Environment Waikato Technical Report 2007/13

Air Emission Inventory – Matamata, Putaruru and Waihi 2006

www.ew.govt.nz
ISSN 1172-4005 (Print)
ISSN 1177-9284 (Online)

Environment Waikato
REGIONAL COUNCIL

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26 April 2007

ISSN: 1172-4005

Document #: 1172647

Peer reviewed by:
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Approved for release by:
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Acknowledgements

Environment Waikato staff including Brent Sinclair, Jonathan Caldwell and Amanda McCabe provided details of industrial activities in Putaruru and Waihi. Peter Carruthers (Newmont Waihi Gold) provided data and information relating to activities at the Martha Mine. Nick Kim and Viv Smith made useful comments on the draft of this report.

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Abstract

Air quality monitoring and other air quality investigations are required to better characterise the extent of NES compliance within the Region. Air quality monitoring in the Waikato Region has been carried out in Hamilton, Tokoroa, Taupo, Te Kuiti, Matamata and Putaruru. Concentrations of PM_{10} in excess of National Environment Standards (NES) have been observed in Hamilton, Tokoroa, Taupo and Te Kuiti. Emission inventory studies, which estimate the quantity of PM_{10} and other contaminants discharged into air and the relative contribution of different sources, have been carried out in these areas.

This report outlines the results of an air emission inventory carried out in the areas of Matamata, Putaruru and Waihi. Contaminants included were: particles (PM_{10} and $PM_{2.5}$), carbon monoxide, nitrogen oxides, sulphur oxides, volatile organic compounds and carbon dioxide. This report primarily focuses on emissions of particles (PM_{10}), as the only contaminant in breach of the NES in the Waikato Region. Sources included in the inventory were: domestic heating, motor vehicles, industrial and commercial activities, and outdoor rubbish burning.

A survey of household heating methods and the frequency of outdoor rubbish burning was carried out for each of the areas. Results showed that wood burners were used by 49 per cent of households in Putaruru and were the main heating method in the town. Electricity was the main heating method used in Matamata, with 53 per cent of households using this method of heating. Woodburners (39 per cent) and gas appliances (21 per cent) were the next most common methods of heating Matamata. In Waihi, woodburners (42 per cent) and electrical appliances (41 per cent) were the most common methods of heating. In all towns, many households used more than one method to heat the main living area of their home.

The main source of PM_{10} emissions in all three areas during the winter was domestic home heating, which accounted for 92, 58 and 59 per cent of total emissions in Matamata, Putaruru and Waihi respectively. PM_{10} emissions of 229, 354 and 346 kilograms per day in winter were estimated for each town respectively.

Industry contributes 39 per cent of winter PM_{10} emissions in Putaruru, and the main industrial sources are CHH timber plant and Rapid Mineral's lime processing operation. The industrial contribution to contaminant concentrations in Putaruru air is likely to be much less than the contribution to total emissions because industrial discharge is via high stacks that promote more effective dispersion of contaminants.

In Waihi, there is considerable uncertainty about fugitive emissions from the Martha Mine pit, although the best estimate is that 37 per cent of winter emissions are from industry. Waihi's PM_{10} emissions in summer may be as high as 806 kilograms per day which is around twice those in winter. However, the summer emissions are dominated by industrial discharges and the uncertainty makes it very difficult to accurately interpret the results. When discontinuous compliance monitoring data are considered in light of the best estimates of emissions, continuous monitoring of PM_{10} is recommended at Waihi.

While survey monitoring has only recently commenced in Putaruru, PM_{10} concentrations in Matamata have been relatively low since monitoring began in June 2005. There has been a decrease in PM_{10} emissions at Matamata since 2001, so cessation of PM_{10} monitoring in the town would be justified if similarly low concentrations are observed in winter 2007.

1 Introduction

Air quality monitoring in the Waikato Region has been carried out in Hamilton, Tokoroa, Taupo, Te Kuiti, Matamata and Putaruru. The National Environmental Standard (NES) specifies that air quality monitoring be carried out in all airsheds where respirable particulate (PM_{10}) concentrations are likely to exceed a 24 hour average of 50 µg m^{-3}. Hamilton, Tokoroa, Taupo and Te Kuiti are regarded as "Category 1" airsheds, due to concentrations of PM_{10} observed to be in excess of National Environment Standards (NES) in these towns.

In areas where the NES limit for PM_{10} is not met by 2013, Environment Waikato will be unable to grant resource consents for discharges of PM_{10} to air. In addition, between September 2005 and 2013 consents for discharges to air can only be granted if Councils can demonstrate a "straight-line path" to compliance that will not be transgressed by the granting of the consent.

Emission inventory studies, which estimate quantities of PM_{10} and other contaminants discharged into air and the relative contribution of different sources, have been carried out in a number of urban areas of the Waikato, including all areas where monitoring has been conducted. In addition to providing a useful tool for evaluating the effectiveness of different management measures in reducing pollution, these studies can assist with prioritising areas for monitoring and the setting of straight-line paths, should monitoring indicate non-compliance with the NES.

Other variables involved in setting a straight or curved-line path to compliance include:
1. Monitoring data to determine the starting point; that is the extent to which existing concentrations exceed the NES.
2. Meteorological data and airshed modelling.

The latter approach is used to determine the relationship between emissions and concentrations. This modelling indicates the relationship between the reduction required in PM_{10} concentrations relative to the reduction required in emissions. Many areas do not have detailed modelling data illustrating the relationship between 24-hour emissions and concentrations of PM_{10}. One detailed study for Christchurch suggests that the relationship is linear in that a one per cent reduction in emissions would result in a one per cent reduction in concentrations (Gimson & Fisher, 1997). Thus in the absence of modelling information for other areas, the relationship has often been assumed to be linear.

This report details the results of an air emission inventory carried out for Matamata, Putaruru and Waihi for 2006. The purposes of the inventory are to estimate the amount of PM_{10} discharged into the air in these areas on a worst-case and average winter's night, the relative contribution from different sources, and provide information from which management measures to reduce PM_{10} may be evaluated.

2 Inventory Design

The inventory has been designed with a focus on emissions of PM_{10}, although it does include estimates of emissions of other contaminants. With the exception of Hamilton and monitoring of benzene in Tokoroa, no monitoring of other contaminants has been carried out by Environment Waikato. It is unlikely, based on monitoring carried out in other areas of New Zealand, that concentrations of other contaminants will exceed the NES or air quality guidelines. One exception may be the air quality guideline for benzo(a)pyrene (BaP) as concentrations of this contaminant have been found to be high in areas where PM_{10} concentrations are elevated as a result of emissions from domestic home heating. No NES has been proposed for BaP at this stage.

The inventory design includes an evaluation of:

- Sources to include in the inventory
- Contaminants to include in the inventory
- The study areas
- Temporal resolution.

2.1 Selection of sources

The inventory includes detailed estimates of emissions from domestic heating, outdoor burning, motor vehicles and industry. Emissions from other minor sources are also discussed in the report. Estimation techniques for natural sources, such as sea spray, aeolian dust and vegetation, are limited and have not been evaluated.

2.2 Selection of contaminants

The inventory included an assessment of emissions of respirable particles (PM_{10}), carbon monoxide (CO), sulphur oxides (SOx), nitrogen oxides (NOx), volatile organic compounds (VOC), carbon dioxide (CO_2) and fine particles ($PM_{2.5}$).

Emissions of PM_{10}, CO, SOx and NOx are included as these contaminants comprise class one air quality indicators as described by MfE (1994) and are included in the NES because of their potential for adverse health impacts. Carbon dioxide is typically included in emission inventory investigations in New Zealand to allow for the assessment of regional greenhouse gas CO_2 emissions. The finer $PM_{2.5}$ particles were also included, as this size fraction is also of interest from a health impacts perspective.

Volatile organic compounds are typically included in emission inventory investigations because of their potential contribution to the formation of photochemical pollution. These have been retained in the inventory to allow an assessment of emissions of precursors to ozone, should future monitoring indicate concentrations of concern.

2.3 Selection of areas

Urban limits were used to define the study areas of Matamata (Figure 2-1) and Putaruru (Figure 2-2). Urban boundaries were obtained from the Environment Waikato GIS dataset “Urban Footprints Layer” that is largely based on LCDB2 class “Built up area” (MfE, 2005).

Rather than using the urban boundary for Waihi, the Waihi Airshed boundary (Figure 2-3) was instead considered more representative for this town due to the inclusion of Newmont’s Martha Mine, which would otherwise be excluded from the urban area. The Waihi airshed is one of many that Environment Waikato submitted to MfE in 2006 and will become a legal boundary once gazetted in 2007.

Two timber processing plants near Putaruru, Pacific Pine and Kiwi Lumber, are excluded from the study area because these activities are at least one kilometre from the urban area. Because of this distance, contaminant emissions would be dispersed and concentrations diluted before reaching the urban area. Emissions from Pacific Pine and Kiwi Lumber are therefore not comparable to emissions within the urban area of Putaruru.

Census Area Unit (CAU) boundaries were not used to define area, due to the changing nature of CAU boundaries as populations change. However, CAUs with names identical to the study areas were used to supply population data.

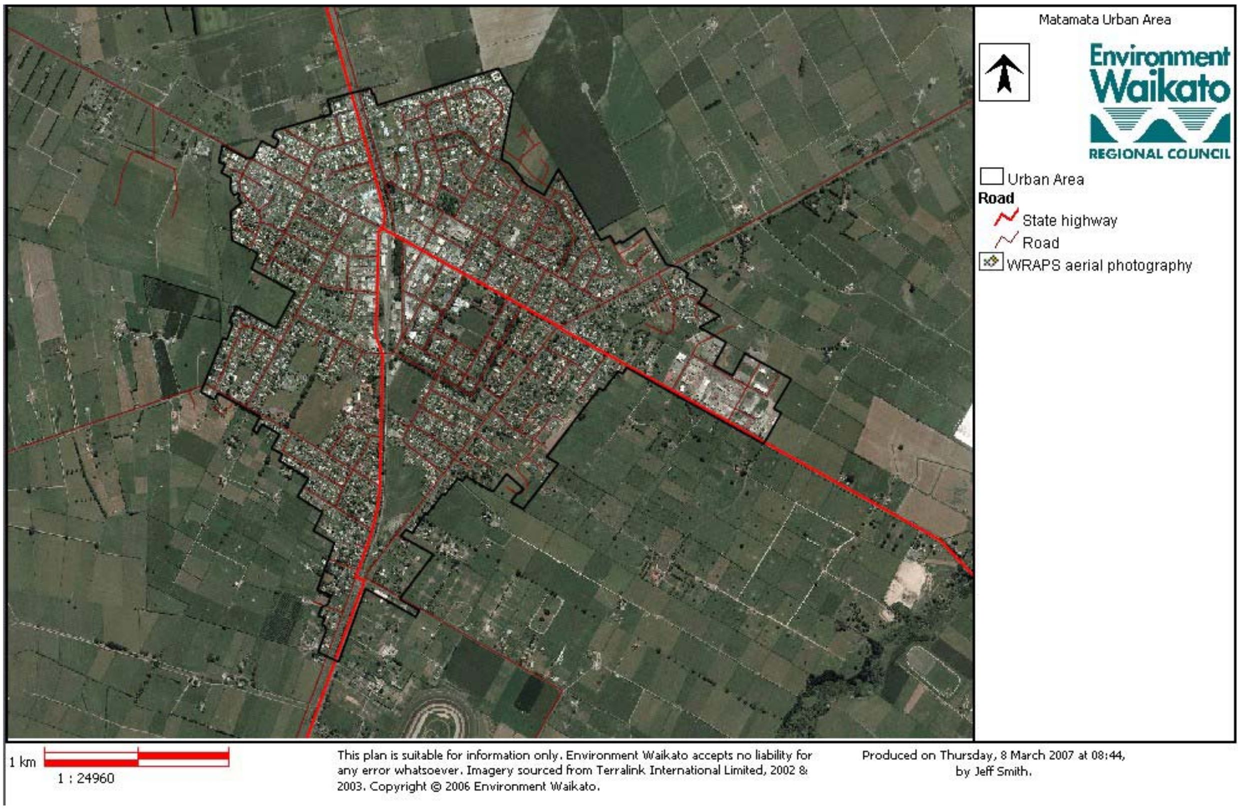

Figure 2-1 **Matamata 2006 study area, defined by urban boundary and identified with black line.**

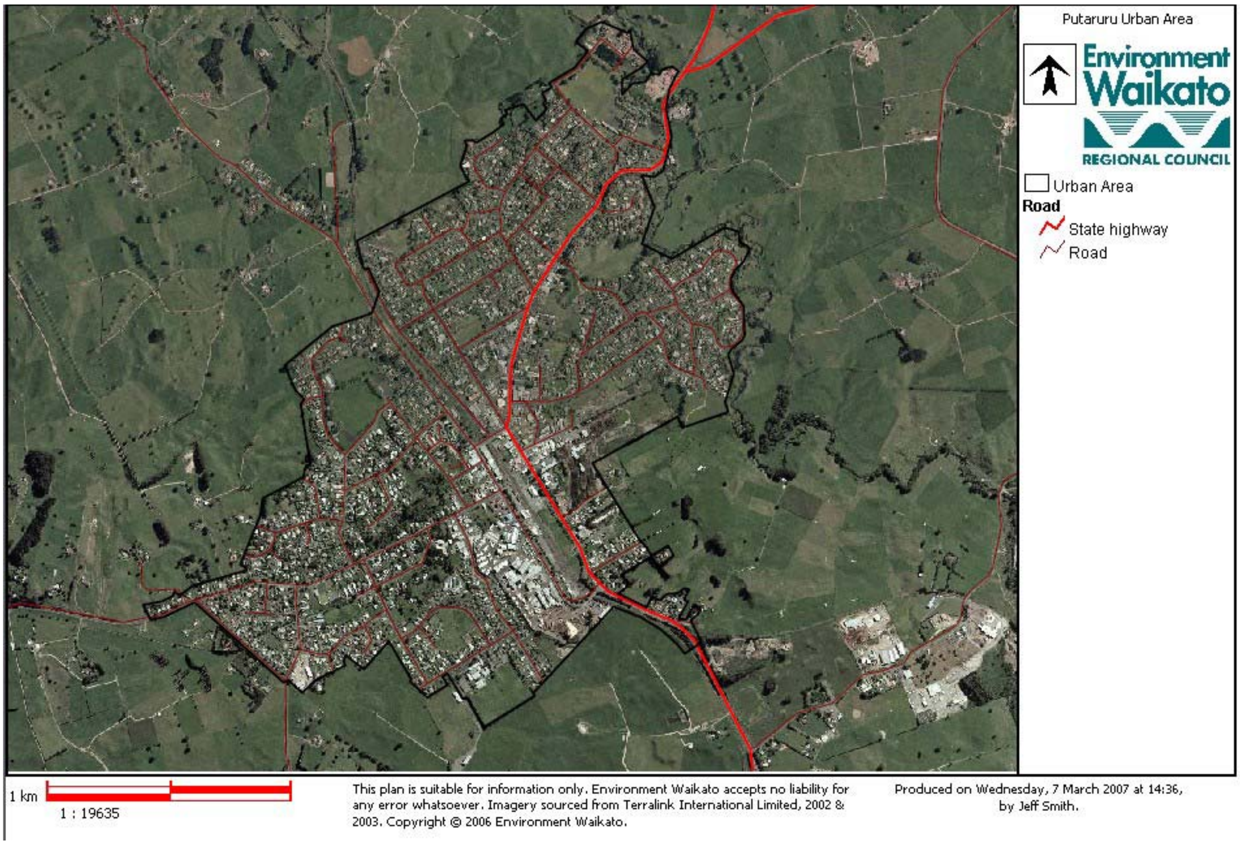

Figure 2-2 **Putaruru 2006 study area, defined by urban boundary and identified with black line. Pacific Pine and Kiwi Lumber are at bottom right, outside the urban area.**

