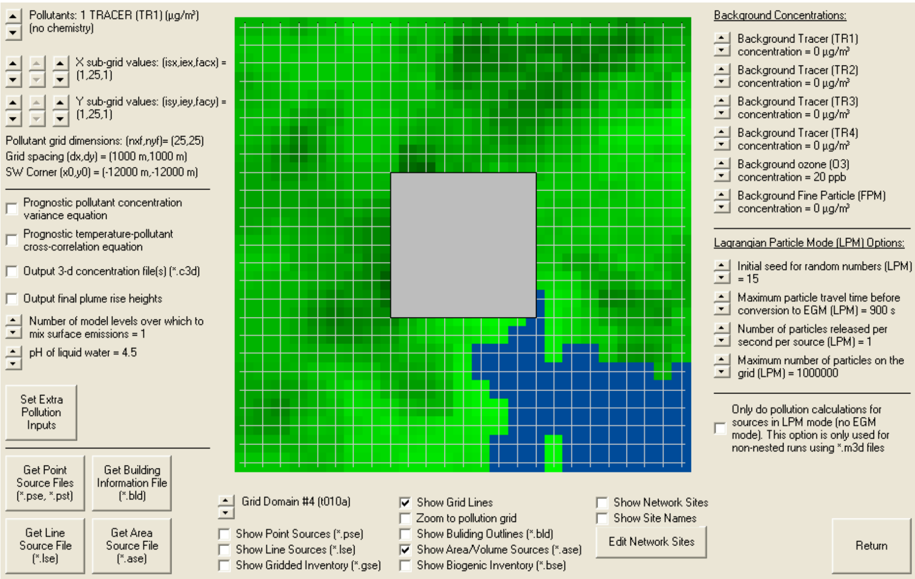

Figure 5.1: Model configuration panel for pollution mode showing grid domain number 4 and the area source configuration (grey box).

5.2 Model results and discussion

TAPM PM_{10} predictions were extracted from grid point location (16, 9) which is the approximate location of the Robert Street Air Quality Monitoring Site (Figure 2.1). Model predictions of wind speed, wind direction and temperature were extracted from a different grid point location (18, 7) as meteorological observational equipment is located at Whangarei Airport.

All model predictions were extracted from grid 4 because the edge of grid 5 (the highest resolution grid) coincided with the monitoring site and, because model domain boundaries are often unstable, this would most likely not provide reliable results.

Model predictions were extracted as hourly data and subsequently averaged over 24 hours to give a daily average profile of wind speed, wind direction and temperature.

5.2.1 Wind speed, wind direction and temperature

a) Wind speed

Predicted wind speed results are shown in Figure 5.2a. TAPM tended to over predict wind speeds for the duration of study. The trend, however, is reasonably accurate despite the over prediction and exaggeration of wind speed increases and decreases. For instance, for the period 5 to 12 July 2006, TAPM predicts the changing wind speed reasonably well. An increase from 3 m s-1 to 7 m s-1 is predicted on 5 July 2006 and this is similar to the observed wind speed increase from 1 m s-1 to 4 m s-1. Similarly, TAPM predicted a decrease in wind speed from 8 to 10 July 2006 with comparable skill.

b) Wind direction

Predicted wind direction results are shown in Figure 5.2b. Over the first 9 days, TAPM struggled to accurately predict wind direction. However for the remainder of the simulation period the model was in close agreement with the observations for trend and direction. An exception to this was from 14 to 19 July 2006 where the change in modelled wind direction was too great – a swing from the west to east to north, whereas the observed wind direction change was from west to south.

c) Temperature

Predicted temperature results are shown in Figure 5.2c. TAPM over predicted temperature throughout the duration of the study period, but similar to wind direction, most over prediction occurred at the start of the simulation period. TAPM does not appear to handle sudden changes in temperature particularly well. The rapid observed changes on 4 July 2006 and 13 July 2006 are not well predicted. Indeed, the model does not predict the low temperatures observed on 5, 6, 13 and 22 July 2006. The model does predict the temperature trend. Prediction of temperature is very much dependent on soil moisture content, for this work the default setting was used. Improvements to the quality of the data would mean that temperature evolution can be predicted more accurately, which would result in a more accurate prediction of wind speed and direction.

