Environment Waikato Technical Report 2008/02

Air Emission Inventory – Tokoroa and Te Kuiti 2007

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

Environment Waikato
REGIONAL COUNCIL

Prepared by:
Emily Wilton and Melanie Baynes
Environet Ltd
130b Montreal Street
Christchurch

For:
Environment Waikato
PO Box 4010
HAMILTON EAST

October 2007

Document #: 1268105

Peer reviewed by:
Nick Kim Date February 2008

Approved for release by:
Dr Vivienne Smith Date February 2008

Disclaimer

This technical report has been prepared for the use of Waikato Regional Council as a reference document and as such does not constitute Council's policy.

Council requests that if excerpts or inferences are drawn from this document for further use by individuals or organisations, due care should be taken to ensure that the appropriate context has been preserved, and is accurately reflected and referenced in any subsequent spoken or written communication.

While Waikato Regional Council has exercised all reasonable skill and care in controlling the contents of this report, Council accepts no liability in contract, tort or otherwise, for any loss, damage, injury or expense (whether direct, indirect or consequential) arising out of the provision of this information or its use by you or any other party.

Table of Contents

List of Figures

List of Tables

Executive summary

Air quality monitoring in Tokoroa and Te Kuiti has shown that concentrations of PM_{10} breach the National Environmental Standard (NES) for air quality regularly during winter months. The NES is set at 50 µg m^{-3} (24-hour average), which can be exceeded only once per year. The Waikato Regional Plan sets a more stringent target for PM_{10} of 33 µg m^{-3} (24-hour average).

The highest measured PM_{10} concentration for Tokoroa is 75 µg m^{-3}, which was measured during 2001. Recent measurements have recorded higher values but significant concerns exist about the accuracy of the monitoring equipment during these times (Smith, 2006). An evaluation of recent data estimates a higher maximum PM_{10} concentration for Tokoroa is likely but indicates that an assumed maximum of around 75 µg m^{-3} is reasonable for air quality management purposes (Kim, 2007). For Te Kuiti, the highest measured PM_{10} level is 69 µg m^{-3} and was measured in 2006.

Previous emission inventory assessments for Tokoroa and Te Kuiti suggest that the main source of PM_{10} during winter months was solid fuel burning used for domestic home heating. This report outlines the results of an air emissions inventory for Tokoroa and Te Kuiti for 2007.

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 it is the only contaminant in breach of the NES in Tokoroa and Te Kuiti.

Domestic heating, motor vehicles, industrial and commercial activities and outdoor burning are the sources of PM_{10} which were included in the emissions inventory.

A domestic home heating survey was carried out for Tokoroa and Te Kuiti to determine the proportions of households using different heating methods and fuels. Tokoroa results show that wood burners are the most common method of heating in the main living area with 45 per cent of households using them. Thirty three percent of householders use electricity as the main form of heating and 23 per cent of householders use gas to heat their main living area. Many households used more than one method to heat the main living area of their home.

Te Kuiti results show that wood burners are the most common method of heating in the main living area with 45 per cent of households using them. Forty two percent of householders use electricity to as their main form of heating and 20 per cent of householders use gas to heat their main living area. As with Tokoroa many households in Te Kuiti used more than one method to heat the main living area of their home.

The main source of PM_{10} emissions for Tokoroa was domestic home heating, which accounted for 86 per cent of total emissions. Other sources in Tokoroa included motor vehicles (seven percent) industry (one percent) and outdoor burning (six percent). In Te Kuiti the main source was domestic heating (67 per cent). The industry contribution was higher than at Tokoroa, at 20 per cent, and motor vehicles and outdoor burning contributed seven percent and five percent respectively.

The industrial contribution to measured PM_{10} concentrations may be less because of the additional dispersion associated with the higher discharge heights of most industrial chimneys and the locations of industry on the outskirts of the Te Kuiti township.

1 Introduction

Air quality in Tokoroa and Te Kuiti exceeds the National Environmental Standard (NES) and air quality target specified in the Regional Plan of 33 µg m^{-3} (24-hour average) regularly during winter months.

Air quality monitoring for PM_{10} has been carried out in Tokoroa each year since 2001. The highest measured PM_{10} concentration for Tokoroa is 75 µg m^{-3} and was measured during 2001. Some more recent measurements have recorded higher values but significant concerns exist about the accuracy of the monitoring equipment during these times (Smith, 2006). An evaluation of recent data estimates a higher maximum PM_{10} concentration for Tokoroa is likely but indicates that an assumed maximum of around 75 µg m^{-3} is reasonable for air quality management purposes (Kim, 2007). Concentrations of PM_{10} in Tokoroa have been in breach of the NES of 50 µg m^{-3} for between nine and 41 days.

Continuous air quality monitoring for PM_{10} has been carried out in Te Kuiti since May 2003 using an FH62 beta attenuation PM_{10} monitor. The highest measured PM_{10} level was measured during 2006 and is 69 µg m^{-3}. Concentrations of PM_{10} in Te Kuiti have been in breach of the NES between two and six days per year.

If the NES is not met by 2013, Environment Waikato will be unable to grant resource consents for discharges to air in non-compliant airsheds. In addition, between September 2005 and 2013 consents for discharges to air can be granted only if councils can demonstrate that the granting of the consent will not impinge on the “straight-line path” to compliance.