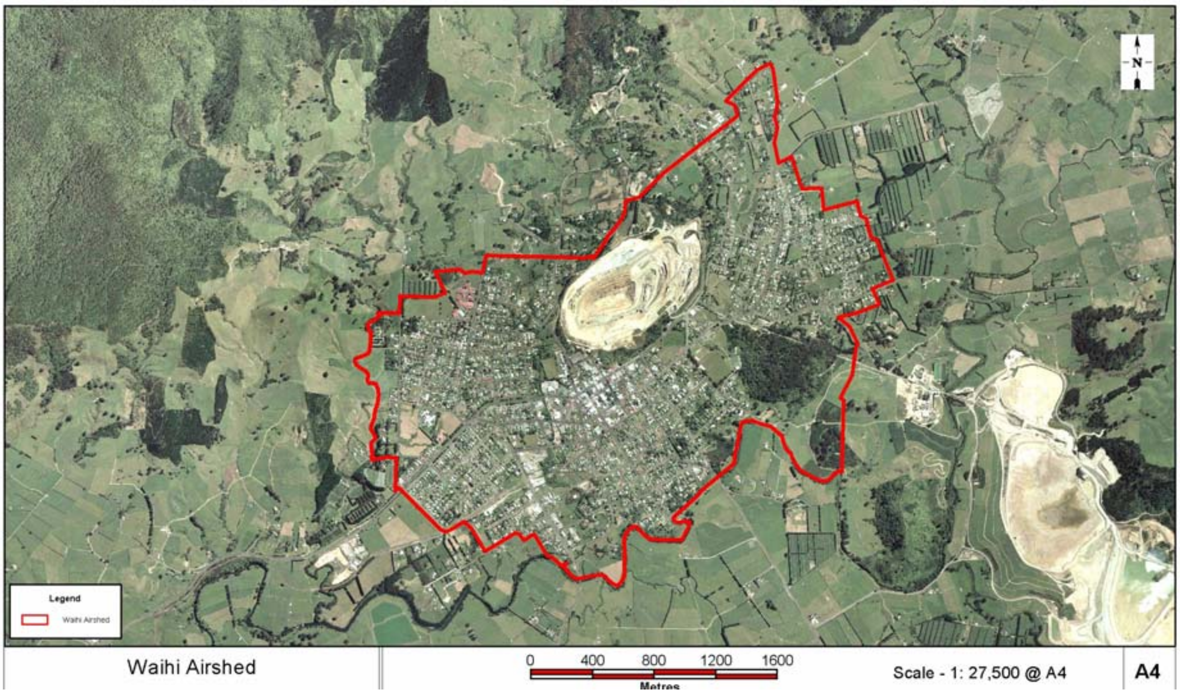

Figure 2-3 Waihi Airshed boundary (red line), used to define the 2006 study area.

2.4 Temporal distribution

Most data were collected based on wintertime daily average emissions. Domestic heating data were collected based on average and worst-case wintertime emissions. Emissions calculated for a worst-case winter's day are based on the assumption that all households using solid fuel for home heating will use it at the same time. This is a worst-case estimate because, in reality, not everyone will operate their solid fuel appliance on any given day and time.

For most sources, data were also collected by month of the year to provide an estimate of the relative contributions of different sources to annual average PM_{10} concentrations. No differentiation was made for weekday and weekend emissions, as variances are likely to be minimal for most sources. One exception is outdoor rubbish burning which may occur with greater frequency during the weekend.

The main focus of the study is on daily PM_{10} emissions during the winter period as this is when concentrations invariably exceeded the ambient air quality guidelines and NES for PM_{10} (24-hour average). In addition, the inclusion of an annual average guideline for PM_{10} in the ambient air quality guidelines (MfE, 2002) increases the importance of including emission estimates for different seasons. The inventory has therefore also been designed for the collection of seasonal data.

3 Domestic heating

3.1 Methodology

The activity data for domestic heating was collected by Digipol using a telephone survey of 259 to 280 households for each study area in September 2006. The number of households within each study area was based on 2001 census data for occupied dwellings. Statistics New Zealand did not predict population increase for the districts of Matamata-Piako, South Waikato and Hauraki, so no extrapolations were made to the 2001 data for Matamata, Putaruru and Waihi respectively. Summary data for the survey and study area are shown in Table 3-1.

A copy of the survey questionnaire is shown in Appendix 1.

Table 3-1: Home heating survey area and sample details

	Households	Sample size	Area (ha)	Sample error
Matamata	2385	280	451	5.5%
Putaruru	1410	259	331	5.5%
Waihi	1767	269	606	5.5%

Home heating methods were classified as electricity, open fires, wood burners 10 years or older (pre 1996), wood burners 5-10 years old (1996-2001), wood burners less than 5 years old (post 2001), multi fuel burners, gas burners and oil burners.

Emission factors were applied to the results of the home heating survey to provide an estimate of emissions for the urban areas of Matamata, Putaruru and Waihi. The emission factors used to estimate emissions from domestic heating are shown in Table 3-2 and are those used in an emissions inventory for Te Awamutu, Ngaruawahia and Turangi (Wilton, 2006). As for previous inventories carried out for the Waikato Region, the open fire and multi fuel burner factors were based on the Christchurch 1999 emission factors. The basis for these is detailed in Appendix 2. The older wood burner emission rates were based on testing of older wood burners “in situ” in Tokoroa during 2005 as detailed in Wilton and Smith, 2006, with adjustments for wet wood. The gas and oil PM_{10} emission factors have also been revised as a result of more recent testing in New Zealand (Scott, 2004).

Emissions calculated for the worst-case winter’s day were based on the assumption that all households that used solid fuel for home heating were using it at the same time. Average winter’s day emissions were also calculated. For this estimate, the daily fuel use was adjusted based on the average number of days per week each household used their heating method.

Daily emissions were also calculated for each month of the year to give an indication of the annual profile of PM_{10} emissions. These data were based on the average fuel use allowing for households not using particular heating methods on some nights during the week.

Fuel weights were identified from Wilton (2006), including the assumption of 1.6 kilograms per log for woodburning appliances.

Table 3-2: Emission factors for domestic heating methods

	PM_{10} (g/kg)	$PM_{2.5}$ (g/kg)	CO (g/kg)	NOx (g/kg)	SO_2 (g/kg)	VOC (g/kg)	CO_2 (g/kg)
Gas	0.03	0.03	0.18	1.30	<0.01	0.20	2500
Oil	0.30	0.70	0.60	2.20	3.80	0.25	3200
Open fire - wood	10.00	10.00	100.00	1.60	0.20	30.00	1600
Open fire - coal	21.00	12.00	80.00	4.00	5.00	15.00	2600
Pre 1996 burner	11.00	11.00	110.00	0.50	0.20	33.00	1800
1996-2001 burners	6.50	6.50	65.00	0.50	0.20	19.50	1800
Post 2001 burners	6.00	6.00	60.00	0.50	0.20	18.00	1800
Multi fuel[1] - wood	13.00	13.00	130.00	0.50	0.20	39.00	1600
Multi fuel[1] - coal	28.00	12.00	120.00	1.20	3.00	15.00	2600
Pellet burner	2.00	2.00	20.00	0.50	0.20	6.00	1600

[1] - includes potbelly, incinerator, coal range and any enclosed burner that is used to burn coal

Emissions for each contaminant and for each time period and season were calculated based on Equation 3-1:

Equation 3-1 CE (g/day) = EF (g/kg) * FB (kg/day)

Where:	
	CE = contaminant emission
	EF = emission factor
	FB = fuel burnt

The main assumptions underlying the emissions calculations are as follows:

- The average weight of a log of wood is 1.6 kg.
- The average weight of a bucket of coal is 9 kg.

3.2 Home heating methods

3.2.1 Matamata

Electricity was the main heating method in Matamata for 2006 with 53 per cent of households using this method to heat their main living area (Table 3-3). Woodburners were the second most common method (39 per cent) followed by gas appliances (21 per cent). Table 3-3 shows that households rely on more than one method of heating their main living area during the winter months.

Wood burning is the most common fuel for households using solid fuel heating methods in Matamata with 45 per cent of households using this fuel. About 26 tonnes of wood is burnt on an average winter’s night. In comparison coal is used by less than three per cent of Matamata households and less than a tonne is burnt per night.

Only a small proportion of Matamata residents use open fires (four per cent) or multi fuel burners (three per cent) to heat their main living area.

Table 3-3: Home heating methods and fuels in Matamata (HH = number of households)

	Heating methods		Fuel Use	
	%	HH	t/day	%
Electricity	52.9%	1261		
Gas	21.1%	503	0.4	1.6%
Oil	0.0%	0	0.0	0.0%
Open fire	3.9%	94		
Open fire - wood	3.9%	94	2.0	7.3%
Open fire - coal	1.1%	26	0.2	0.9%
Total wood burner	38.6%	920	22.8	84.8%
Pre 1996 wood burner	15.7%	375	9.5	35.3%
1996-2001 wood burner	11.1%	264	4.9	18.2%
Post 2001 wood burner	11.8%	281	8.4	31.3%
Multi fuel burners	2.9%	68		
Multi fuel burners - wood	2.9%	68	1.0	3.9%
Multi fuel burners - coal	1.4%	34	0.4	1.5%
Pellet burners	0.0%	0	0.0	0.0%
Total wood	45.4%	1082	25.8	96.0%
Total coal	2.5%	60	0.6	2.4%
Total		2385	26.9	

3.2.2 Putaruru

In Putaruru, wood burners were the most commonly used home heating method during 2006 with 49 per cent of households using this method to heat their main living area (Table 3-4). Electricity and gas were the second most common methods (37 per cent and 25 per cent). Table 3-4 shows that households rely on more than one method of heating their main living area during the winter months.

The most common fuel for households using solid fuel heating methods in Putaruru was wood with 56 per cent of households using this fuel. About 22 tonnes of wood is burnt on an average winter's night in Putaruru. Coal was used by around two per cent of Putaruru households with less than 1 tonne being burnt per night.

Around 3.5 per cent of Putaruru households use open fires and 3.5 per cent use multi fuel burners to heat their main living area.

Table 3-4: Home heating methods and fuels in Putaruru (HH = number of households)

	Heating methods		Fuel Use	
	%	HH	t/day	%
Electricity	36.7%	517		
Gas	25.1%	354	0.3	1.2%
Oil	0.4%	5	0.0	0.1%
Open fire	3.5%	49		
Open fire - wood	3.5%	49	0.8	3.3%
Open fire - coal	0.4%	5	0.1	0.4%
Total wood burner	49.0%	691	20.6	87.0%
Pre 1996 wood burner	25.5%	359	10.5	44.5%
1996-2001 wood burner	11.2%	158	3.9	16.4%
Post 2001 wood burner	12.4%	174	6.2	26.0%
Multi fuel burners	3.5%	49		
Multi fuel burners - wood	3.5%	49	1.1	4.5%
Multi fuel burners - coal	1.9%	27	0.8	3.5%
Pellet burners	0.8%	11	0.0	0.1%
Total wood	56.0%	789	22.4	94.9%
Total coal	2.3%	33	0.9	3.9%
Total		1410	23.7	

3.2.3 Waihi

Wood burners and electrical appliances were the most commonly used home heating methods in Waihi during 2006 with 42 per cent and 41 per cent of households using these methods respectively (Table 3-5). Gas heaters were the next most common method, with 22 per cent of households using gas in their main living area. Table 3-5 shows that households rely on more than one method of heating their main living area during the winter months.

The most common fuel for households using solid fuel heating methods in Waihi was wood with 51 per cent of households using this fuel. About 24 tonnes of wood is burnt on an average winter’s night in Waihi. Coal was used by around four per cent of Waihi households with 1 tonne being burnt per night

Around five per cent of Waihi households use open fires and three per cent use multi fuel burners to heat their main living area.

Table 3-5: Home heating methods and fuels in Waihi (HH = number of households)

	Heating methods		Fuel Use	
	%	HH	t/day	%
Electricity	41.3%	729		
Gas	22.3%	394	0.3	1.0%
Oil	0.4%	7	0.0	0.1%
Open fire	4.8%	85		
Open fire - wood	4.8%	85	4.6	18.0%
Open fire - coal	1.5%	26	0.2	0.9%
Total wood burner	42.4%	749	18.7	73.3%
Pre 1996 wood burner	14.1%	250	6.1	23.8%
1996-2001 wood burner	13.3%	236	5.9	23.1%
Post 2001 wood burner	14.9%	263	6.7	26.3%
Multi fuel burners	3.3%	59		
Multi fuel burners - wood	3.3%	59	1.0	3.8%
Multi fuel burners - coal	1.9%	33	0.7	2.9%
Pellet burners	0.0%	0	0.0	0.0%
Total wood	50.6%	893	24.3	95.1%
Total coal	3.3%	59	1.0	3.8%
Total		1767	25.5	

4 Emissions from domestic heating

4.1 Matamata

The greatest amount of PM_{10} from domestic heating at Matamata during the winter comes from pre 1996 wood burners (45 per cent). Woodburners of all ages contribute 81 per cent of PM_{10} emissions, while multi fuel burners contribute around 11 per cent and open fires eight per cent (Figure 4-1).