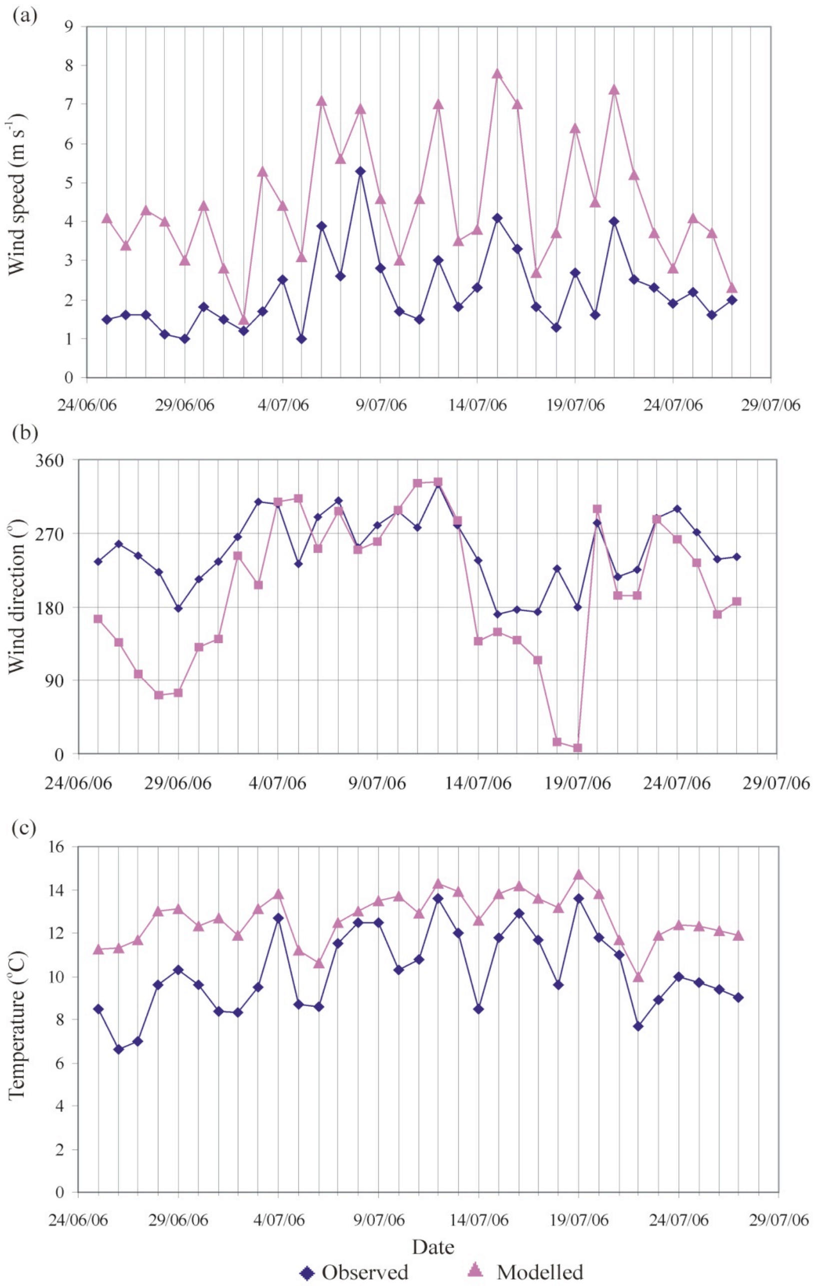

Figure 5.2: Model predicted daily averages of wind speed, wind direction and temperature for Whangarei, compared with observed meteorological data.

d) Probability distribution functions

Probability distribution functions of predicted wind speed and direction are shown in Figure 5.3a and Figure 5.3b. Figure 5.3a shows that wind speeds ranging from 3 to 5 m s^{-1} were most common throughout the study period, accounting for more than 50% of the distribution. Wind speeds of 8 m s^{-1} occurred approximately 10% of the time. Wind direction was more variable. No one direction dominated, but wind from the south east was predicted slightly greater than any other direction.

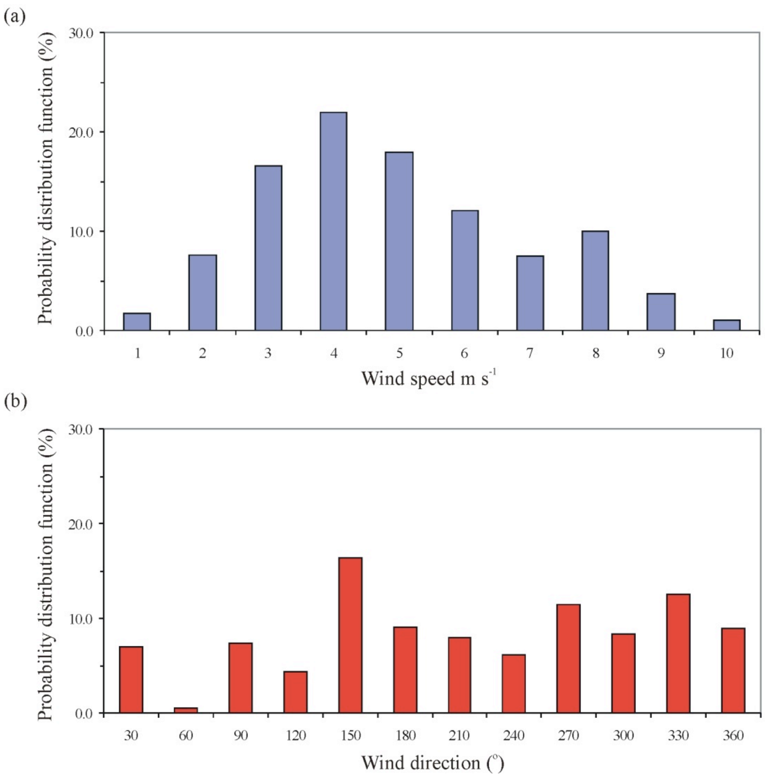

Figure 5.3: Probability distribution functions of wind speed and direction for the study period. In Figure 5.3a, wind speed of 4 m s^{-1} occurred more than 20% of the time. The wind direction, however, shown in Figure 5.3b, indicates that no one wind direction prevailed over the course of study, although south east winds tended to occur most regularly.