One important tool in tracking compliance with the straight-line path and assessing the probability of achieving the reductions predicted is an air emission inventory. An emissions inventory was prepared for Tokoroa in 2004 (Wilton 2004) and domestic heating emissions were estimated again during 2005 and revised estimates of the relative contribution were made (Wilton, 2005c). This data was used to evaluate the effectiveness of different management options in achieving reductions in PM_{10} emissions in Tokoroa initially for the air plan (Wilton, 2006) and more recently to meet the requirements of the NES (Wilton, 2007).

In Te Kuiti, estimates of emissions from different sources have been made at different times. Industrial and motor vehicle emissions were estimated in 1997 (Noonan, 1997). Domestic heating emissions were also estimated in 1997, 2001 and more recently in 2004 as a part of the Ministry for the Environment’s “warm homes” project.

This report details the results of an updated air emission inventory carried out for Tokoroa and Te Kuiti for 2007. The inventory provides an estimate of the amount of PM_{10} discharged into the air in a worst-case situation and an average winter’s night, and the relative contribution from different sources.

2 Inventory Design

The project has been designed with a focus on emissions of PM_{10}, because air quality monitoring shows this is the main issue of concern in Tokoroa and Te Kuiti. Concentrations of other contaminants are unlikely to exceed air quality guidelines and the NES. 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.

2.1 Selection of sources

The inventory includes detailed estimates of emissions from domestic heating, motor vehicles, industry and outdoor burning. Emissions from a number of other minor sources are also discussed in the report.

2.2 Selection of contaminants

The inventory included an assessment of emissions of suspended 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 are in the NES because of their potential for adverse health impacts. Carbon dioxide has been typically included in emission inventory investigations in New Zealand to allow for the assessment of regional greenhouse gas CO_2 emissions. However, these data are now generally collected nationally and for a broader range of greenhouse gases. Estimates of CO_2 have been retained in the inventory but readers should be directed to national statistics (e.g., www.climatechange.govt.nz.) if detailed data on this source is required. The finer $PM_{2.5}$ size fraction was 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. Ozone formation is unlikely to be a key concern for Tokoroa and Te Kuiti. In this report, VOC emissions have been estimated for existing sources but data on emissions from VOC specific sources (e.g., spray painting) has not been included.

2.3 Selection of areas

The Tokoroa and Te Kuiti inventory study areas ("airsheds") are the airshed areas that are gazetted by the Ministry for the Environment. Previous air emission inventories for these areas were based on census area units. Figure 2.1 and 2.2 illustrate the current inventory boundary based on the airshed boundary, the previous inventory based on census area units, and also the urban area boundary used for other planning purposes.

The census area units used in the previous air emission inventories for Tokoroa and Te Kuiti were as follows:

- Tokoroa: Paraonui, Parkdale, Matarawa, Stanley Park, Tokoroa Central, Aotea, and Strathmore.
- Te Kuiti.

The industrial assessment excludes emissions from Kinleith pulp and paper mill, as these were considered unlikely to significantly impact on PM_{10} concentrations in Tokoroa (Wilton, 2005b) and are outside the Tokoroa airshed.

2.4 Temporal distribution

Data were collected based on daily data with some seasonal variations. Domestic heating data were collected based on average and worst-case wintertime scenarios and by month of the year. Motor vehicle data were collected for an average day, as models do not contain seasonal variations in vehicle movements. Industrial data were collected by season, as was outdoor burning data.

No differentiation was made for weekday and weekend sources.

Limited time-of-day breakdowns were obtained for the data.