Estimates of wintertime contaminant emissions for different heating methods under worst-case and average scenarios are also shown in Table 4-1 and Table 4-2. The emission estimates indicate the following:

- Around 236 kilograms of PM_{10} are discharged under the worst-case scenario of all households using solid fuel burners on a given night.
- Average daily wintertime PM_{10} emissions are less, at around 210 kilograms per day. This accounts for days when households may not be using specific home heating methods.
- The majority of this PM_{10} is in the finer $PM_{2.5}$ size fraction.
- The majority (93 per cent) of the wintertime domestic PM_{10} emissions come from the burning of wood with seven per cent from the burning of coal.

Table 4-3 shows seasonal variations in contaminant emissions. The majority of the annual PM_{10} emissions from domestic home heating occurs during late autumn and winter, from May to August.

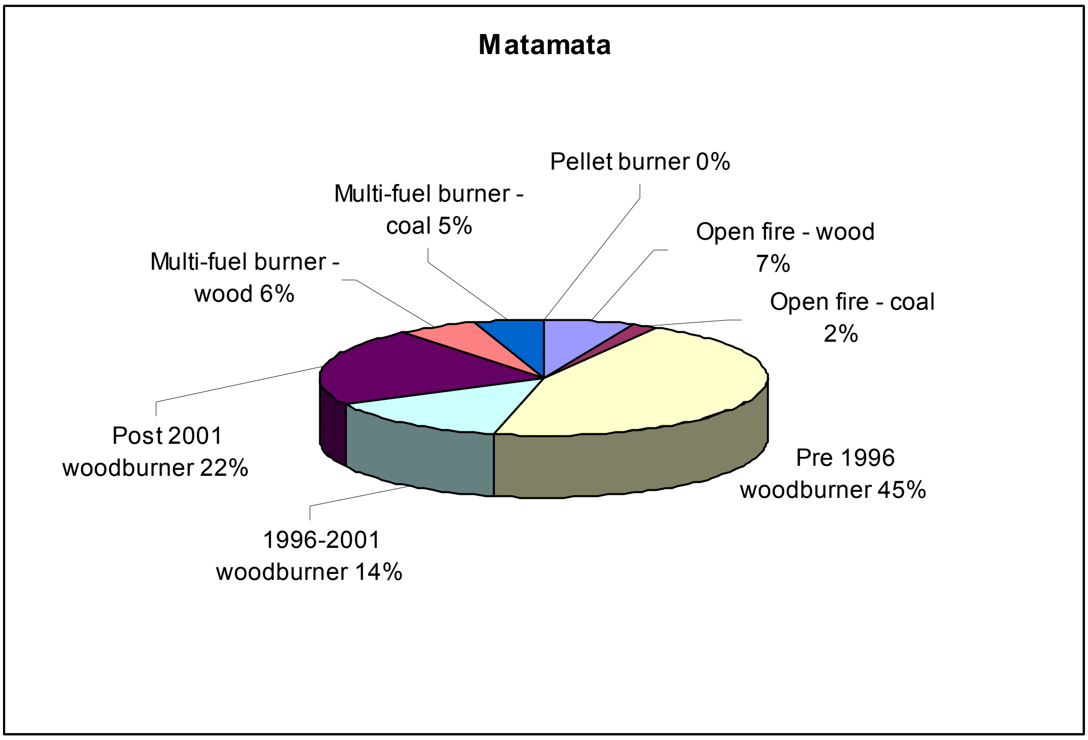

Figure 4-1: Relative contribution of different heating methods to average daily PM_{10} (July) from domestic heating in Matamata

Table 4-1: Matamata worst-case winter daily domestic heating emissions by appliance type

	Fuel Use	PM_{10}			$PM_{2.5}$			CO			NOx			SOx			VOC			CO_2		
	t/day	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	kg/ha	%
Gas	0.4	0	0	0%	0	0	0%	0	0	0%	1	1	3%	0	0	0%	0	0	0%	1	2	2%
Oil	0.0	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Open fire																						
Open fire - wood	2.0	20	44	8%	20	44	9%	197	437	9%	3	7	19%	0	1	5%	59	131	9%	3	7	6%
Open fire - coal	0.2	5	11	2%	3	6	1%	18	41	1%	1	2	5%	1	3	15%	3	8	1%	1	1	1%
Wood burner																						
Pre 1996 wood burner	9.5	104	231	44%	104	231	46%	1043	2312	46%	5	11	28%	2	4	25%	313	694	47%	17	38	35%
1996-2001 wood burner	4.9	32	70	13%	32	70	14%	317	703	14%	2	5	14%	1	2	13%	95	211	14%	9	19	18%
Post 2001 wood burner	8.4	50	112	21%	50	112	22%	505	1119	22%	4	9	25%	2	4	22%	151	336	23%	15	34	31%
Multi fuel burners																						
Multi fuel burners - wood	1.0	13	30	6%	13	30	6%	135	299	6%	1	1	3%	0	0	3%	40	90	6%	2	4	3%
Multi fuel burners - coal	0.4	11	25	5%	5	11	2%	49	109	2%	0	1	3%	1	3	16%	6	14	1%	1	2	2%
Pellet burners	0.0	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Total wood	25.8	220	487	93%	220	487	97%	2196	4870	97%	15	33	88%	5	11	68%	659	1461	99%	46	102	94%
Total coal	0.6	16	36	7%	8	17	3%	67	150	3%	1	3	8%	2	5	32%	10	21	1%	2	4	3%
Total		**236**	**523**		**227**	**504**		**2264**	**5020**		**17**	**38**		**8**	**17**		**669**	**1482**		**49**	**108**	

Table 4-2: Matamata average winter daily domestic heating emissions by appliance type

	Fuel Use	PM_{10}			$PM_{2.5}$			CO			NOx			SOx			VOC			CO_2		
	t/day	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	kg/ha	%
Gas	0.4	0	0	0%	0	0	0%	0	0	0%	0	1	3%	0	0	0%	0	0	0%	1	2	2%
Oil	0.0	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Open fire																						
Open fire - wood	1.4	14	31	7%	14	31	7%	141	312	7%	2	5	15%	0	1	4%	42	94	7%	2	5	5%
Open fire - coal	0.2	3	8	2%	2	4	1%	13	29	1%	1	1	4%	1	2	13%	2	5	0%	0	1	1%
Wood burner																						
Pre 1996 wood burner	8.6	95	210	45%	95	210	47%	949	2104	47%	4	10	29%	2	4	26%	285	631	48%	16	34	36%
1996-2001 wood burner	4.4	29	64	14%	29	64	14%	289	640	14%	2	5	15%	1	2	14%	87	192	15%	8	18	18%
Post 2001 wood burner	7.7	46	102	22%	46	102	23%	459	1019	23%	4	8	26%	2	3	23%	138	306	23%	14	31	32%
Multi fuel burners																						
Multi fuel burners - wood	0.9	12	27	6%	12	27	6%	123	272	6%	0	1	3%	0	0	3%	37	82	6%	2	3	3%
Multi fuel burners - coal	0.4	10	23	5%	4	10	2%	45	99	2%	0	1	3%	1	2	17%	6	12	1%	1	2	2%
Pellet burners	0.0	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Total wood	23.1	196	435	93%	196	435	97%	1961	4347	97%	13	29	89%	5	10	70%	588	1304	99%	41	91	95%
Total coal	0.5	14	31	7%	6	14	3%	58	128	3%	1	2	8%	2	4	30%	8	18	1%	1	3	3%
Total		**210**	**465**		**203**	**449**		**2018**	**4475**		**15**	**33**		**7**	**15**		**596**	**1322**		**43**	**96**	

Table 4-3: Monthly variations in contaminant emissions from domestic heating in Matamata

	PM_{10} (kg/day)	$PM_{2.5}$ (kg/day)	CO (kg/day)	NOx (kg/day)	SOx (kg/day)	VOC (kg/day)	CO_2 (t/day)
January	1	1	15	0	0	4	0
February	1	1	15	0	0	4	0
March	1	1	15	0	0	4	0
April	22	22	220	1	1	66	5
May	113	110	1094	8	3	324	24
June	198	191	1907	14	6	563	41
July	210	203	2018	15	7	596	43
August	194	187	1859	14	6	549	40
September	61	61	611	4	1	183	13
October	9	9	94	1	0	28	2
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total (kg/yr)	**24882**	**24138**	**240498**	**1702**	**749**	**71195**	**5154**

4.2 Putaruru

Older (pre 1996) wood burners produce the greatest amount of PM_{10} from domestic heating during the winter in Putaruru, contributing around 52 per cent of the daily average wintertime PM_{10}. Overall wood burners contribute 80 per cent of the domestic PM_{10}, with open fires contributing four per cent and multi fuel burners 16 per cent (Figure 4-2).

Estimates of wintertime contaminant emissions for different heating methods under worst-case and average scenarios are also shown in Table 4-4 and Table 4-5. The emission estimates indicate the following:

- Around 225 kilograms of PM_{10} are discharged under the worst-case scenario of all households using solid fuel burners on a given night.
- Average daily wintertime PM_{10} emissions are less, at around 205 kilograms per day. This accounts for days when households may not be using specific home heating methods.
- The majority of this PM_{10} is in the finer $PM_{2.5}$ size fraction.
- The majority (89 per cent) of the wintertime domestic PM_{10} emissions come from the burning of wood with 11 per cent from the burning of coal.

Table 4-6 shows seasonal variations in contaminant emissions. The majority of the annual PM_{10} emissions from domestic home heating occurs during late autumn and winter, from May to August.

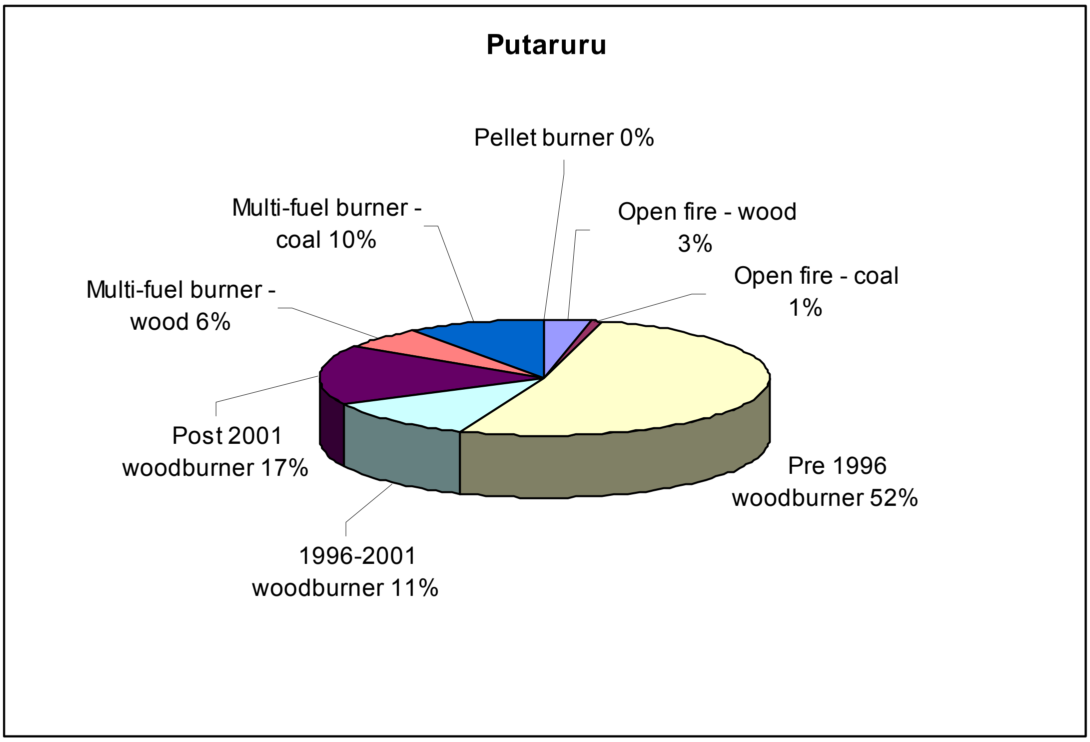

Figure 4-2: Relative contribution of different heating methods to average daily PM_{10} (July) from domestic heating in Putaruru

Table 4-4: Putaruru worst-case winter daily domestic heating emissions by appliance type

	Fuel Use	PM_{10}			$PM_{2.5}$			CO			NOx			SOx			VOC			CO_2		
	t/day	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	kg/ha	%
Gas	0.28	0	0	0%	0	0	0%	0	0	0%	0	1	3%	0	0	0%	0	0	0%	1	2	2%
Oil	0.03	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%
Open fire																						
Open fire - wood	0.78	8	17	3%	8	17	4%	78	174	4%	1	3	9%	0	0	2%	24	52	4%	1	3	3%
Open fire - coal	0.10	2	5	1%	1	3	1%	8	17	0%	0	1	3%	0	1	7%	1	3	0%	0	1	1%
Wood burner																						
Pre 1996 wood burner	10.54	116	257	52%	116	257	55%	1159	2571	55%	5	12	38%	2	5	28%	348	771	57%	19	42	44%
1996-2001 wood burner	3.89	25	56	11%	25	56	12%	253	561	12%	2	4	14%	1	2	10%	76	168	12%	7	16	16%
Post 2001 wood burner	6.16	37	82	16%	37	82	17%	369	819	18%	3	7	22%	1	3	16%	111	246	18%	11	25	26%
Multi fuel burners																						
Multi fuel burners - wood	1.07	14	31	6%	14	31	7%	139	309	7%	1	1	4%	0	0	3%	42	93	7%	2	4	4%
Multi fuel burners - coal	0.82	23	51	10%	10	22	5%	98	217	5%	1	2	7%	2	5	33%	12	27	2%	2	5	5%
Pellet burners	0.02	0	0	0%	0	0	0%	0	1	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Total wood	22.44	200	443	89%	200	443	95%	1999	4433	95%	12	27	87%	4	10	60%	600	1330	98%	40	89	93%
Total coal	0.91	25	55	11%	11	24	5%	106	235	5%	1	3	10%	3	7	39%	14	30	2%	2	5	6%
Total		**225**	**499**		**211**	**468**		**2106**	**4669**		**14**	**31**		**8**	**17**		**614**	**1361**		**43**	**96**	