5.2.2 Model performance

According to Willmott (1981), the root mean square error (RMSE) is an error index that calculates the actual size of error produced by the model. An RMSE error less than or equal to 2 m s^{-1} is considered by Emery (2001) as the threshold for good model performance. Another useful skill test of validity is the index of agreement (IOA), which is the degree to which the observed variate is accurately estimated by the simulated variate (Willmott, 1981). The IOA can take a value between 0 and 1, with 1 indicating perfect agreement between the observed and modelled data. For satisfactory model performance, Emery (2001) stated an IOA threshold of 0.60 or better is required.

Statistics of model performance are shown in Table 5.1. The mean and standard deviation of both observed and predicted temperature, wind speed and east-west (U) and north-south (V) components of wind speed were compared to establish correlation (CORR), RMSE and IOA between the sets of data.

Mean statistics confirm that average predicted temperature and wind speed were slightly greater than observed. Wind speed, when split into U and V components, shows that on average, the U component of wind speed was 0.3 m s^{-1} slower than observed, and the V component 0.1 m s^{-1} faster than observed. The slightly higher average for the latter is likely a function of the greater percentage of southerly winds predicted over any other wind direction during the simulation period.

The RMSE for all variables was over the 2 m s^{-1} threshold for good model performance. The IOA, however, indicated TAPM performed sufficiently for all variables but wind speed, but this was only 0.1 outside the threshold for good performance. The U and V components were particularly sound, 0.73 and 0.75 respectively, which indicated TAPM handled the directional speed of the wind soundly.

Table 5.1: Model evaluation statistics.

Meteorological variable	MEAN OBS	MEAN MOD	STD OBS	STD MOD	CORR	RMSE	IOA
Wind speed (m s^{-1})	2.2	4.6	1.6	2.0	0.62	2.83	0.59
U-Comp (m s^{-1})	0.9	0.6	1.8	3.3	0.65	2.55	0.73
V-Comp (m s^{-1})	0.1	0.2	1.8	3.7	0.73	2.64	0.75
Temperature (°C)	10.2	12.7	3.3	1.5	0.74	3.39	0.65

MEAN OBS: Mean values of observed data; MEAN MOD: Mean values of model predicted data; STD OBS: Standard deviation of observed data; STD MOD: Standard deviation of model predicted data; CORR: Correlation coefficient; RMSE: Root mean square error; IOA: Index of agreement between observed and modelled data.

5.2.3 Ground level PM_{10} concentrations

Average daily observed and predicted PM_{10} concentrations are shown in Figure 5.4. The predicted PM_{10} concentrations are the maximum recorded values from the model domain at each hour, then averaged for 24 hours to obtain a single daily average. The average concentrations indicate TAPM does not predict PM_{10} with acceptable accuracy. Poor prediction of PM_{10} concentrations might be a function of model setup, but this is unlikely as two further configurations were used and these yielded similar results. It is more likely to be a model physics issue, which is not explored here.

Despite the less than adequate prediction of PM_{10}, TAPM predicted three days of moderately high PM_{10} concentrations on 13, 17 and 18 July 2006. These concentrations were all well below the NES of 50 µg m^{-3}. The highest measured PM_{10} concentration of 29 µg m^{-3} (24-hour average) occurred on 18 July 2006. Even with poor performance of TAPM, the trend of PM_{10} over the study period somewhat aligned to that of the observed. The fact that the model recognises variation is a good start and shows the importance of meteorology in controlling PM_{10} concentrations at this location.

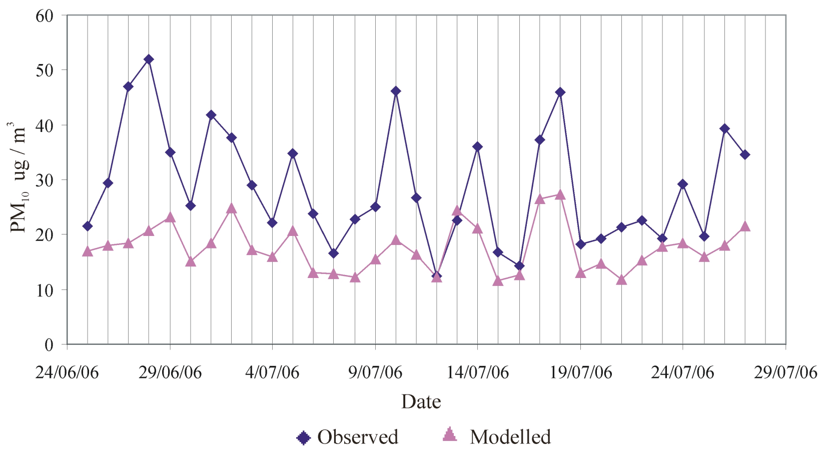

Figure 5.4: Average daily time series plot of PM_{10} concentrations for Whangarei.

The relationship between the observed and predicted PM_{10} was also examined (Figure 5.5). A moderately strong positive relationship was found, which indicates the two sets of data correlate reasonably well.