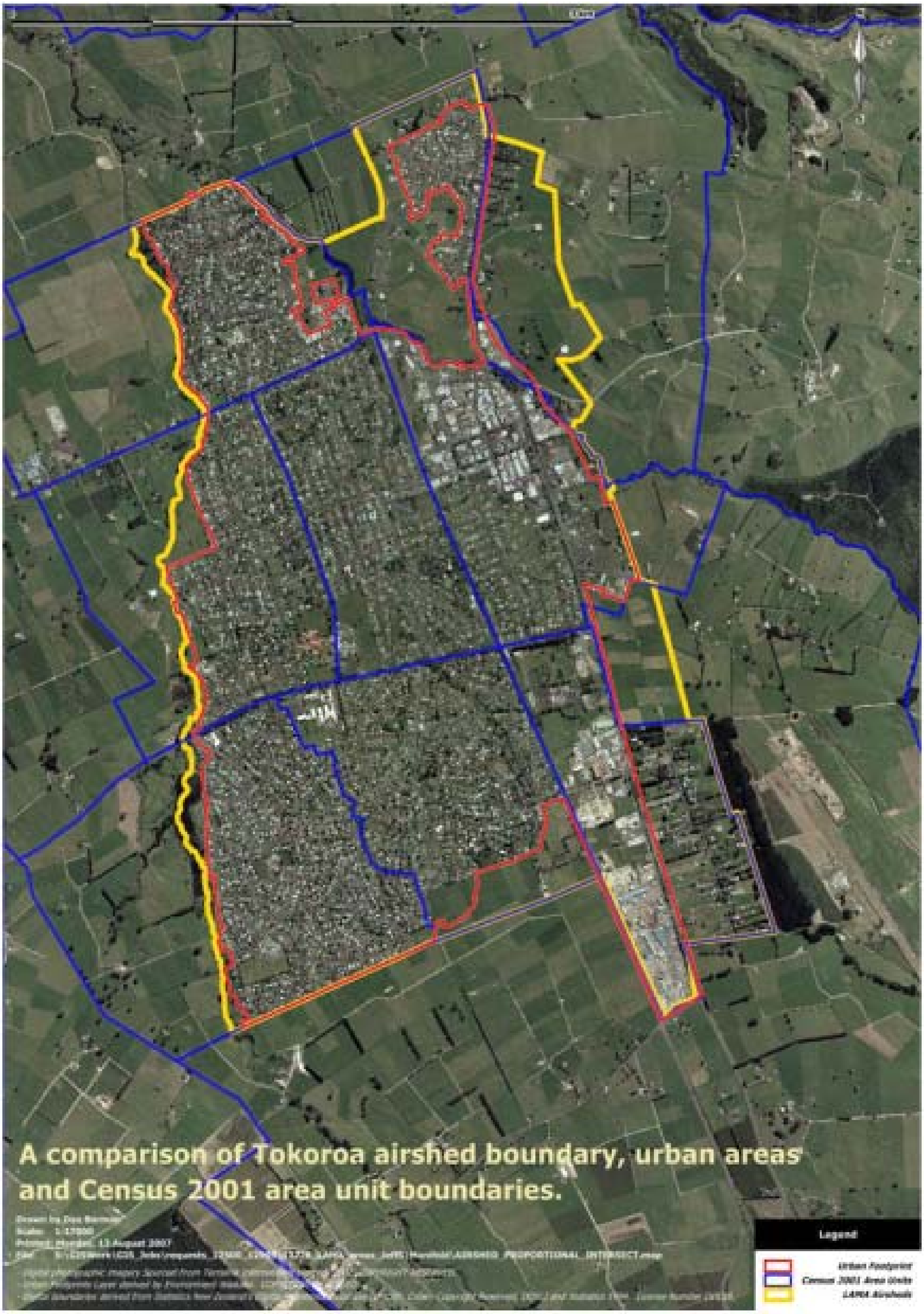

Figure 2-1: **Tokoroa airshed boundary, urban areas and census area unit boundaries.**