Table 4-5: Putaruru average winter daily domestic heating emissions by appliance type

	Fuel Use	PM_{10}			$PM_{2.5}$			CO			NOx			SOx			VOC			CO_2		
	t/day	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	kg/ha	%
Gas	0.2	0	0	0%	0	0	0%	0	0	0%	0	1	3%	0	0	0%	0	0	0%	1	1	2%
Oil	0.0	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%
Open fire																						
Open fire - wood	0.7	7	15	3%	7	15	4%	68	152	4%	1	2	9%	0	0	2%	21	46	4%	1	2	3%
Open fire - coal	0.1	2	4	1%	1	2	1%	7	15	0%	0	1	3%	0	1	6%	1	3	0%	0	0	1%
Wood burner																						
Pre 1996 wood burner	9.7	107	236	52%	107	236	55%	1067	2365	55%	5	11	38%	2	4	28%	320	709	57%	17	39	44%
1996-2001 wood burner	3.6	23	52	11%	23	52	12%	233	516	12%	2	4	14%	1	2	11%	70	155	12%	6	14	16%
Post 2001 wood burner	5.7	34	75	17%	34	75	18%	340	754	18%	3	6	22%	1	3	17%	102	226	18%	10	23	26%
Multi fuel burners																						
Multi fuel burners - wood	1.0	12	28	6%	12	28	6%	124	276	6%	0	1	4%	0	0	3%	37	83	7%	2	3	4%
Multi fuel burners - coal	0.7	20	45	10%	9	19	5%	87	194	5%	1	2	7%	2	5	32%	11	24	2%	2	4	5%
Pellet burners	0.0	0	0	0%	0	0	0%	0	1	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Total wood	20.6	183	406	89%	183	406	95%	1832	4062	95%	11	24	87%	4	9	60%	550	1219	98%	37	81	93%
Total coal	0.8	22	49	11%	10	22	5%	94	209	5%	1	3	10%	3	6	38%	12	27	2%	2	5	5%
Total		**205**	**456**		**193**	**428**		**1927**	**4272**		**13**	**28**		**7**	**15**		**562**	**1246**		**40**	**88**	

Table 4-6: Monthly variations in contaminant emissions from domestic heating in Putaruru

	PM_{10} (kg/day)	$PM_{2.5}$ (kg/day)	CO (kg/day)	NOx (kg/day)	SOx (kg/day)	VOC (kg/day)	CO_2 (t/day)
January	1	1	14	0	0	4	0
February	1	1	14	0	0	4	0
March	10	10	95	1	0	29	2
April	31	31	306	2	1	92	6
May	121	113	1132	7	4	330	23
June	192	180	1792	12	7	521	37
July	205	193	1926	13	7	562	40
August	186	176	1755	11	6	513	36
September	82	81	814	5	2	244	15
October	23	23	226	1	1	68	4
November	7	7	69	0	0	21	1
December	1	1	14	0	0	4	0
Total (kg/yr)	**26358**	**25044**	**249839**	**1596**	**835**	**73232**	**5060**

4.3 Waihi

Older (pre 1996) wood burners produce the greatest amount of PM_{10} from domestic heating during the winter in Waihi, contributing around 29 per cent of the daily average wintertime PM_{10} (Figure 4-3). Overall, wood burners contribute 62 per cent of the domestic PM_{10} in Waihi. Open fires are responsible for a noteworthy contribution of 22 per cent and multi fuel burners contribute16 per cent.

Estimates of wintertime contaminant emissions for different heating methods under worst-case and average scenarios are also shown in Table 4-7 and Table 4-8. The emission estimates indicate the following:

- Around 225 kilograms of PM_{10} are discharged under the worst-case scenario of all households using solid fuel burners on a given night.
- Average daily wintertime PM_{10} emissions are less, at around 205 kilograms per day. This accounts for days when households may not be using specific home heating methods.
- The majority of this PM_{10} is in the finer $PM_{2.5}$ size fraction.
- The majority (89 per cent) of the wintertime domestic PM_{10} emissions come from the burning of wood with 11 per cent from the burning of coal.

Table 4-9 shows seasonal variations in contaminant emissions. The majority of the annual PM_{10} emissions from domestic home heating occurs during late autumn and winter, from May to August.

The greatest amount of PM_{10} from domestic heating during the winter in Waihi comes from wood burning on multi fuel burners which contribute around 29 per cent of the daily average wintertime PM_{10} emissions. Older wood burners (23 per cent) and multi fuel burners burning coal (19 per cent) are the next greatest contributors. Overall wood burning contributes 81 per cent of the PM_{10}.

Estimates of wintertime contaminant emissions for different heating methods under worst-case and average scenarios are also shown in Table 4-7 and Table 4-8. The emission estimates indicate the following:

- Around 412 kilograms of domestic PM_{10} are discharged under the worst-case scenario of all households using solid fuel burners on a given night.

- Average daily wintertime PM_{10} emissions are less at around 329 kilograms per day. This accounts for days when households may not be using specific home heating methods.
- The majority of this PM_{10} is in the finer $PM_{2.5}$ size fraction.
- The majority (81 per cent) of the wintertime PM_{10} emissions come from the burning of wood with 19 per cent from the burning of coal.

Table 4-9 shows seasonal variations in contaminant emissions. The majority of the annual PM_{10} from domestic home heating occur during the months June, July and August.

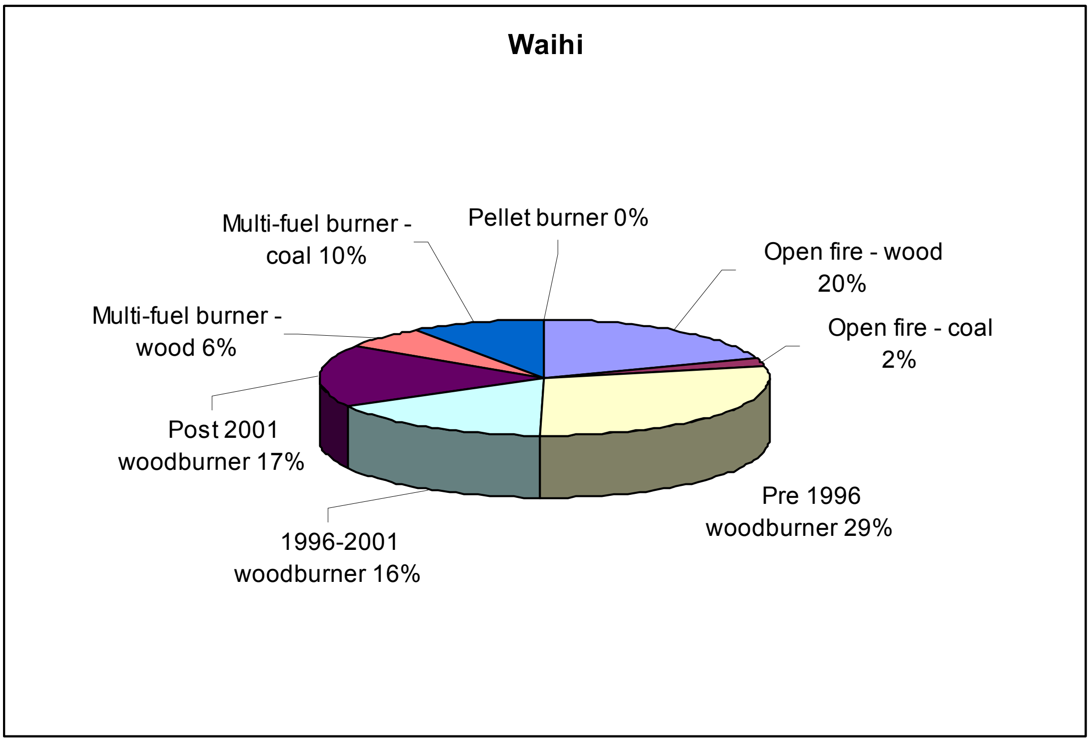

Figure 4-3: Relative contribution of different heating methods to average daily PM_{10} (July) from domestic heating in Waihi

Table 4-7: Waihi worst-case winter daily domestic heating emissions by appliance type

	Fuel Use	PM_{10}			$PM_{2.5}$			CO			NOx			SOx			VOC			CO_2		
	t/day	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	kg/ha	%
Gas	0.25	0	0	0%	0	0	0%	0	0	0%	0	1	2%	0	0	0%	0	0	0%	1	1	1%
Oil	0.01	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%
Open fire																						
Open fire - wood	4.59	46	102	20%	46	102	21%	459	1018	21%	7	16	38%	1	2	11%	138	305	22%	7	16	16%
Open fire - coal	0.24	5	11	2%	3	6	1%	19	42	1%	1	2	5%	1	3	14%	4	8	1%	1	1	1%
Wood burner																						
Pre 1996 wood burner	6.08	67	148	29%	67	148	31%	668	1482	31%	3	7	16%	1	3	15%	201	445	32%	11	24	24%
1996-2001 wood burner	5.90	38	85	17%	38	85	18%	383	850	18%	3	7	15%	1	3	14%	115	255	18%	11	24	23%
Post 2001 wood burner	6.71	40	89	18%	40	89	19%	403	893	19%	3	7	17%	1	3	16%	121	268	19%	12	27	26%
Multi fuel burners																						
Multi fuel burners - wood	0.97	13	28	6%	13	28	6%	126	280	6%	0	1	3%	0	0	2%	38	84	6%	2	3	3%
Multi fuel burners - coal	0.74	21	46	9%	9	20	4%	89	197	4%	1	2	5%	2	5	27%	11	25	2%	2	4	4%
Pellet burners	0.00	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Total wood	24.25	204	452	89%	204	452	95%	2040	4523	95%	17	38	89%	5	11	58%	612	1357	98%	43	94	93%
Total coal	0.98	26	57	11%	12	26	5%	108	239	5%	2	4	9%	3	8	41%	15	32	2%	3	6	6%
Total		**230**	**509**		**216**	**478**		**2148**	**4762**		**19**	**43**		**8**	**18**		**627**	**1390**		**46**	**101**	

Table 4-8: Waihi average winter daily domestic heating emissions by appliance type

	Fuel Use	PM_{10}			$PM_{2.5}$			CO			NOx			SOx			VOC			CO_2		
	t/day	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	kg/ha	%
Gas	0.2	0	0	0%	0	0	0%	0	0	0%	0	1	2%	0	0	0%	0	0	0%	0	1	1%
Oil	0.0	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%
Open fire																						
Open fire - wood	4.0	40	88	20%	40	88	21%	399	884	21%	6	14	37%	1	2	11%	120	265	22%	6	14	16%
Open fire - coal	0.2	4	10	2%	2	5	1%	16	36	1%	1	2	5%	1	2	14%	3	7	1%	1	1	1%
Wood burner																						
Pre 1996 wood burner	5.3	59	130	29%	59	130	31%	587	1301	31%	3	6	16%	1	2	14%	176	390	32%	10	21	24%
1996-2001 wood burner	5.2	34	75	16%	34	75	18%	336	746	18%	3	6	15%	1	2	14%	101	224	18%	9	21	23%
Post 2001 wood burner	5.9	35	78	17%	35	78	19%	354	784	19%	3	7	17%	1	3	16%	106	235	19%	11	24	26%
Multi fuel burners																						
Multi fuel burners - wood	0.9	12	27	6%	12	27	6%	122	272	6%	0	1	3%	0	0	3%	37	81	7%	2	3	4%
Multi fuel burners - coal	0.7	20	44	10%	9	19	4%	86	190	5%	1	2	5%	2	5	29%	11	24	2%	2	4	5%
Pellet burners	0.0	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Total wood	21.3	180	399	88%	180	399	94%	1798	3986	95%	15	33	88%	4	9	57%	539	1196	97%	37	83	93%
Total coal	0.9	24	54	12%	11	25	6%	102	227	5%	2	4	10%	3	7	42%	14	31	2%	2	5	6%
Total		**204**	**453**		**191**	**423**		**1900**	**4213**		**17**	**38**		**7**	**17**		**553**	**1226**		**40**	**89**	

Table 4-9: Monthly variations in contaminant emissions from domestic heating in Waihi

	PM_{10} (kg/day)	$PM_{2.5}$ (kg/day)	CO (kg/day)	NOx (kg/day)	SOx (kg/day)	VOC (kg/day)	CO_2 (t/day)
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	2	2	23	0	0	7	1
April	21	20	200	1	1	59	4
May	114	107	1064	9	4	310	23
June	194	181	1799	16	7	523	38
July	204	191	1900	17	7	553	40
August	194	181	1803	16	7	524	38
September	71	68	683	5	2	201	15
October	16	15	147	1	1	42	3
November	4	3	34	0	0	10	1
December	0	0	0	0	0	0	0
Total (kg/yr)	**25139**	**23551**	**234529**	**2009**	**907**	**68319**	**5023**

5 Motor vehicles

To estimate emissions from motor vehicles, the number of vehicle kilometres travelled (VKT) per day are ascertained under different levels of congestion. Emission factors are applied to the VKT data to provide emission estimates for a range of congestion conditions.

While estimates of VKTs have been made using local road network models for some New Zealand urban centres, there are no such models for Matamata, Putaruru or Waihi. Estimates of VKTs for this inventory are therefore based on the ratio of VKTs to households (VKT:HH) for other urban areas of New Zealand (Table 5-1).