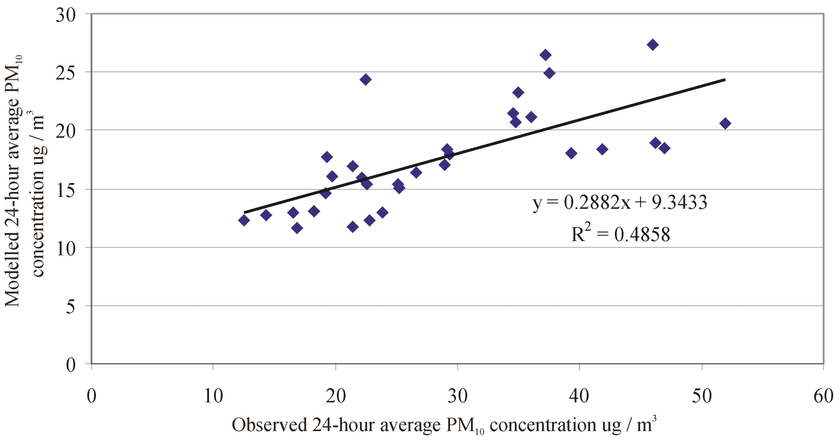

Figure 5.5: Relationship between observed and modelled maximum PM_{10} concentrations (24-hour average). The strength of R^2 indicates a moderately strong positive relationship.

5.2.4 Examination of low and high pollution days

To improve understanding of PM_{10} and meteorology in the Whangarei region, an examination of the differences between an elevated pollution day and a low pollution day was undertaken. The low pollution day (12 July 2006) showed low observed and predicted PM_{10} concentrations (12 µg m^3 observed and 12.3 µg m^{-3} predicted). Figure 5.6 shows model predictions of wind speed, wind direction and temperature on 12 July 2006 compared with observed meteorological data.

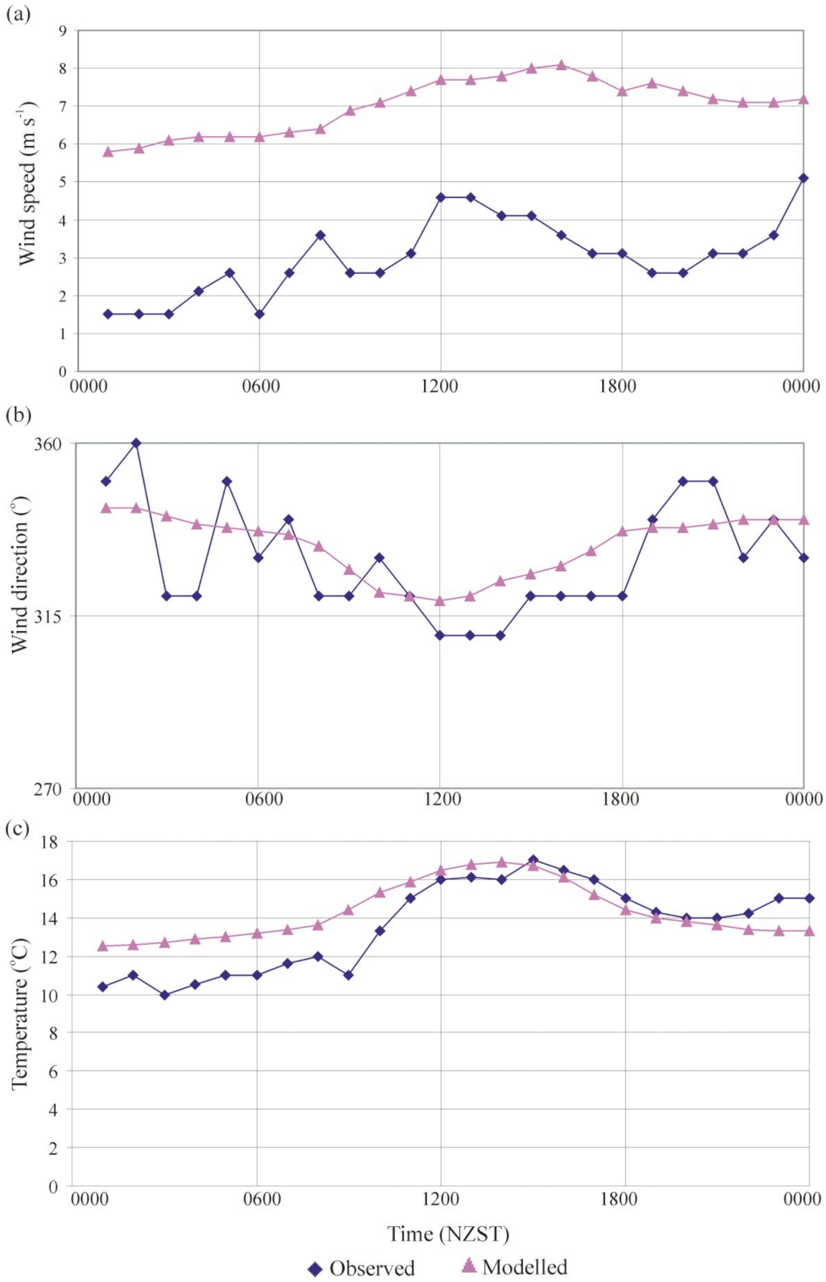

Figure 5.6 Model predictions of wind speed, wind direction and temperature on 12 July 2006 compared to observed meteorological data.

The elevated pollution day (18 July 2006) showed elevated observed and predicted air pollution (47 µg m^{-3} observed and 29 µg m^{-3} predicted). Figure 5.7 shows model predictions of wind speed, wind direction and temperature on 18 July 2006 compared with observed meteorological data.