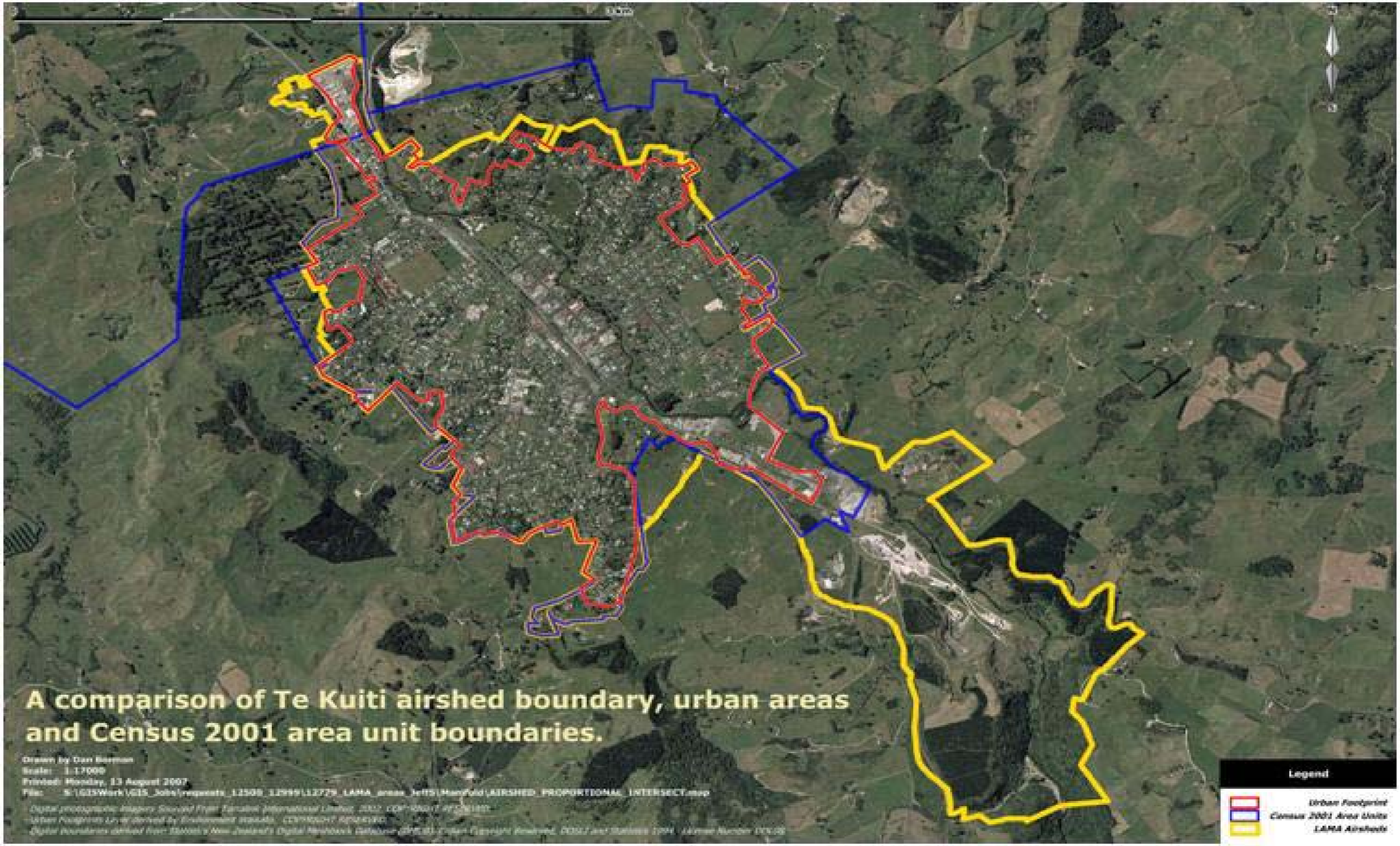

Figure 2-2: Te Kuiti airshed boundary, urban areas and census area unit boundaries.

3 Domestic heating

3.1 Methodology

Information on domestic heating methods and fuel use was collected using a household survey carried out by Digipol during August and September 2007 (Appendix A). A telephone survey of 370 households for Tokoroa and 324 households in Te Kuiti was undertaken. The survey areas were the airsheds detailed in Figures 2.1 and 2.2. A comparison of the differences for determining household numbers by household census area unit (relevant for previous inventories) and airshed boundaries is outlined in Table 3.1.

Table 3-1: Home heating sample details for 2001 and 2006 census area units and households in Tokoroa and Te Kuiti airsheds.

	Households by census area unit 2001	Households by census area unit 2006	Households by airshed	Sample size	Area (ha)	Sample error
Tokoroa	4622	4563	4869	370	1049	5%
Te Kuiti	1584	1611	1735	324	669	5%

Home heating methods were classified as electricity, open fires, wood burners 10 years or older (pre-1997), wood burners five to 10 years old (1997-2002), wood burners less than five years old (post-2002), pellet fires, 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 each study area. The emission factors used to estimate emissions from domestic heating are shown in Table 3.2. The basis for these is detailed in Appendix B.

Table 3-2: Emission factors for domestic heating methods

	PM10 g/kg	CO g/kg	NOx g/kg	SO2 g/kg	VOC g/kg	CO2 g/kg	PM2.5 g/kg
Open fire - wood	10	100	1.6	0.2	30	1600	10
Open fire - coal	21	80	4	5.0	15	2600	12
Pre-1997 burners	11	110	0.5	0.2	33	1800	11
1997-2002 burners	6.5	65	0.5	0.2	19.5	1800	6.5
Post-2002 burners	6	60	0.5	0.2	18	1800	6
Pellet burners	2	20	0.5	0.2	6	1600	2
Multi-fuel[1] - wood	13	130	0.5	0.2	39	1600	13
Multi-fuel[1] – coal	28	120	1.2	3.0	15	2600	12
Oil	0.3	0.6	2.2	3.8	0.25	3200	0.7
Gas	0.03	0.18	1.3	7.6E-09	0.2	2500	0.6

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

One of the assumptions underlying the emissions calculations is the average weight for a log of wood. Average log weights used for inventories in New Zealand have included 1.6 kilograms, 1.4 kilograms and more recently 1.9 kilograms. The latter value is based on a survey of 219 households in Christchurch during 2002 and represents the most comprehensive assessment of average fuel weight. A recent burner emission testing programme carried out in Tokoroa during 2005 gave an average log weight of 1.3

kilograms. The sample size (pieces of wood weighed) for this study was 845. These were spread across only 12 households so it is uncertain how representative of the Tokoroa population a fuel weight of 1.3 kilograms per log might be. However the 1.3 kilogram average was used as it is the most specific information available for Tokoroa and Te Kuiti.

Emissions for each contaminant and for each time period and season were calculated based on the following equation:

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 1.3 kilograms.
- The average weight of a bucket of coal is 9 kilograms.

3.2 Home heating methods

3.2.1 Tokoroa

Wood burners were the main heating method in Tokoroa for 2007 with 45 per cent of households using this method to heat their main living area. Electricity was the second most common method (33 per cent) followed by gas (23 per cent). Only a small proportion of Tokoroa residents use open fires (four percent) or multi-fuel burners (seven percent) to heat their main living area. Of the households using gas, over a third used unflued gas systems. Table 3.3 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 Tokoroa was wood, with 56 per cent of households using this fuel. About 54 tonnes of wood is burnt on an average winter's night in Tokoroa. Coal was used by only one percent of households, with around 0.9 tonne being burnt per night.

Table 3-3: Home heating methods and fuels in Tokoroa

	Heating methods		Fuel Use	
	%	HH	t/day	%
Electricity	33%	1,614		
Total Gas	23%	1,134	2	3%
Flued gas	15%	746		
Unflued gas	8%	388		
Oil	1%	53	0.1	0%
Open fire	4%	213		
Open fire - wood	4%	187	2	4%
Open fire - coal	0%	13	0	0%
Total Wood burner	45%	2,188	45	79%
Pre-1997 wood burner	21%	1,006	21	36%
1997-2002 wood burner	12%	575	12	21%
Post-2002 wood burner	12%	607	12	22%
Multi fuel burners	7%	333		
Multi fuel burners-wood	7%	333	7	12%
Multi fuel burners-coal	1%	53	1	1%
Pellet burners	1%	27	0	0%
Total wood	56%	2,708	54	95%
Total coal	1%	67	0.9	2%
Total		4,869	57	

3.2.2 Te Kuiti

Wood burners were the most commonly used home heating method in Te Kuiti during 2007 with 45 per cent of households using this method to heat their main living area. Electricity was used by around 42 per cent of households. Over half of the 20 per cent of households using gas used unflued gas systems. 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 Te Kuiti was wood, with 57 per cent of households using this fuel. About 14 tonnes of wood is burnt on an average winter’s night in Te Kuiti. Coal was used by around five percent of households with 1.2 tonne being burnt per night.