Table 5-1: Ratios of daily VKT to households for urban areas in New Zealand

	VKT/ day	No. of households	VKT/HH/day
Nelson	916,007	14340	64
Hamilton	2,463,143	40698	60
Taupo	446,258	6973	64
Kaiapoi	215,509	3188	68
Timaru - excluding Washdyke	348,742	10696	33
Christchurch	4,764,837	100470	47
Napier	878,629	19521	45
Havelock North	142,046	3927	36
Hastings	472,747	10746	44
Flaxmere	88,816	2733	33

Putaruru is located on State Highway One (SH1) and is therefore likely to have a VKT:HH ratio similar to other Waikato urban areas on SH1. Consequently, for Putaruru, the mean VKT:HH ratio for Hamilton and Taupo was used (62 VKT:HH). SH1 does not bisect Matamata or Waihi, so the VKT:HH ratio is more likely to be similar to that of other North Island towns including Napier, Havelock North, Hastings and Flaxmere.

The mean ratio for these towns is 39.42 VKT:HH and is used for estimating VKTs for Waihi and Matamata. The daily VKT estimates for Matamata, Putaruru and Waihi are shown in Table 5-2.

Table 5-2: Daily VKT estimates

	VKT/HH/day	No. HH	VKT/day
Matamata	39.42	2,385	**94,012**
Putaruru	62.00	1,410	**87,420**
Waihi	39.42	1,767	**69,651**

Based on a vehicle fleet profile for the Hamilton 2005 inventory, the New Zealand Traffic Emission Rates (NZTER) database was used to estimate motor vehicle emission factors for PM_{10}, CO, NOx and VOC. Further details of the basis for all motor vehicle emission rates are provided in Wilton (2005).

Because vehicle emissions increase significantly when traffic is congested, different VKT emission rates usually vary for free flow conditions, interrupted flow conditions and congested flow conditions. Vehicle movements in Matamata, Putaruru and Waihi are unlikely to be congested, so free-flowing emission factors are used and shown for each contaminant in Table 5-3. These are based on the assumption that 30 per cent of the VKTs occur under cold running conditions.

Table 5-3: Emission factors for Matamata, Putaruru and Waihi based on a suburban driving regime and free flow conditions

	PM_{10} (g/VKT)	$PM_{2.5}$ (g/VKT)	CO (g/VKT)	NOx (g/VKT)	SOx (g/VKT)	VOC (g/VKT)	CO_2 (g/VKT)
Free flow Conditions	0.07	0.04	11.2	1.3	0.2	1.8	363

Emissions for each time period were calculated by multiplying the appropriate average emission factor by the VKT for that time period and level of service.

Emissions (g) = Emission Rate (g/km) x VKT

Separate estimates of emissions were made for PM_{10} and $PM_{2.5}$ from brake and tyre wear.

5.1 Motor vehicle emissions

5.2 Matamata

The number of VKTs for Matamata is likely to be around 94,000 per day for 2006 and, based on these data, around eight kilograms of PM_{10} is likely to be contributed per day from motor vehicles in the town (Table 5-4). About 25 per cent of the daily PM_{10} emissions from motor vehicles are estimated to occur as a result of the wearing of brakes and tyres.

Other contaminant emissions from motor vehicles in Matamata include around one tonne of CO, 122 kilograms of NOx and 19 kilograms of SOx. In comparison, in Christchurch, where CO concentrations exceed ambient air quality guidelines at least once during most winters, motor vehicles emit around 109 tonnes of CO within the main urban area.

Table 5-4: Summary of daily motor vehicle emissions in Matamata, Putaruru and Waihi

	Hectares	PM_{10} kg	PM_{10} g ha^{-1}	$PM_{2.5}$ kg	$PM_{2.5}$ g ha^{-1}	CO kg	CO g ha^{-1}	NOx kg	NOx g ha^{-1}
Matamata	451	8.3	18	4.3	10	1053	2335	122	271
Putaruru	331	7.7	23	4.0	12	979	2958	114	343
Waihi	606	6.1	10	3.2	5	780	1287	91	149

	Hectares	SOx kg	SOx g ha^{-1}	VOC kg	VOC g ha^{-1}	CO_2 t	CO_2 kg ha^{-1}
Matamata	451	19	42	169	375	34	76
Putaruru	331	17	53	157	475	32	96
Waihi	606	14	23	125	207	25	42

5.3 Putaruru

The number of VKTs for Putaruru is likely to be around 87,000 per day for 2006 and, based on these data, nearly eight kilograms of PM_{10} is likely to be contributed per day from motor vehicles in the town (Table 5-4). Around 25 per cent of the daily PM_{10} emissions from motor vehicles are estimated to occur as a result of the wearing of brakes and tyres.

Other contaminant emissions from motor vehicles in Putaruru include around 980 kilograms of CO, 114 kilograms of NOx and 17 kilograms of SOx.

5.4 Waihi

The number of VKTs for Waihi is likely to be almost 70,000 per day for 2006 and, based on these data, six kilograms of PM_{10} is likely to be contributed per day from motor vehicles in the town (Table 5-4). Around 25 per cent of the daily PM_{10} emissions from motor vehicles are estimated to occur as a result of the wearing of brakes and tyres.

Other contaminant emissions from motor vehicles in Waihi include around 780 kilograms of CO, 91 kilograms of NOx and 14 kilograms of SOx.

6 Industrial and Commercial

Industrial discharges to air located within Matamata, Putaruru and Waihi were identified using a combination of resource consent information and searches of particular activity types such as schools and hospitals.

Newmont Waihi Gold's open cast Martha gold mine is situated within the Waihi airshed (Figure 2-3). PM_{10}, as a component of dust, is the major contaminant of concern at Martha mine and is the main focus for the purposes of this investigation. There are no other consented activities in Waihi and the only non-consented activities that were identified in the town are school boilers.

There are two resource consents for air discharges in the Putaruru urban area, for Carter Holt Harvey (CHH) Timber and Rapid Minerals. The activities related to these industries are timber manufacturing and lime fertiliser processing respectively. School boilers were the only other relevant activities identified in Putaruru.

In Matamata, the industrial emissions assessment was limited to a small number of school boilers.

6.1 Methodology

The selection of industries for inclusion in the inventory was primarily based on potential for PM_{10} emissions. Industrial activities such as spray painting or dry cleaning operations, which discharge primarily volatile organic compounds (VOC) were not included in the assessment. Activity data from industry includes information such as the quantities of fuel used or, in the case of non-combustion activities, materials used or produced.

Emission factors used to estimate the quantity of emissions discharged are shown in Table 6-1. The coal fired boiler emission factors for PM_{10} are based on CRL Energy Ltd emission factors. Emission factors for $PM_{2.5}$ are based on the USEPA AP42 database[1] particle size distribution factors, as are emission factors for CO, NOx and SOx. The VOC and CO_2 and all gas emission factors are based on factors derived by NIWA for the Christchurch 1996 emission inventory (NIWA, 1998).

Table 6-1: Emission factors for discharges from coal-fired boilers

	PM_{10} g/kg	$PM_{2.5}$ g/kg	CO g/kg	NOx g/kg	SO_2 g/kg	VOC g/kg	CO_2 g/kg
Coal boiler (underfeed stoker)	3.1	1.9	5.5	4.8	13.5	0.1	2400
Coal boiler - chaingrate	1.8	0.7	3	3.8	18	0.1	2400

Schools in all study areas were identified using lists provided by the Ministry of Education. Each school was contacted and asked for information about fuel used for heating. Combustion emissions were then calculated by combining the fuel use data with emission factors for school boilers, as indicated in Equation 6-1.

Equation 6-1 Emissions (kg) = Emission factor (kg/tonne) x Fuel use (tonnes)

Emissions from CHH Timber and Rapid Lime at Putaruru were identified from information provided in resource consent applications and compliance monitoring data. It is assumed that emissions are consistent throughout the year.

Emissions from Newmont's Martha Mine at Waihi were calculated from 2006 activity data provided by Newmont Waihi Gold[2]. Activities responsible for emissions within the Waihi airshed are:

1. Drilling
2. Blasting
3. Dozing, scraping and grading within the pit
4. Loading trucks
5. Hauling ore from pit to crushers
6. Primary crushing

Activities beyond the Martha Mine pit are outside the airshed and excluded from this investigation. Using the data provided by Newmont, emissions from each of these activities were calculated following the procedures outlined in the Australian NPI emission assessment manual (Environment Australia, 2001). The majority of emissions from the Martha Mine are PM_{10} generated from loading, hauling and crushing ore.

During 2006, a total of 1.7Mt of ore was mined from the Martha pit and most of the activity occurred during spring and summer (Figure 6-1).

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1 http://www.epa.gov/ttn/chief/ap42/index.html

2 Spreadsheets provided by Peter Carruthers and saved to EWdocs#1170916; EWdocs#1170914; and EWdocs#1171142.

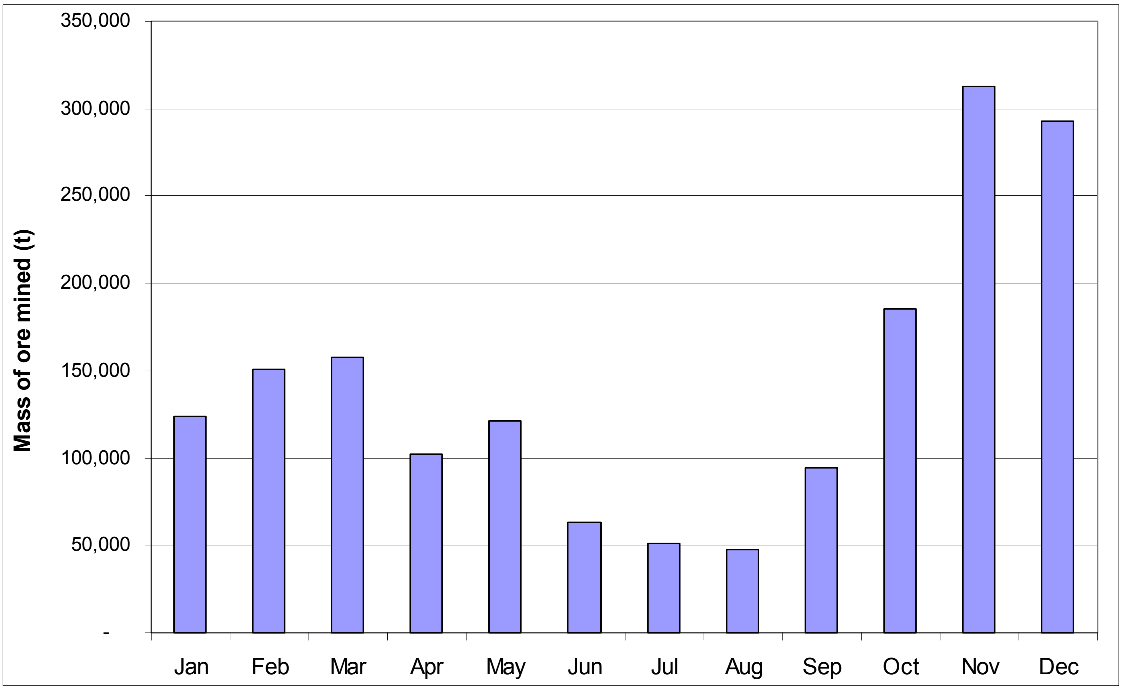

Figure 6-1: Mass of ore mined at Newmont Waihi Gold's Martha Mine, during 2006.

To mitigate dust emissions, water is applied by water cart and sprays during dry working days at the mine. Following Environment Australia's (2001) procedures, PM_{10} emission estimates were therefore reduced by 50 per cent to account for this control technology.

6.2 Industrial and commercial emissions

6.2.1 Matamata

Around 1.4 kilograms of PM_{10} per day were estimated to be emitted to air in Matamata from industrial and commercial activities during the winter of 2006 (Table 6-2)[3]. The industrial and commercial emissions at Matamata are relatively minor, because the sources in this category are restricted to four schools using coal for winter heating.

Table 6-2: Summary of daily industrial/ commercial emissions at Matamata, Putaruru and Waihi during winter

		PM_{10}		$PM_{2.5}$		CO		NOx	
	Hectares	kg	g ha^{-1}	kg	g ha^{-1}	kg	g ha^{-1}	kg	g ha^{-1}
Matamata	451	1.4	3.2	0.9	2.0	2.5	5.6	2.2	4.9
Putaruru	331	136.4	412.1	83.7	252.9	750.2	2266.5	85.2	257.4
Waihi	606	129.0	212.9	19.5	32.2	28.8	47.5	103.1	170.1

		SOx		VOC		CO_2	
	Hectares	kg	g ha^{-1}	kg	g ha^{-1}	t	kg ha^{-1}
Matamata	451	6.2	13.8	0.1	0.1	1.1	2.5
Putaruru	331	44.3	133.8	9.6	29.0	111.0	335.3
Waihi	606	1.7	2.8	10.0	16.5	1.8	3.0

6.2.2 Putaruru

Industrial and commercial discharges contributed around 177 kilogram of PM_{10} to air within Putaruru per day during July (Table 6-2). The main sources of these emissions are from activities at Carter Holt Harvey's timber manufacturing site and Rapid

[3] Emission estimates based on July values

Minerals' lime processing plant. A relatively minor contribution of PM_{10} is also from the burning of coal in school boilers.

Industry also contributes 85 kilograms of NOx and 44 kilogram of SOx per day during winter in Putaruru (Table 6-2).

6.2.3 Waihi

Around 129 kilograms of PM_{10} are estimated to be emitted to air from industrial and commercial activities within Waihi per day (Table 6-2). While there is a contribution of PM_{10} from the burning of coal in school boilers, the majority of the industrial emissions in Waihi are from Newmont Waihi Gold's Martha Mine.

The PM_{10} from Martha Mine is chiefly a component of fugitive dust emissions from mining and hauling of ore from the pit to crushers.

It is recognised that there is considerable uncertainty of emission factors used for estimating fugitive PM_{10} emissions at mine sites and "the numbers generated could be considered as a guess or at best, order of magnitude estimates only" (DEP, 1999). Caution therefore needs to be exercised in drawing firm conclusions regarding the industrial emissions at Waihi, and for this report they should be regarded as best estimates only.

Due to the seasonal nature of activity at the Martha Mine during 2006 (Figure 6-1), the maximum PM_{10} emissions occurred in November and are estimated at 806 kg/day (Figure 6-2). Industrial emissions were around seven times lower during winter 2006.