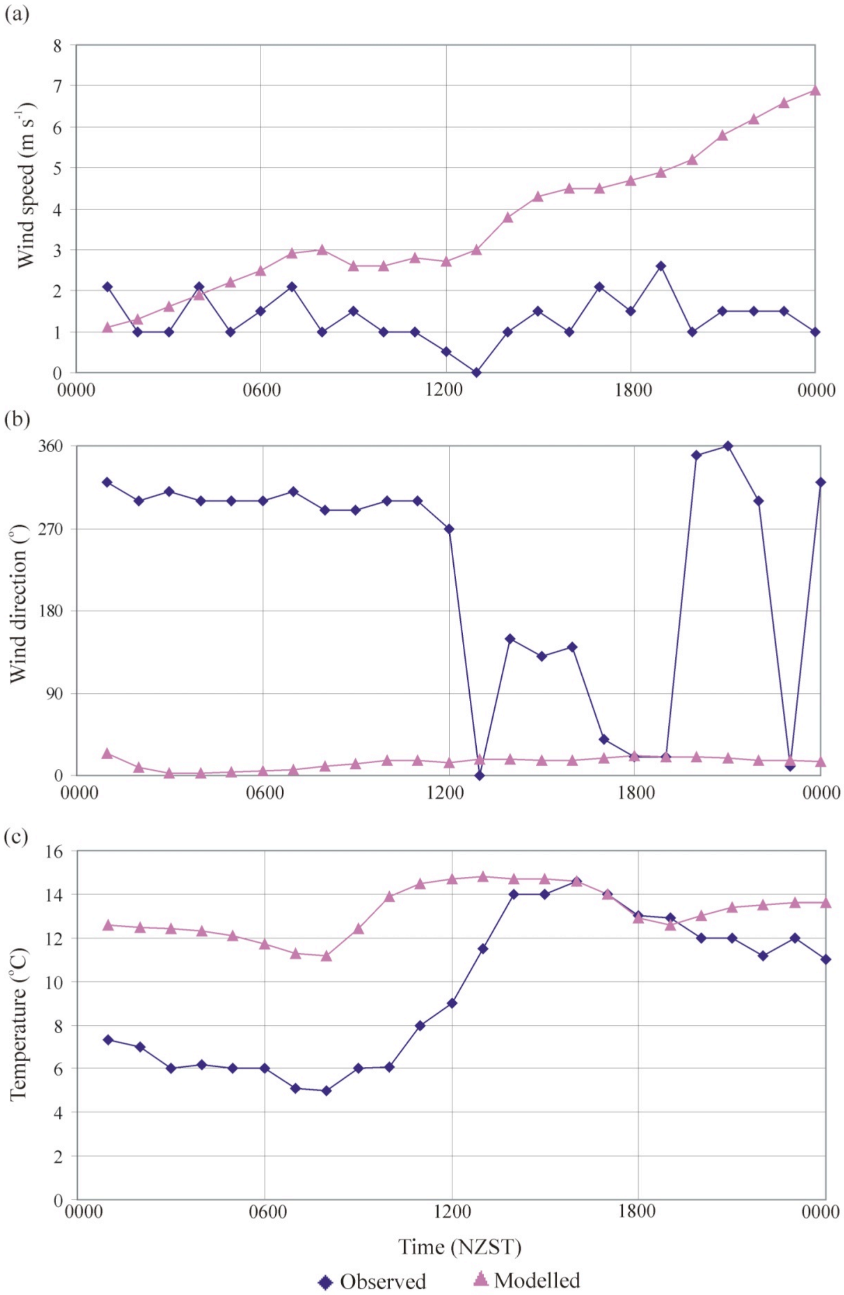

Figure 5.7: Model predictions of wind speed, wind direction and temperature on 18 July 2006 compared to observed meteorological data.

Figures 5.6 and 5.7 show some distinct meteorological differences. Observed wind speed on the elevated pollution day is, on average, 1.7 m s^{-1} slower than on the low pollution day. Also night time and early morning temperatures are on average 3.9 °C cooler on elevated pollution days. The differences in conditions which occur between elevated and low pollution days indicate the meteorological conditions required for elevated pollution days include cold temperatures (especially during the night) with little or no wind.

A concentration plot of TAPM predicted PM_{10} for 18 July 2006 is shown in Figure 5.8. The urban area of Whangarei is outlined in red. In this instance, concentrations are all below the NES, and the highest concentrations are located in the northwest suburbs. The observed wind direction on this day was mainly from the south, but TAPM predicted a northerly flow. Some entrainment of PM_{10} is evident and the highest concentrations appear to have been transported to the north west The current location of the Robert Street monitoring site is appropriately located around the area where maximum concentrations are predicted.