Table 3-4: Home heating methods and fuels in Te Kuiti

	Heating methods		Fuel Use	
	%	HH	t/day	%
Electricity	42%	723		
Total Gas	20%	353	0	2%
Flued gas	9%	163		
Unflued gas	11%	191		
Oil	1%	11	0.0	0%
Open fire	8%	139		0%
Open fire - wood	8%	134	1	9%
Open fire - coal	2%	37	0	2%
Total Wood burner	45%	782	12	76%
Pre-1997 wood burner	19%	330	5	32%
1997-2002 wood burner	10%	181	3	18%
Post-2002 wood burner	16%	271	4	26%
Multi fuel burners	5%	80		
Multi fuel burners-wood	5%	80	1	5%
Multi fuel burners-coal	3%	54	1	6%
Pellet burners	0%	5	0	0%
Total wood	57%	996	14	90%
Total coal	5%	91	1.2	8%
Total		1,735	16	

3.3 Emissions from domestic heating

3.3.1 Tokoroa

Figure 3.1 shows that the greatest amount of PM_{10} from domestic heating during the winter comes from pre-1997 wood burners (44 per cent) and multi-fuel burners (21 per cent). Burners installed between 1997 and 2002 contribute to 16 per cent of the PM_{10} emissions, with open fires contributing around five percent.

Estimates of wintertime contaminant emissions for different heating methods under worst-case and average scenarios are also shown in Tables 3.5 and 3.6. The emission estimates indicate the following:

- Around 680 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 (June to August) PM_{10} emissions are less at around 517 kilograms per day. This accounts for days when households may not be using specific home heating methods.
- The majority (95 per cent) of the wintertime domestic PM_{10} emissions come from the burning of wood with five percent from the burning of coal.

Monthly variations in appliance use and average days per week used are shown in Figures 3.2 and 3.3. Table 3.7 shows seasonal variations in contaminant emissions.

The majority of the annual PM_{10} from domestic home heating occurs during the months June, July and August (Figure 3.4).

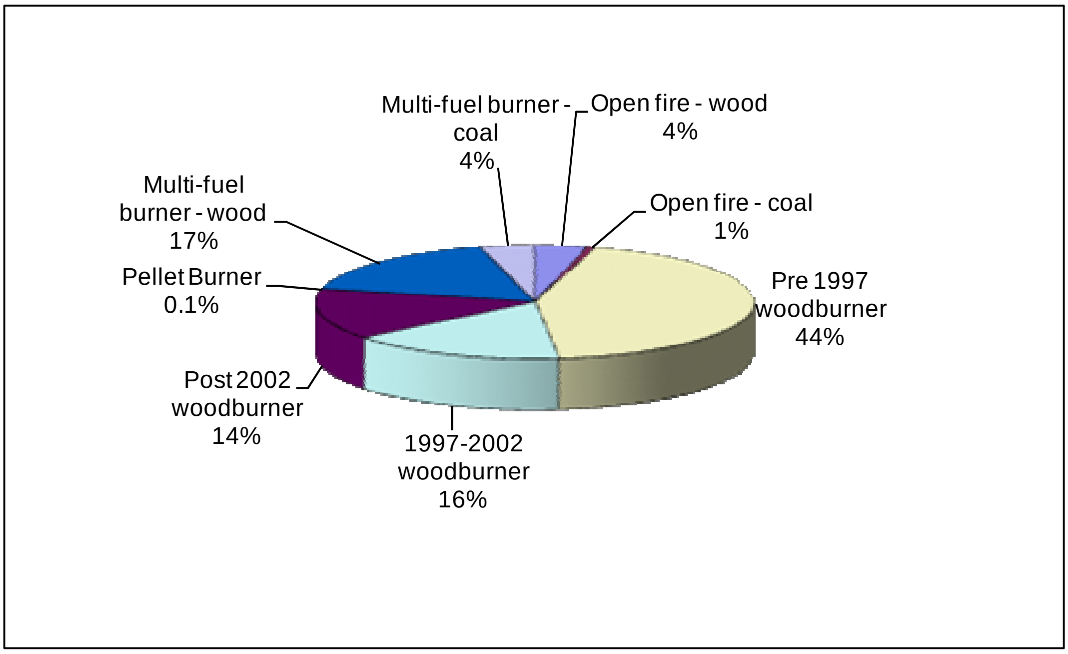

Figure 3-1: Relative contribution of different heating methods to average daily PM10 (winter average) from domestic heating in Tokoroa