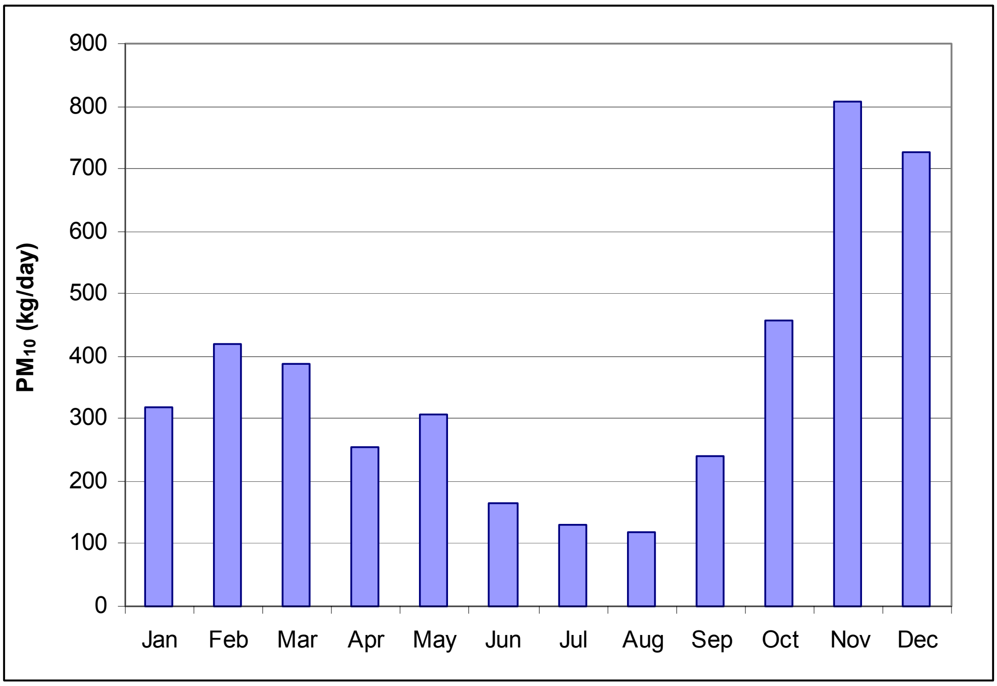

Figure 6-2: Daily PM_{10} emissions from industrial activities in Waihi during 2006.

Industry also contributes 103 kilograms of NOx per day during the winter in Waihi (Table 6-2). SOx emissions are much lower due to the reduction of sulphur in diesel that was mandated by central government and implemented throughout New Zealand in January 2006.

7 Outdoor burning

The burning of household or garden wastes outdoors in a drum, incinerator or open air can result in emissions to air of key air contaminants, including PM_{10}. Emissions from outdoor burning can contribute to ambient concentrations of these contaminants and cause localised health and nuisance problems. In some urban areas of New Zealand outdoor burning is prohibited because of these impacts. Presently emissions from outdoor burning of garden waste are permitted by the Waikato Regional Plan, subject to compliance with conditions that essentially control nuisance.

7.1 Methodology

Data on the frequency and extent of outdoor rubbish burning in Matamata, Putaruru and Waihi was collected using the household survey described in section 3.1. Survey results showed that outdoor burning was carried out by around nine per cent of households in Matamata, eight per cent of households in Putaruru and 15 per cent of households in Waihi.

Following anecdotal evidence and data collected in Otago (ESR, 1999), a material density of 75 kg m^{-3} was assumed. Based on this assumption, survey data were then converted to kilograms of material burnt and emissions were calculated using the emission factors in Table 7-1.

Table 7-1: Outdoor burning emission factors (USEPA AP42, 2001)

	PM_{10} (g/kg)	$PM_{2.5}$ (g/kg)	CO (g/kg)	NOx (g/kg)	SOx (g/kg)	VOC (g/kg)	CO_2 (g/kg)
Open burning - general refuse	8	8	42	3	0.5	4.3	1470

7.2 Emissions from outdoor burning

7.3 Matamata

During the winter it is likely that around 9 kilograms of PM_{10} per day is emitted from outdoor burning in Matamata (Table 7-2). Of this, the majority (93 per cent) is within the finer, $PM_{2.5}$ size fraction. Outdoor burning also produces around 48 kg of carbon monoxide per day during winter.

It should be noted that there are a number of uncertainties relating to this estimation. In particular it is assumed that burning is carried out evenly throughout the winter, whereas it is likely that a greater amount of domestic outdoor burning is carried out during weekend days. Thus on some days no PM_{10} from outdoor burning may occur and on other days it might be many times the daily estimate in this assessment.

Table 7-2: Seasonal variations in outdoor burning emissions in Matamata

	PM_{10} (kg/day)	$PM_{2.5}$ (kg/day)	CO (kg/day)	NOx (kg/day)	SOx (kg/day)	VOC (kg/day)	CO_2 (t/day)
January	9	9	47	3	1	5	2
February	9	9	47	3	1	5	2
March	10	10	52	4	1	5	2
April	10	10	52	4	1	5	2
May	10	10	52	4	1	5	2
June	9	9	48	3	1	5	2
July	9	9	48	3	1	5	2
August	9	9	48	3	1	5	2
September	10	10	51	4	1	5	2
October	10	10	51	4	1	5	2
November	10	10	51	4	1	5	2
December	9	9	47	3	1	5	2
Total (kg/yr)	**3435**	**3435**	**18035**	**1288**	**215**	**1837**	**631**

7.4 Putaruru

In Putaruru, outdoor burning is estimated to contribute around 4 kg of PM_{10} per day during the winter months (Table 7-3).

As with Matamata, there are a number of uncertainties relating to this estimation. In particular it is assumed there is no daily variation of burning throughout the winter, whereas it is likely that a greater amount of burning is carried out during weekend days. Thus on some days no PM_{10} from outdoor burning may occur and on other days it might be many times the amount estimated in this assessment.

Table 7-3: Seasonal variations in outdoor burning emissions in Putaruru

	PM_{10} (kg/day)	$PM_{2.5}$ (kg/day)	CO (kg/day)	NOx (kg/day)	SOx (kg/day)	VOC (kg/day)	CO_2 (t/day)
January	5	5	25	2	0	3	1
February	5	5	25	2	0	3	1
March	4	4	23	2	0	2	1
April	4	4	23	2	0	2	1
May	4	4	23	2	0	2	1
June	4	4	23	2	0	2	1
July	4	4	23	2	0	2	1
August	4	4	23	2	0	2	1
September	5	5	26	2	0	3	1
October	5	5	26	2	0	3	1
November	5	5	26	2	0	3	1
December	5	5	25	2	0	3	1
Total (kg/yr)	**1677**	**1677**	**8803**	**629**	**105**	**897**	**308**

7.5 Waihi

Outdoor burning is estimated to contribute around 7 kilograms of PM_{10} per day in Waihi during the winter months on average (Table 7-4).

However, as with Matamata and Putaruru, there are a number of uncertainties relating to this estimation. Most noteworthy is the assumption that there is no daily variation of burning throughout the winter, whereas it is likely that a greater amount of burning is carried out during weekend days. Thus on some days no PM_{10} from outdoor burning may occur and on other days it might be many times the amount estimated in this assessment.

Table 7-4: Seasonal variations in outdoor burning emissions in Waihi

	PM_{10} (kg/day)	$PM_{2.5}$ (kg/day)	CO (kg/day)	NOx (kg/day)	SOx (kg/day)	VOC (kg/day)	CO_2 (t/day)
January	5	5	28	2	0	3	1
February	5	5	28	2	0	3	1
March	5	5	29	2	0	3	1
April	5	5	29	2	0	3	1
May	5	5	29	2	0	3	1
June	7	7	37	3	0	4	1
July	7	7	37	3	0	4	1
August	7	7	37	3	0	4	1
September	6	6	31	2	0	3	1
October	6	6	31	2	0	3	1
November	6	6	31	2	0	3	1
December	5	5	28	2	0	3	1
Total (kg/yr)	**2173**	**2173**	**11406**	**815**	**136**	**1162**	**399**

7.6 Other sources of emissions

This inventory includes all likely major sources of PM_{10} that can be adequately estimated using inventory techniques. Other potentially significant sources of emissions not included in the inventory include lithogenic dusts (PM_{10}) and sea spray.

Another source not included in the inventory is vegetation, which can emit VOC and NOx. Neither of these latter contaminants is likely to be an air quality concern and vegetation is unlikely to be a significant source in the predominantly urban areas. A natural emissions inventory for the Waikato Region was prepared in 1999 and includes estimates of emissions from vegetative sources (NIWA, 1999).

Lawn mowers, leaf blowers and chainsaws can also contribute small amounts of particulate. These are not typically included in emission inventory studies owing to the relatively small contribution, particularly in areas where solid fuel burning is a common method of home heating. Based on data for other areas, PM_{10} emissions from lawn mowing in all areas are likely to be less than 1 kilogram per day[4].

8 Total Emissions

8.1 Matamata

Around 229 kilograms of PM_{10} is discharged to air in Matamata on an average winter's[5] day (Table 8-1). This is less than the estimated 361 kilograms per day domestic emissions in 2001 (Wilton, 2001). The reason for the decrease in emissions might be due to change in home heating methods: the percentage of households using electricity has increased from 29 percent in 2001 to 53 percent in 2006. Moreover, the percentage of households reporting burning wood has decreased to 39 per cent from 49 per cent in 2001.

PM_{10} monitoring in Matamata was initiated in June 2005 and the highest recorded 24 hour concentration of 34 µg m^{-3} is well below the NES limit of 50 µg m^{-3}. Due to the decrease in PM_{10} emissions at Matamata since 2001, consideration should be given to discontinuing PM_{10} monitoring in the town if similarly low concentrations are observed in winter 2007.

[4] Pacific Air and Environment (1999) indicates around 0.07 grams of PM_{10} are emitted per household per day for the Wellington Region.

[5] Winter emission estimates are based on July values

The main source of PM_{10} in Matamata is solid fuel burning for domestic home heating, which contributes around 92 per cent of the daily PM_{10} (Figure 8-1). Outdoor burning contributes four per cent of PM_{10} and motor vehicles another four per cent. The contribution of industry to PM_{10} emissions in Matamata is less than one per cent.

Table 8-1: Summary of total daily emissions at Matamata, Putaruru and Waihi during winter

		PM_{10}		$PM_{2.5}$		CO		NOx	
	Hectares	kg	g ha^{-1}	kg	g ha^{-1}	kg	g ha^{-1}	kg	g ha^{-1}
Matamata	451	229	507	217	481	3122	6921	142	316
Putaruru	331	354	1069	285	862	3679	11115	213	644
Waihi	606	346	571	221	364	2745	4530	213	352

		SOx		VOC		CO_2	
	Hectares	kg	g ha^{-1}	kg	g ha^{-1}	t	kg ha^{-1}
Matamata	451	31	68	770	1708	80	178
Putaruru	331	69	208	731	2209	183	553
Waihi	606	24	39	692	1142	69	113

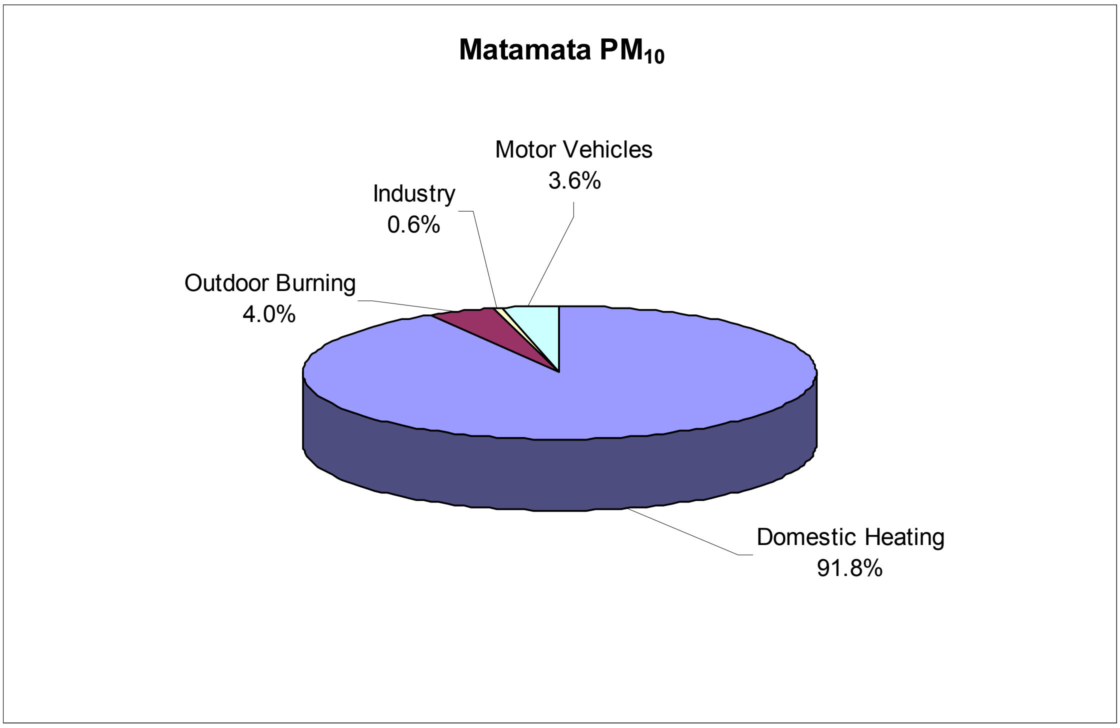

Figure 8-1: Relative contribution of sources to daily winter PM_{10} emissions in Matamata

Table 8-2 shows seasonal variations in PM_{10} emissions. Although domestic home heating is the dominant source of PM_{10} emissions during the winter months, during the summer, motor vehicles and outdoor burning are the dominant contributors to PM_{10} emissions. However, the total mass of PM_{10} from vehicles is always relatively low at 8 kg/day.