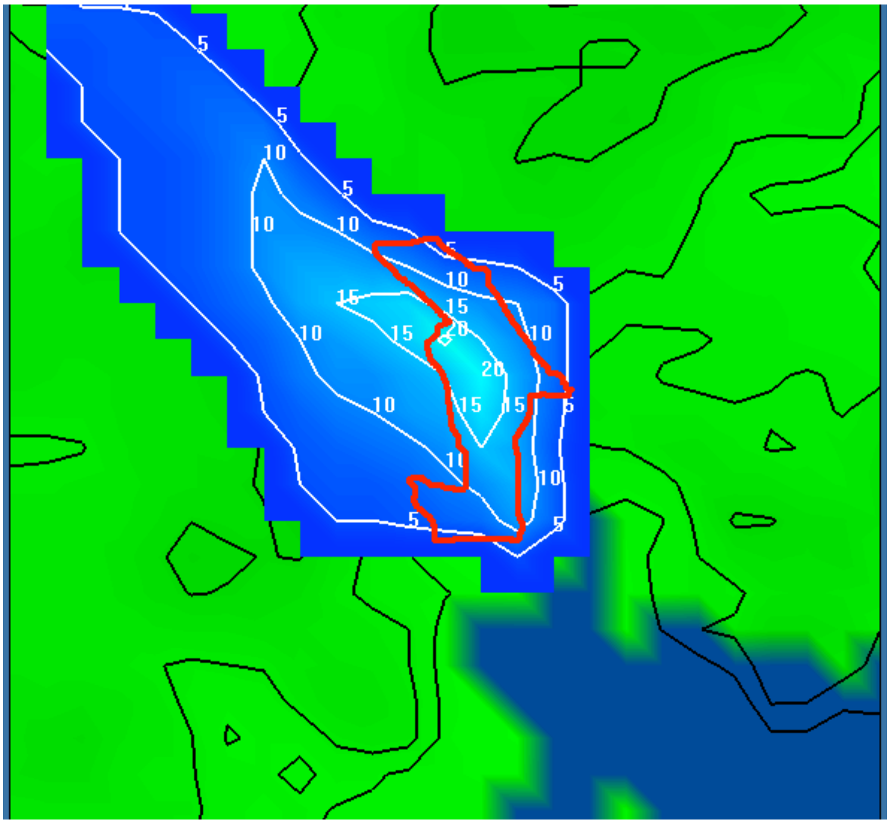

Figure 5.8: Plot showing the TAPM predicted 24-hour average PM_{10} concentrations for 18 July 2006 (an elevated pollution day). The red contour is the Whangarei urban area boundary. The contour interval is 5 meters.

6 Management options for PM_{10}

6.1 Baseline projections

Figure 6.1 shows the estimates of trends in PM_{10} concentrations by source for Whangarei. The estimates are based on the assumptions outlined in Table 6.2. Figure 6.1 shows a significant decrease in PM_{10} from domestic home heating as a result of households replacing older more polluting burners with NES authorised burners. The significant decrease is due to the large proportion of burners that were installed before 1996 that will be ending their useful lives and are likely to be replaced over upcoming years.

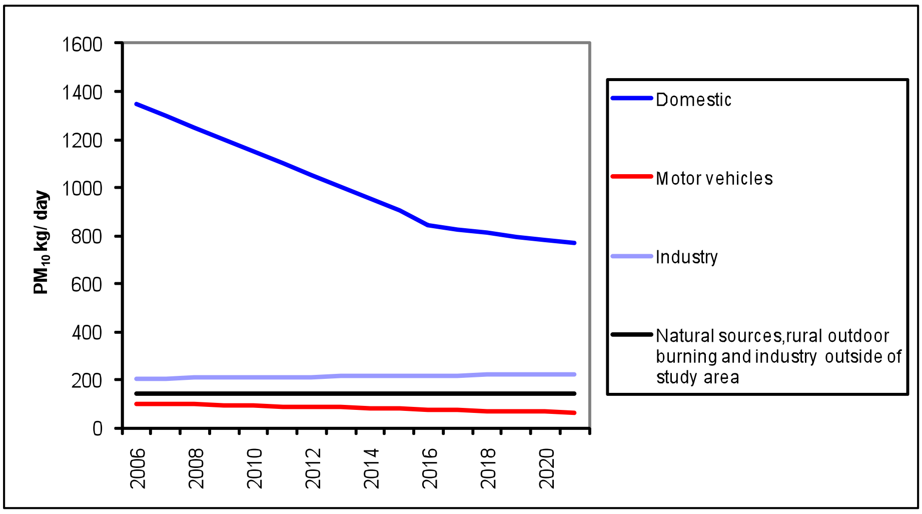

Figure 6.1: Estimates in trends in PM_{10} concentrations by source.

Figure 6.2 shows the effect of the Northland Regional Council regulation to ban outdoor burning while assuming a 15 year natural attrition for burners. The figure shows that without the outdoor burning ban the NES is likely to be achieved, but the 'Acceptable' air quality category is unlikely to be achieved. The purple line shows the impact of the outdoor burning ban, and that the 'Acceptable' air quality category is likely to be met by 2011. The outdoor burning ban, although operative in December 2008 is depicted as being effective from 2009 as this was the first winter the ban was effective.

It is likely, however, that some households will replace their burners beyond 15 years, particularly in the current economic climate. The assumption of a 20 year phase out for burners is likely to provide more certainty for determining emission reductions. Figure 6.3 shows the effect of the Northland Regional Council regulation to ban outdoor burning while assuming a 20 year natural attrition for burners. The figure shows the outdoor burning ban is likely to achieve the 'Acceptable' air quality category by 2016.