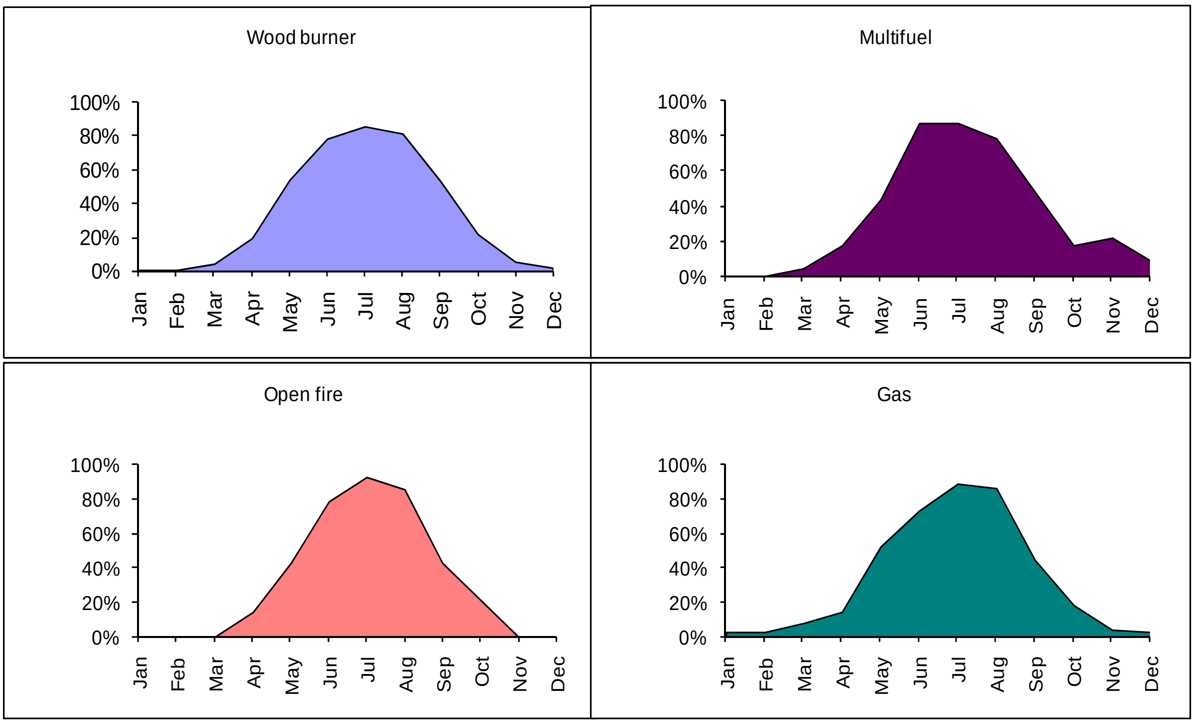

Figure 3-2: Monthly variations in appliance use in Tokoroa

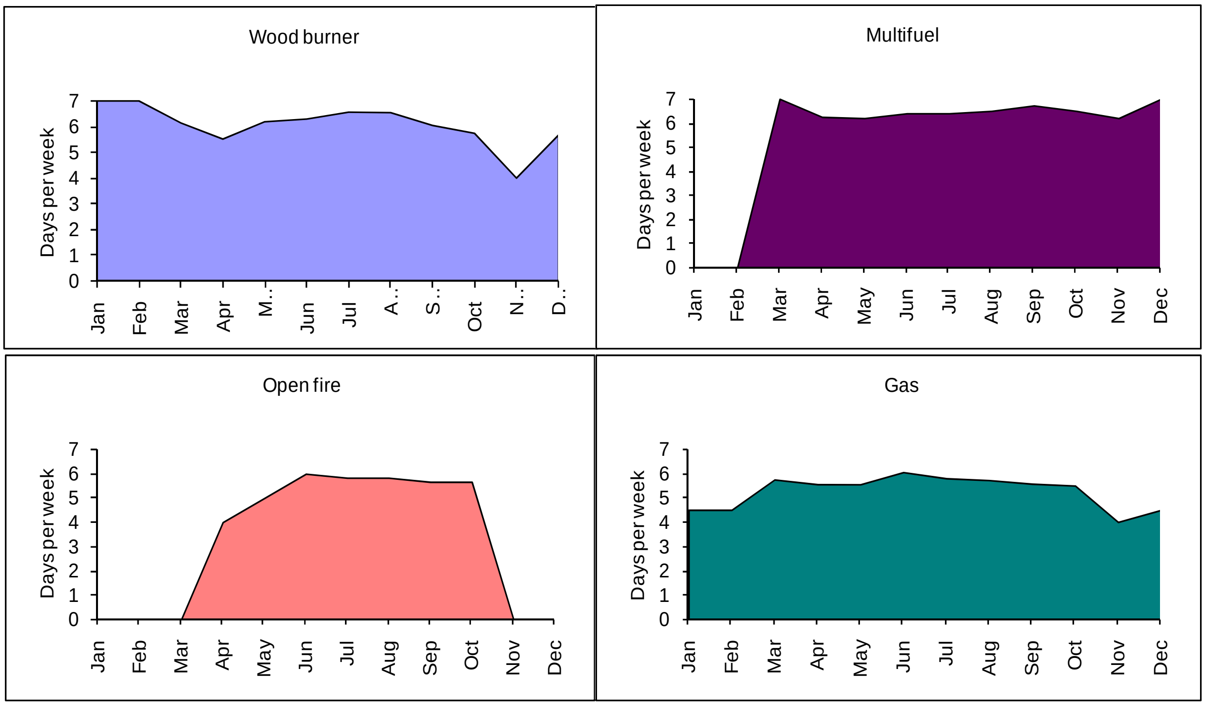

Figure 3-3: Average number of days per week that appliances are used in Tokoroa

Table 3-5: Tokoroa worst-case winter daily domestic heating emissions by appliance type