Table 8-2: Monthly variations in daily PM_{10} emissions in Matamata

	Domestic Heating		Outdoor Burning		Industry		Motor Vehicles		TOTAL
	(kg/day)	%	(kg/day)	%	(kg/day)	%	(kg/day)	%	(kg/day)
January	1	8%	9	48%	0.0	0.0%	8	44%	19
February	1	8%	9	48%	0.0	0.0%	8	44%	19
March	1	8%	10	51%	0.0	0.0%	8	42%	20
April	22	55%	10	25%	0.0	0.0%	8	21%	40
May	113	85%	10	8%	1.4	1.1%	8	6%	132
June	198	91%	9	4%	1.4	0.7%	8	4%	217
July	210	92%	9	4%	1.4	0.6%	8	4%	229
August	194	91%	9	4%	1.4	0.7%	8	4%	213
September	61	76%	10	12%	1.4	1.8%	8	10%	80
October	9	33%	10	34%	1.4	5.0%	8	29%	29
November	0	0%	10	54%	0.0	0.0%	8	46%	18
December	0	0%	9	52%	0.0	0.0%	8	48%	17
Total (kg/yr)	**24,882**		**3,435**		**263**		**3,022**		**31,603**

8.2 Putaruru

Around 354 kilograms of PM_{10} is discharged to air in Putaruru on an average winter's day (Table 8-1). Domestic heating contributes 58 per cent of PM_{10} emissions in Putaruru during winter (Figure 8-2), which is less than most areas of the Waikato that typically show at least 80 per cent from domestic home heating. Industry contributes 39 per cent of winter PM_{10} emissions at Putaruru and the main industrial sources are timber processing at CHH Timber and lime processing at Rapid Minerals.

Motor vehicle and outdoor burning of waste contribute 2 per cent and 1 per cent respectively of PM_{10} emissions during winter. In summer, domestic heating activity is negligible and industry contributes 89 per cent of PM_{10} emissions (Table 8-3).

While industry contributes 39 per cent of winter time PM_{10} emissions at Putaruru, the industrial contribution to ambient PM_{10} concentrations will be lower. This is because the industrial stacks are much higher than household chimneys and will disperse PM_{10} emissions farther and wider than emissions from domestic sources.

In 2001, a domestic heating emissions inventory estimated 175 kilograms of PM_{10} was emitted per day from domestic sources in Putaruru. This is comparable to the estimated 205 kilograms per day from domestic sources in this report. Because industrial emissions are likely to be similar to those in 2001, it is reasonable to assume that total emissions in Putaruru have changed little since 2001.

Continuous survey monitoring of PM_{10} was initiated in July 2006 at Putaruru. This inventory will serve as a benchmark of emissions, to compare with monitoring results and emission inventories in the future.

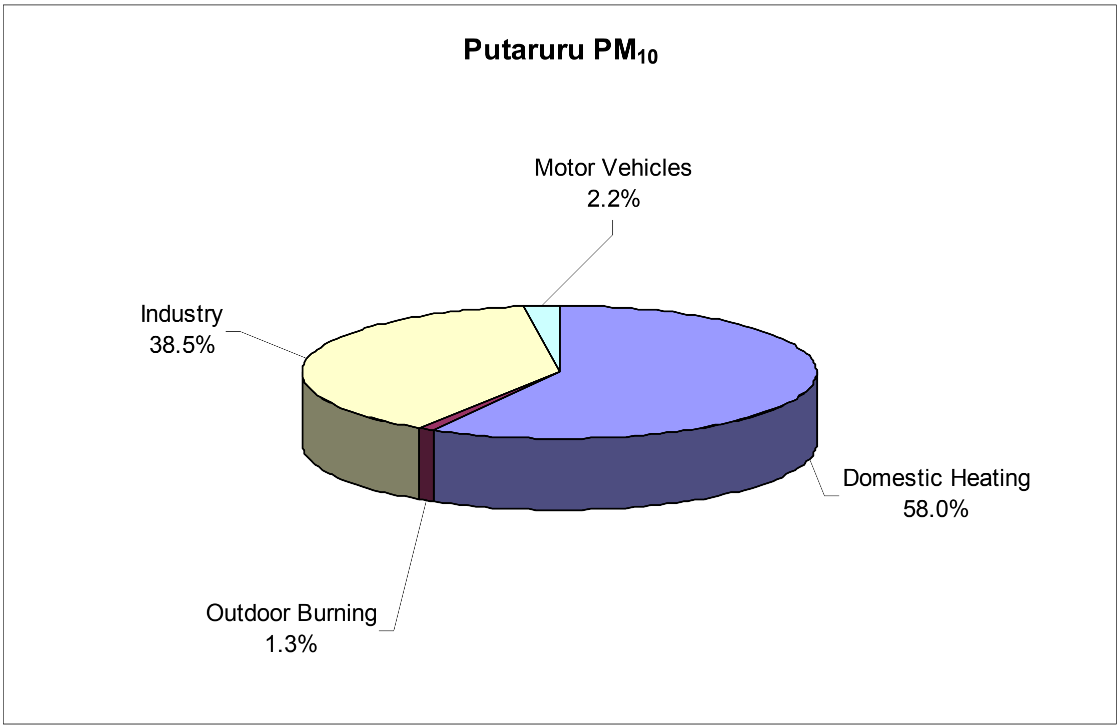

Figure 8-2: Relative contribution of sources to daily winter PM_{10} emissions in Putaruru

Table 8-3: Monthly variations in daily PM_{10} emissions in Putaruru

	Domestic Heating		Outdoor Burning		Industry		Motor Vehicles		TOTAL
	(kg/day)	%	(kg/day)	%	(kg/day)	%	(kg/day)	%	(kg/day)
January	1	1%	5	3%	136	91%	8	5%	149
February	1	1%	5	3%	136	91%	8	5%	149
March	10	6%	4	3%	136	86%	8	5%	157
April	31	17%	4	2%	136	76%	8	4%	179
May	121	45%	4	2%	136	51%	8	3%	269
June	192	56%	4	1%	136	40%	8	2%	341
July	205	58%	4	1%	136	39%	8	2%	354
August	186	56%	4	1%	136	41%	8	2%	335
September	82	35%	5	2%	136	59%	8	3%	230
October	23	13%	5	3%	136	79%	8	4%	172
November	7	4%	5	3%	136	87%	8	5%	155
December	1	1%	5	3%	136	91%	8	5%	149
Total (kg/yr)	**26,358**		**1,677**		**49,626**		**2,810**		**80,472**

8.3 Waihi

During winter, 346 kilograms of PM_{10} is discharged to air in Waihi per day (Table 8-1). Domestic heating contributes 59 per cent of PM_{10} emissions in Waihi during winter (Figure 8-3), which is less than most areas of the Waikato that typically show at least 80 per cent from domestic home heating.

It is estimated that industry contributes 37 per cent of winter PM_{10} emissions at Waihi. However, caution is required due to considerable uncertainty of fugitive emissions from mining activity as described in Section 6.2.3. Therefore, the magnitude of PM_{10} emissions and relative contribution from Waihi industry is uncertain.

Moreover, mining activities at Martha Mine are reducing. Present air emissions at the Martha Mine are associated with the stabilisation of one of the pit walls. This is projected to take up to three years to occur. In the longer term the pit will be filled to form a lake. Whilst the exact date this will occur is yet to be finalised, future emission inventories at Waihi are not likely to include emissions from the Martha Mine. If Martha Mine emissions were excluded from the present analysis, the total discharge of PM_{10} during winter would be 218 kilograms per day and domestic heating would contribute 92 per cent of PM_{10} emissions in winter.

Due to the uncertainty of Martha Mine emissions, the best estimate of present emissions of PM_{10} during winter is somewhere between 218 and 346 kilograms per day. Therefore, the industrial contribution to PM_{10} emissions during winter at Waihi may be considered to be between 0.2 and 37 per cent.

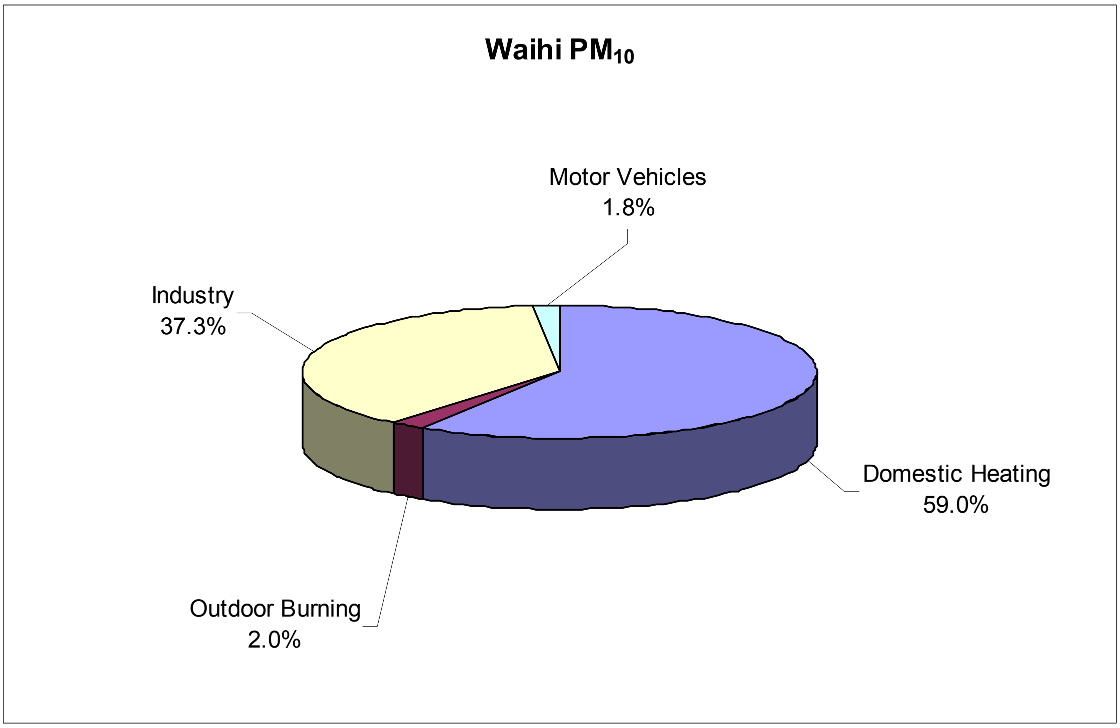

Figure 8-3: Relative contribution of sources to daily winter PM_{10} emissions in Waihi

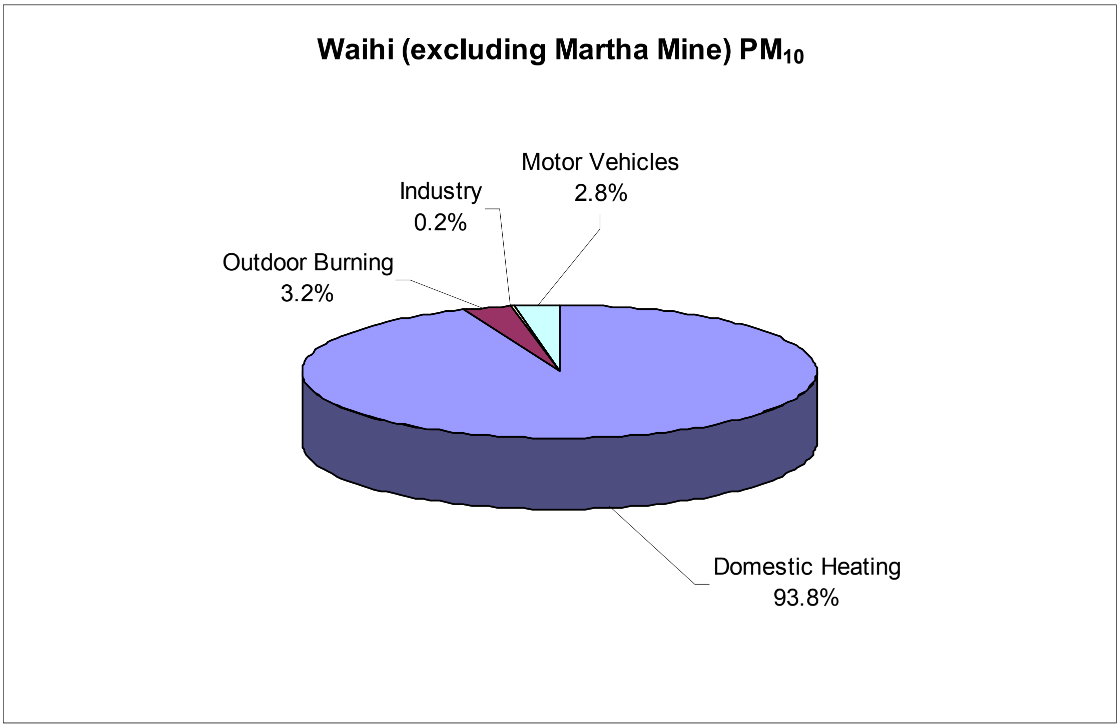

Figure 8-4: Relative contribution of sources to contaminant emissions in Waihi if Martha Mine emissions are excluded

In November 2006, industry was estimated to contribute 806 kilograms of PM_{10} per day and this represents 98 per cent of the total 822 kg/day PM_{10} emissions at Waihi (Table 8-4).

While the estimates of emissions at Waihi are considerable, it is difficult to interpret whether there are likely to be exceedances of the NES for PM_{10} at the town. Compliance monitoring of PM_{10} and total suspended particulates (TSP) by Waihi Gold suggest that NES exceedances due to the mining operation are unlikely to occur, although the record is not comprehensive enough to be entirely definitive. As part of resource consent conditions, Waihi Gold have monitored PM_{10} every third day from January to April and TSP as seven day averages (e.g. Rolfe, 2005). While PM_{10} observations have not been greater than the NES limit of 50 µg m^{-3}, the dataset is not comprehensive enough to be certain that NES exceedances are unlikely at Waihi.

Along with the considerable uncertainty of emission estimates from Martha mine, the discontinuous monitoring records make an interpretation of PM_{10} concentrations difficult. Due to this uncertainty, continuous monitoring is required to investigate whether PM_{10} exceedances are likely at Waihi.