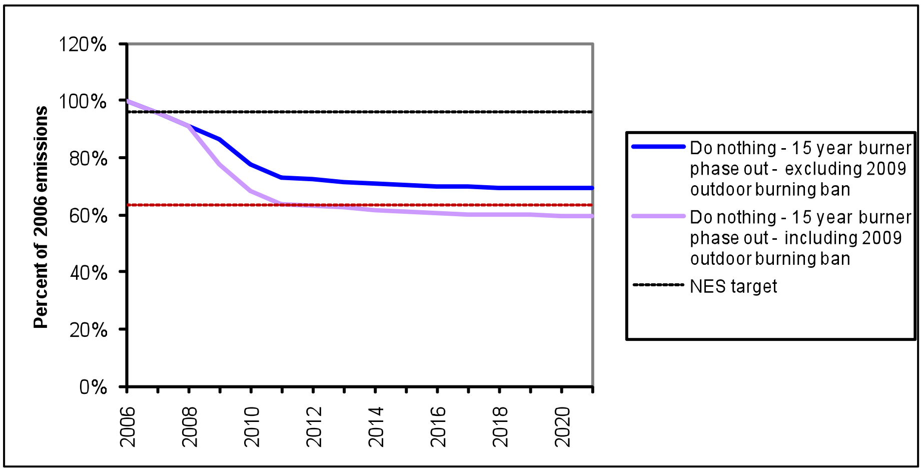

Figure 6.2: Do nothing projections for Whangarei showing the effect that the outdoor burning ban has on reducing emissions. This option assumes natural attrition of 15 years for burners.

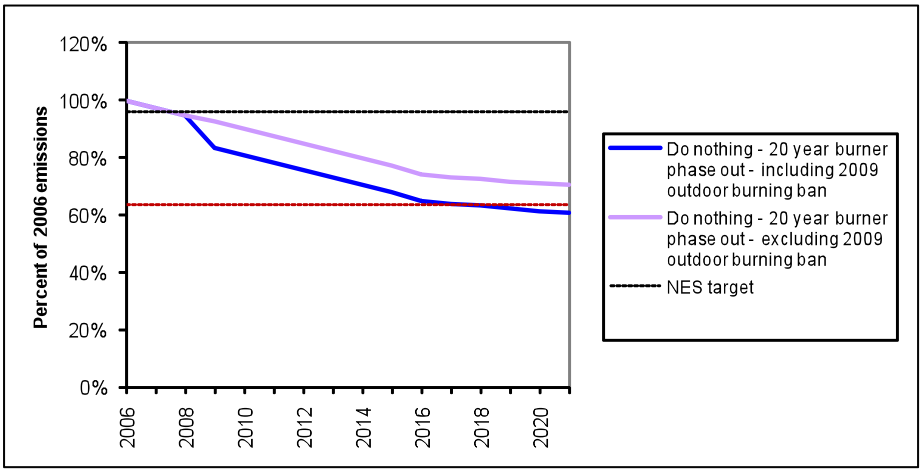

Figure 6.3: Do nothing projections for Whangarei showing the effect that the outdoor burning ban has on reducing emissions. This option assumes natural attrition of 20 years for burners.

Figures 6.4 and 6.5 show the effect of various management options based on a 15 and 20 year replacement of burners through natural attrition. Figure 6.4 shows the effect of the existing outdoor burning regulations and a ban on the use of open fires in 2011. If a 20 year assumption for the replacement for burners is assumed then it is likely that the 'Acceptable' air quality category would be met by 2010. This management approach is likely to require mitigation of the potential adverse impacts that could arise through the ban on open fires.

Figure 6.5 shows the effect on PM_{10} emissions with the existing ban on outdoor burning, and a ban on open fires in 2011 and no new multi fuel burner installations from 2010 in Whangarei. If a 20 year replacement period for burners was assumed then it is likely that the 'Acceptable' air quality category would be reached by 2012.

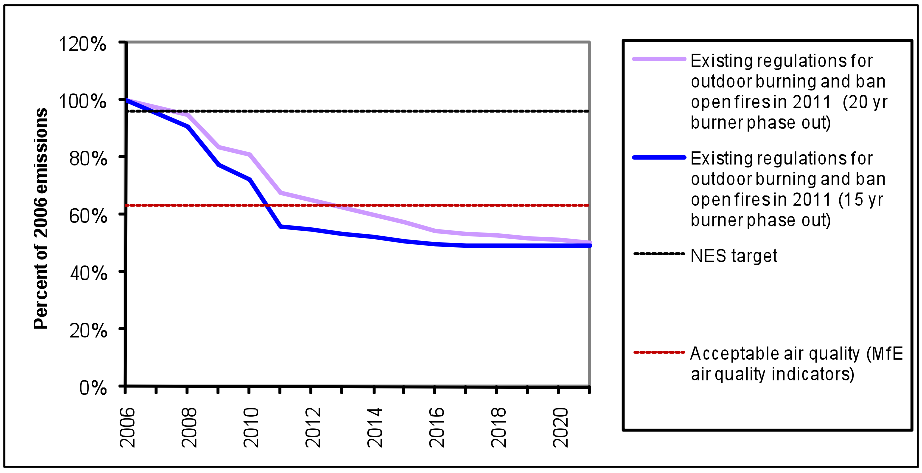

Figure 6.4: Ban open fires in 2009 and existing regulations for outdoor burning in Whangarei. This option assumes natural attrition of 20 years for burners and 15 years.