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	kg/ha	%	kg	g/ha	%
Open fire																								
Open fire - wood	2.8	4%	28	27	4%	279	266	4%	4	4	10%	1	1	3%	84	80	4%	4	4	4%	28	27	4%
Open fire - coal	0.2	0%	4	4	1%	15	15	0%	1	1	2%	1	1	5%	3	3	0%	0	0	0%	2	2	0%
Wood burner																								
Pre-1997 wood burner	27.1	36%	298	284	44%	2984	2845	45%	14	13	31%	5	5	30%	895	853	46%	43	41	36%	298	284	45%
1997-2002 wood burner	15.5	21%	109	103	16%	1085	1034	16%	8	7	18%	3	3	17%	326	310	17%	25	24	20%	109	103	16%
Post-2002 wood burner	16.4	22%	98	94	14%	982	936	15%	8	8	19%	3	3	18%	295	281	15%	26	25	21%	98	94	15%
Pellet Burner	0.2	0%	0	0	0%	4	4	0%	0	0	0%	0	0	0%	1	1	0%	0	0	0%	0	0	0%
Multi fuel burner																								
Multi fuel burner – wood	8.9	12%	116	111	17%	1160	1106	18%	4	4	10%	2	2	10%	348	332	18%	14	14	12%	116	111	17%
Multi fuel burner – coal	1.0	1%	27	26	4%	115	110	2%	1	1	3%	3	3	16%	14	14	1%	2	2	2%	15	15	2%
Gas	2.3	3%	0	0	0%	0	0	0%	3	3	7%	0	0	0%	0	0	0%	6	5	5%	0	0	0%
Oil	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	71	95%	649	619	95%	6494	6191	98%	39	37	89%	14	14	79%	1948	1857	99%	113	108	93%	649	619	97%
Total Coal	1	2%	31	29	5%	131	125	2%	2	2	4%	4	4	21%	17	16	1%	3	3	2%	18	17	3%
Total	74		680	649		6625	6316		43	41		18	17		1966	1874		122	116		667	636	

Table 3-6: Tokoroa average winter daily domestic heating emissions by appliance type (winter average)

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	kg/ha	%	kg	g/ha	%
Open fire																							
Open fire - wood	2.0	4%	20	19	4%	201	192	4%	3	3	10%	0	0	3%	60	58	4%	3	3	3%	20	19	4%
Open fire - coal	0.1	0%	3	3	1%	11	11	0%	1	1	2%	1	1	5%	2	2	0%	0	0	0%	2	2	0%
Wood burner																							
Pre-1997 wood burner	20.6	36%	226	216	44%	2265	2159	45%	10	10	31%	4	4	29%	679	648	45%	33	31	35%	226	216	45%
1997-2002 wood burner	11.8	21%	82	79	16%	824	785	16%	6	6	18%	2	2	17%	247	236	17%	19	18	20%	82	79	16%
Post- 2002 wood burner	12.4	22%	75	71	14%	745	710	15%	6	6	19%	2	2	18%	224	213	15%	20	19	21%	75	71	15%
Pellet Burner	0.2	0%	0.4	0	0%	4	4	0%	0	0	0%	0	0	0%	1	1	0%	0	0	0%	0	0	0%
Multi fuel burner																							
Multi fuel burner – wood	6.9	12%	90	85	17%	896	854	18%	3	3	10%	1	1	10%	269	256	18%	11	11	12%	90	85	18%
Multi fuel burner – coal	0.7	1%	21	20	4%	89	85	2%	1	1	3%	2	2	16%	11	11	1%	2	2	2%	12	11	2%
Gas	1.7	3%	0	0	0%	0	0	0%	2	2	7%	0	0	0%	0	0	0%	4	4	4%	0	0	0%
Oil	0.1	0%	0	0	0%	0	0	0%	0	0	0%	0	0	2%	0	0	0%	0	0	0%	0	0	0%
Total Wood	53.9	95%	494	470	95%	4935	4705	98%	29	28	89%	11	10	77%	1481	1411	99%	86	82	93%	494	470	97%
Total Coal	0.9	2%	24	23	5%	100	95	2%	1	1	4%	3	3	21%	13	13	1%	2	2	2%	14	13	3%
Total	57		517	493		5036	4801		33	31		14	13		1494	1424		93	89		507	483	

Table 3-7: Monthly variations in contaminant emissions from domestic heating in Tokoroa

	PM_{10} kg/day	CO kg/day	NOx kg/day	SOx kg/day	VOC kg/day	CO_2 t/day	$PM_{2.5}$ kg/day
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	31	313	2	1	94	6	31
May	280	2790	17	7	836	51	279
June	477	4693	30	12	1400	84	471
July	534	5243	35	14	1563	97	527
August	467	4583	31	13	1366	86	461
September	218	2178	13	5	654	40	218
October	37	370	2	1	111	7	37
November	10	75	0	1	19	1	8
December	1	11	0	0	3	0	1
Total (kg/year)	62947	620670	3971	1596	185250	11366	62305