Table 8-4: Monthly variations in daily PM_{10} emissions in Waihi

	Domestic Heating		Outdoor Burning		Industry		Motor Vehicles		TOTAL
	(kg/day)	%	(kg/day)	%	(kg/day)	%	(kg/day)	%	(kg/day)
January	0	0%	5	2%	319	97%	6	2%	330
February	0	0%	5	1%	418	97%	6	1%	430
March	2	1%	5	1%	387	97%	6	2%	401
April	21	7%	5	2%	256	89%	6	2%	289
May	114	26%	5	1%	306	71%	6	1%	432
June	194	52%	7	2%	166	45%	6	2%	373
July	204	59%	7	2%	129	37%	6	2%	346
August	194	60%	7	2%	118	36%	6	2%	325
September	71	22%	6	2%	240	74%	6	2%	323
October	16	3%	6	1%	457	94%	6	1%	485
November	4	0%	6	1%	806	98%	6	1%	822
December	0	0%	5	1%	725	98%	6	1%	737
Total (kg/yr)	**25,139**		**2,173**		**131,444**		**2,239**		**160,995**

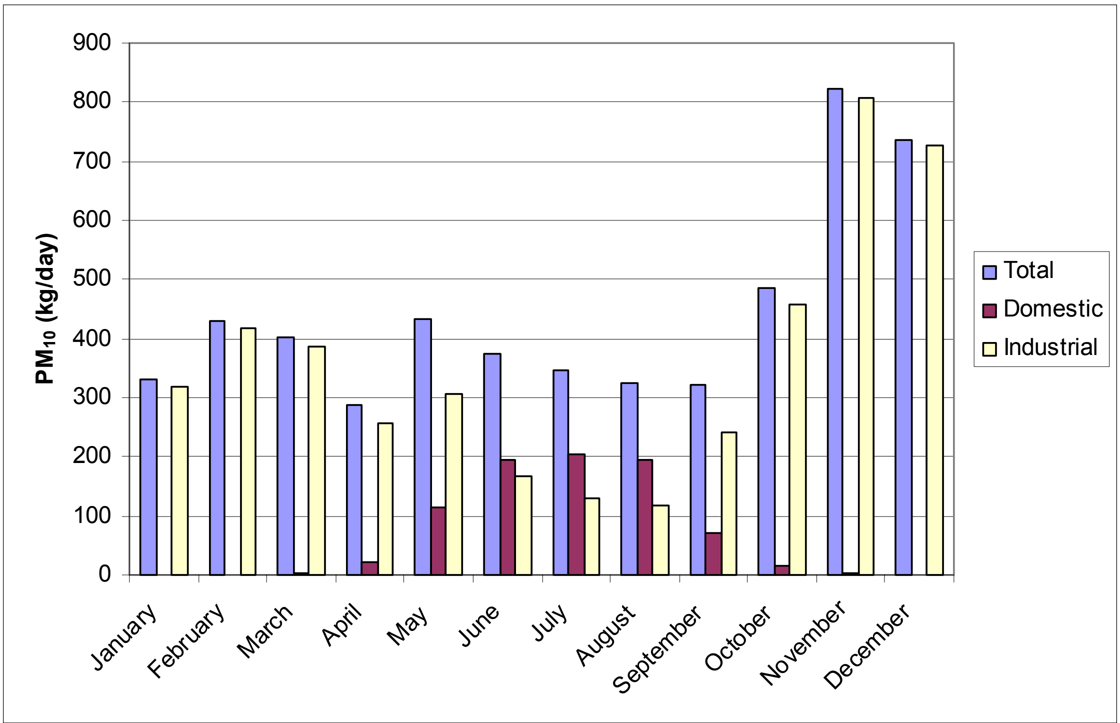

Figure 8-5: Monthly PM_{10} emissions at Waihi during 2006, showing relative contributions of domestic and industrial sources

9 Summary and conclusion

This report outlines the results of an air emission inventory carried out in the areas of Matamata, Putaruru and Waihi, with a focus on emissions of PM_{10}. Sources included in the inventory were: domestic heating, motor vehicles, industrial and commercial activities, and outdoor rubbish burning.

The main source of PM_{10} emissions in all three areas during the winter was domestic home heating, which accounted for 92, 58 and 59 per cent of total emissions in

Matamata, Putaruru and Waihi respectively. PM_{10} emissions of 229, 354 and 346 kilograms per day in winter were estimated for each town respectively.

It is estimated that industry contributes 39 per cent of winter PM_{10} emissions in Putaruru, and the main industrial sources are CHH timber plant and Rapid Mineral's lime processing operation. The industrial contribution to contaminant concentrations in Putaruru is likely to be much less than the contribution to emissions because industrial discharge is via high stacks that promote more effective dispersion of contaminants.

In Waihi, there is considerable uncertainty of fugitive emissions from the Martha Mine pit, however the best estimate is that 37 per cent of winter emissions are from industry. PM_{10} emissions at Waihi in summer may be as high as 806 kilograms per day which is around twice those in winter. However, the summer emissions are dominated by industrial discharges and the uncertainty makes it very difficult to accurately interpret the results. When discontinuous compliance monitoring data are considered in light of the best estimates of emissions, continuous monitoring of PM_{10} is recommended at Waihi.

While survey monitoring has only recently commenced in Putaruru, PM_{10} concentrations in Matamata have been relatively low since monitoring began there in June 2005. There has been a decrease in estimated PM_{10} emissions at Matamata since 2001, so cessation of PM_{10} monitoring in the town would be justified if similarly low concentrations are observed in winter 2007.

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Appendix 1: Home Heating Questionnaire

1. Good morning / afternoon/evening - Is this a home or business number?(- terminate if business)
Hi, I'm _________from DigiPoll and I am calling on behalf of the Environment Waikato
May I please speak to an adult in your household who knows about your home heating systems? We are currently undertaking a survey in your area on methods of home heating. We wish to know what you use to heat your main living area during a typical year. The survey will take about 5 minutes. Is it a good time to talk to you now?

2.(a) Do you use any type of electrical heating in your MAIN living area during a typical year?

(b) What type of electrical heating do you use? Would it be...

- ☐ Night Store
- ☐ Radiant
- ☐ Portable Oil Column
- ☐ Panel
- ☐ Fan
- ☐ Heat Pump
- ☐ Don't Know/Refused
- ☐ Other (specify)

(c). Do you use any other heating system in your main living area in a typical year? *(If yes then question 3 otherwise Q9)*

3.(a) Do you use any type of gas heating in your MAIN living area during a typical year? *(If No then question 4)*

(b) Is it flued or unflued gas heating? If necessary: (A flued gas heating appliance will have an external vent or chimney)

(c) Which months of the year do you use your gas burner

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(d) How many days per week would you use your gas burner during

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(e) Do you use mains or bottled gas for home heating?

(f) What size gas bottle do you use?

(f.2) How many times in a winter would you refill your x kg gas bottle? Interviewer: Winter is defined as May to August inclusive.

4.(a) Do you use a log burner in your MAIN living area during a typical year? (This is a fully enclosed burner but does not include multi fuel burner i.e., those that burn coal) (If No then question 5)

(b) Which months of the year do you use your log burner

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(c) How many days per week would you use your log burner during?

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(d) How old is your log burner?

(e) In a typical year, how many pieces of wood do you use on an average winters day? Interviewers note: winter is defined as May to August inclusive.

(f) Ask only If they used their log burner during non winter months How many pieces of wood do you use per day during the other months? Interviewers note: winter is defined as May to August inclusive.

(g) In a typical year, how much wood would you use per year on your log burner? (record wood use in cubic metres - note 1 cord equals 3.6 cubic meters of loosely piled blocks, one trailer equals about 1.65 cubic metres without cage, or 2.2 with cage)

(h) Do you buy wood for your log burner, or do you receive it free of charge?

(i) What proportion would be bought?

5.(a) Do you use an enclosed burner which burns coal as well as wood – i.e., a multi fuel burner in your MAIN living area during a typical year? (This includes incinerators, pot belly stoves, McKay space heaters etc but does not include open fires.) (If No then question 6)

(b) Which months of the year do you use your multi fuel burner?

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(c) How many days per week would you use your multi fuel burner during?

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(d) How old is your multi fuel burner?
(e) What type of multi fuel burner is it?
(f) In a typical year, how much wood do you use on your multi fuel burner per day during the winter? (ask them how many pieces of wood (logs) they use on an average winters day) Interviewer: Winter is defined as May to August inclusive
(g) ask only If they used their multi fuel burner during non winter months How much wood do you use per day during the other months?
(h) In a typical year, how much wood would you use per year on your multi fuel burner?_____ (record wood use in cubic metres - note 1 cord equals 3.6 cubic meters of loosely piled blocks one trailer equals about 1.65 cubic metres without cage, or 2.2 with
(i) Do you use coal on your multi fuel burner?
(j) How many buckets of coal do you use per day during the winter? (how many buckets of coal used on an average winters day) Interviewer: Winter is defined as May to August inclusive.
(k) Ask only If they used their multi fuel burner during non winter months How much coal do you use per day during the other months?
(l) Do you buy wood for your multi fuel burner, or do you receive it free of charge?
(m) What proportion would be bought?

6.(a) Do you use an open fire (includes a visor fireplace which is one enclosed on three sides but open to the front) in your MAIN living area during a typical year? *(If No then question 7)*
(b) Which months of the year do you use your open fire

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(c) How many days per week would you use your open fire during?

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(d) Do you use wood on your open fire?
(e) On a typical year, how much wood do you use per day during the winter? (ask them how many pieces of wood (logs) they use on an average winters day) Interviewer: Winter is defined as may to August inclusive
(f) Ask only If they used their open fire during non winter months How much wood do you use per day during the other months?
(g) In a typical year, how much wood would you use per year on your open fire? (record wood use in cubic metres - note 1 cord equals 3.6 cubic meters of loosely piled blocks one trailer equals about 1.65 cubic metres without cage, or 2.2 with cage)
(h) Do you use coal on your open fire?
(i) How many buckets of coal do you use per day during the winter? (how many buckets of coal used on an average winters day)____ Interviewer: Winter is defined as may to August inclusive
(j) Ask only If they used their open fire during non winter months How much coal do you use per day during the other months?
(k) Do you buy wood for your open fire, or do you receive it free of charge?
(l) What proportion would be bought?

7.(a) Do you use a pellet burner in your MAIN living area during a typical year? *(If No then question 8)*
(b) Which months of the year do you use your pellet burner

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(c) How many days per week would you use your pellet burner during?

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(d) How old is your pellet burner?
(e) What make and model is your pellet burner? First, can you tell me the make?
(e) and what model is your pellet burner?
(f) In a typical year, how many kilograms of pellets do you use on an average winters day? Interviewers note : winter is defined as May to August inclusive.
(g) Ask only If they used their pellet burner during non winter months How many kgs of pellets do you use per day during the other months? Interviewers note: winter is defined as May to August inclusive.
(h) In a typical year, how many kilograms of pellets would you use per year on your pellet burner?

8.(a) Do you use any other heating system in your MAIN living area during a typical year? *(If No then question 9)*
(b) What type of heating system do you use (if they respond with diesel or oil burner go to question c otherwise go to Q8)
(c) Which months of the year do you use your oil burner

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(d) How many days per week would you use your diesel/oil burner during?

☐ Jan	☐ Feb	☐ March	☐ April	☐ May	☐ June
☐ July	☐ Aug	☐ Sept	☐ Oct	☐ Nov	☐ Dec

(e) How much oil do you use per year?

9. Do you burn rubbish or garden waste outside in the open or in an incinerator or rubbish bin

How many days would you burn rubbish outdoors during

a) winter (June, July, August)

b) spring (September, October, November)

c) summer (December, January, February)

d) autumn (March, April, May)

How much garden waste or rubbish would you burn each session. We are looking for cubic metres, or number of wheelbarrows full per fire.

10. Does you home have insulation?

- Ceiling
- Under floor
- Wall
- Cylinder wrap
- Double glazing
- None
- Don't know
- Other

DEMOGRAPHICS We would like to ask some questions about you now, just to make sure we have a cross-section of people for the survey. We keep this information strictly confidential.

D1. Would you mind telling me in what year you were born?

D2. Which of the following describes you and your household situation?

- Single person below 40 living alone
- Single person 40 or older living alone
- Young couple without children
- Family with oldest child who is school age or younger
- Family with an adult child still at home
- Couple without children at home
- Flatting together
- Boarder

D3 With which ethnic group do you most closely relate?

Interviewer: tick gender.

How many people live at your address?

Do you own your home or rent it?

D5 What is your employment status:

Thank you for your time today. Your answers will be very helpful. In case you missed it, my name is ---------- from DigiPoll in Hamilton. Have a nice day/evening.

Appendix 2: Emission factors for domestic heating.

Emission factors for domestic heating were those used in the Ministry for the Environment's (2005) assessment of burner removals to meet the NES in 31 urban areas of New Zealand. With the exception of gas, oil and post 1990 wood burners, these were based largely on the review of New Zealand emission rates carried out for the Christchurch 1999 emission inventory with adaptations made for different burner age categories. The latter review resulted in revised factors for open fires burning wood and the burning of coal on open fires and multi fuel burners. The open fire wood emission factor was reduced from 15 g/kg (used in previous inventories) to 10 g/kg. This was based on a combination of overseas literature, in particular the studies by Stern (1992) and Dasch (1982), and the results of a limited number of tests carried out in New Zealand. The New Zealand tests were carried out by Applied Research and gave emission rates of around 7 g/kg.

An emission factor of 22 g/kg was selected for coal burning on an open fire and was based on the average of the tests carried out in New Zealand, weighted for the more predominant use of bituminous coals, based on the 80 per cent to 20 per cent figures quoted by Hennessy (1999). Previous emission factors were around 33 g/kg. An emission factor for PM_{10} for multi fuel burners burning coal of 28 g/kg was selected based on a weighted average of the test results available for different appliance types.

Emission factors for the post 1995 wood burner categories were based on data collected in Nelson on burner types in different age categories. Gas and oil emission factors were based on factors derived by Angie Scott (pers comm., 2004) based on more recent testing of these appliances.

Domestic heating emission factors for CO, NOx, SOx and CO_2 for all but post 1995 burners were also based on the Christchurch 1999 emission factor revisions.

Emission factors for $PM_{2.5}$ data for the burning of wood are based on the assumption that 100 per cent of the PM_{10} emissions are $PM_{2.5}$ (USEPA, 1997). For coal burning USEPA AP-42 generalised particle size distributions for the $PM_{2.5}$ component were used. Oil burning emission rates were based on AP-42 data for a utility boiler. No data for LPG gas use was available so it was assumed that 100 per cent of the PM_{10} would be in the finer $PM_{2.5}$ size fraction, based on AP-42 data for natural gas.