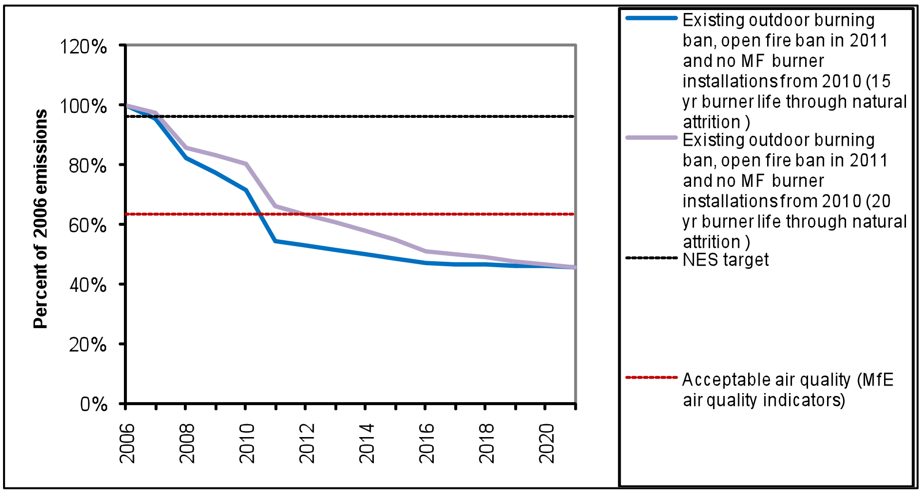

Figure 6.5: Ban outdoor burning. Ban open fires in 2011 and no new multi fuel burner installations from 2010 in Whangarei. This option assumes natural attrition of 20 years for burners and 15 years.

6.2 Assumptions

The average fuel use and emission factors used for different appliance and fuel type categories are shown in Table 6.1. Further assumptions underpinning the emissions projections and management options assessments are specified in Table 6.2.

Table 6.1: Average emission factors and fuel use

	Emission Factor g/kg	Fuel Use kg
Open fire - wood	10	20
Open fire - coal	21	19
Wood burner -pre 1996	11	18
Wood burner - 1996-2001	7	18
Wood burner -Post 2001	6	18
Woodburner 1.5 g/kg	3	18
Multifuel – wood	13	10
Multifuel – coal	28	6
Oil	0.3	1.5
Gas	0.03	1.0
Pellet	2	8

Table.6.2: Assumptions underlying the assessment of the effectiveness of management options for reducing PM_{10} emissions

1	A decrease in PM_{10} emissions from motor vehicles of around 40% by 2021 based improvements in vehicle technology predicted by NZTER and allowing for increases in VKTs.
2	A 10% increase in emissions from industry with time.
3	Emission factors for burners as per Table 6.1.
4	Average fuel use for NES authorised burners of 17.7 kg per night as per the 2006 Whangarei emission inventory survey.
5	Average fuel use for other burners as per the 2006 Whangarei emission inventory survey (Table 6.1).
6	A proportional reduction in concentrations for any given reduction in emissions.
7	No variations in the impact of emissions occurring at different times of the day.
8	A 0.7% per year increase in the number of households in Whangarei.
9	Only 50% of households replacing open fires, if prohibited, will install solid fuel

	burners.
10	An emission factor for 1.5 g/kg burners of 3 g/kg.
11	A 10% reduction in the number of open fires from 2006 to 2021.
12	A small proportion (0.25% per year) of houses currently using other heating methods will convert to solid fuel.
13	10% of new burner installations will be multi fuel burners.
14	All houses replacing wood burners and multi fuel burners with wood burners replace with NES compliant models
15	8% of the PM_{10} on high pollution days is from sources not included in the emission inventory

6.2.1 Summary

No additional regulations are required for Whangarei to comply with the NES as it is likely that the NES compliance has been achieved as a result of recent legislation that has banned outdoor burning and through the replacement of old burners as a result of natural attrition. The MfE 'Acceptable' air quality environmental indicator category of 33 $\mu g\ m^{-3}$ for PM_{10} is likely to be met by 2016 if a 20 year replacement of burners is realistic.

Other management options that would increase the probability of the 'Acceptable' air quality category being met include banning the use of open fires and prohibiting the installation of multi fuel burners.

The management options discussed in this report will effect wintertime PM_{10} emissions and will not address sources of high concentrations of PM_{10} during summer months. Additional research would be required to determine appropriate measures to reduce summertime concentrations should they become an issue.

7 Conclusions

Based on 2006 air quality monitoring data, a four percent reduction in PM_{10} emissions is required to meet the NES in Whangarei. The large proportion of pre 1996 burners in Whangarei means that the replacement of these burners through natural attrition will lead to ongoing decreases in PM_{10} concentrations and it is likely that the NES was met by 2008. The introduction of regulations by Northland Regional Council to ban outdoor burning have increased the certainly of complying with the NES and it is likely that the MfE 'Acceptable' air quality category of 33 μgm^{-3} will be met by 2016 (assuming a 20 year replacement of burners through natural attrition). If a 15 year replacement of burners through the natural attrition is assumed then it is likely that the 'Acceptable' air quality category will be met in 2011.

If Northland Regional Council requires further improvements to air quality in Whangarei then possible management options include banning open fires in 2011 and prohibiting the insulation of multi fuel burners in 2011. However, further considerations of the costs of implementing these options compared to the environmental benefits would be required.

The management options discussed in this report will effect wintertime PM_{10} emissions and will not address emissions reductions during summer months. Additional research would be required to determine management options for reducing PM_{10} emissions during summer.

Dispersion modelling using TAPM generally under predicted PM_{10} concentrations on days when concentrations were highest at Whangarei. The assessment of spatial variability suggests the highest PM_{10} concentrations occur around central to North West Whangarei. The current location of the Robert Street monitoring site is appropriately located around the area where maximum concentrations are predicted.

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