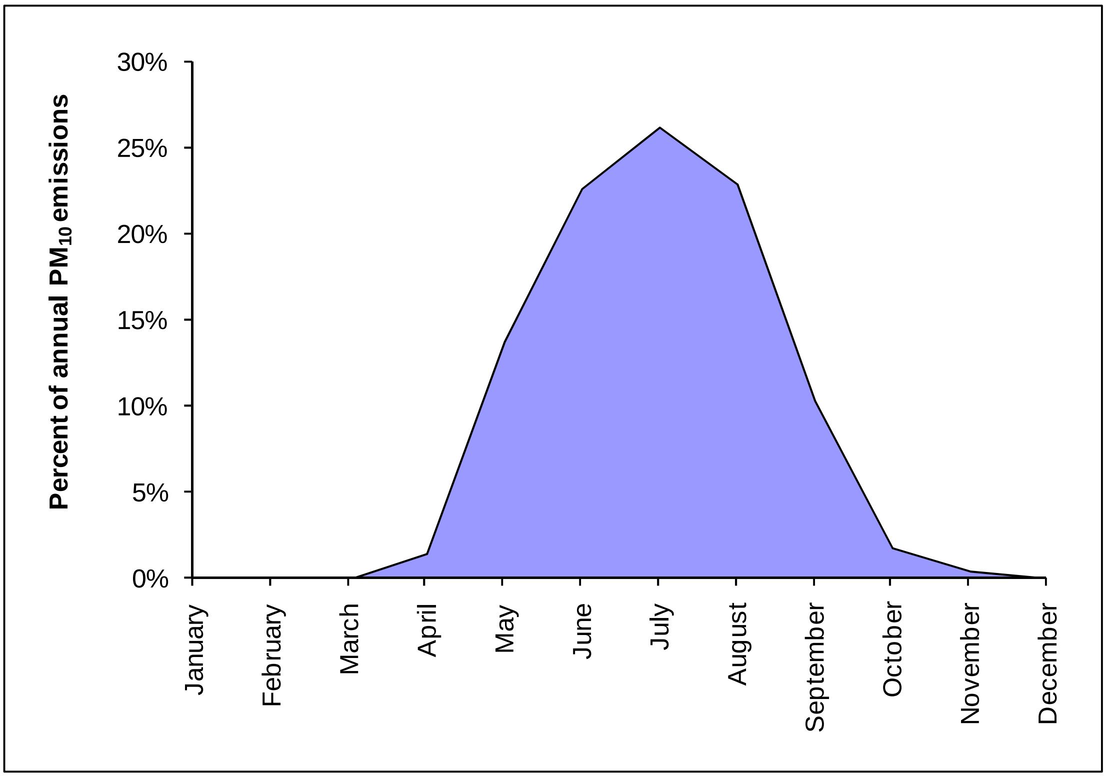

Figure 3-4: Proportion of annual PM10 emissions from domestic heating in Tokoroa

3.3.2 Te Kuiti

Older (pre-1997) wood burners produce the greatest amount of PM_{10} from domestic heating during the winter in Te Kuiti, contributing around 35 per cent of the daily average wintertime PM_{10}. Burners in the age category 1997 to 2002 contribute around 12 per cent with modern burners emitting around 16 per cent of the PM_{10}. Multi-fuel burners contribute 23 per cent of the domestic PM_{10}, with open fires contributing 14 per cent (Figure 3.5).

Estimates of wintertime contaminant emissions for different heating methods under worst-case and average scenarios are also shown in Tables 3.8 and 3.9. The emission estimates indicate the following:

- Around 213 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 155 kilograms per day. This accounts for days when households may not be using specific home heating methods.
- The majority (79 per cent) of the wintertime PM_{10} emissions come from the burning of wood with 21 per cent from the burning of coal.

Monthly variations in appliance use and average days per week used are shown in Figures 3.6 and 3.7. While Figure 3.7 shows the frequency (days per week) of wood burning is higher during the summer months, Figure 3.6 shows that a smaller proportion of households are burning during this time. Thus, it appears that the small proportion of the population that use wood burners all year round tend to burn on more days of the week than the average household. Table 3.10 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 3.8).

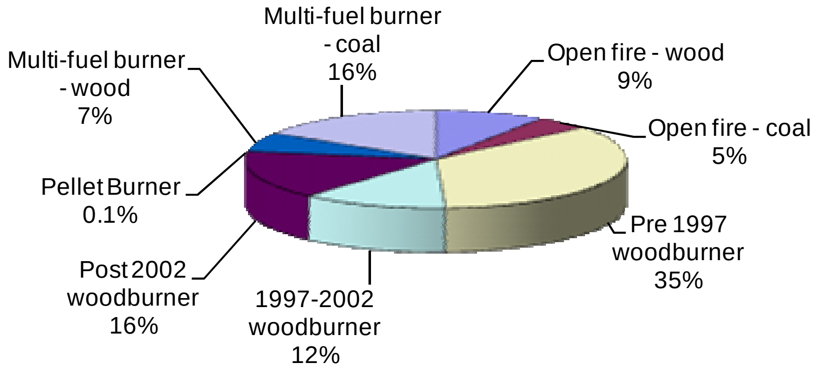

Figure 3-5: Relative contribution of different heating methods to average daily PM10 (winter average) from domestic heating in Te Kuiti

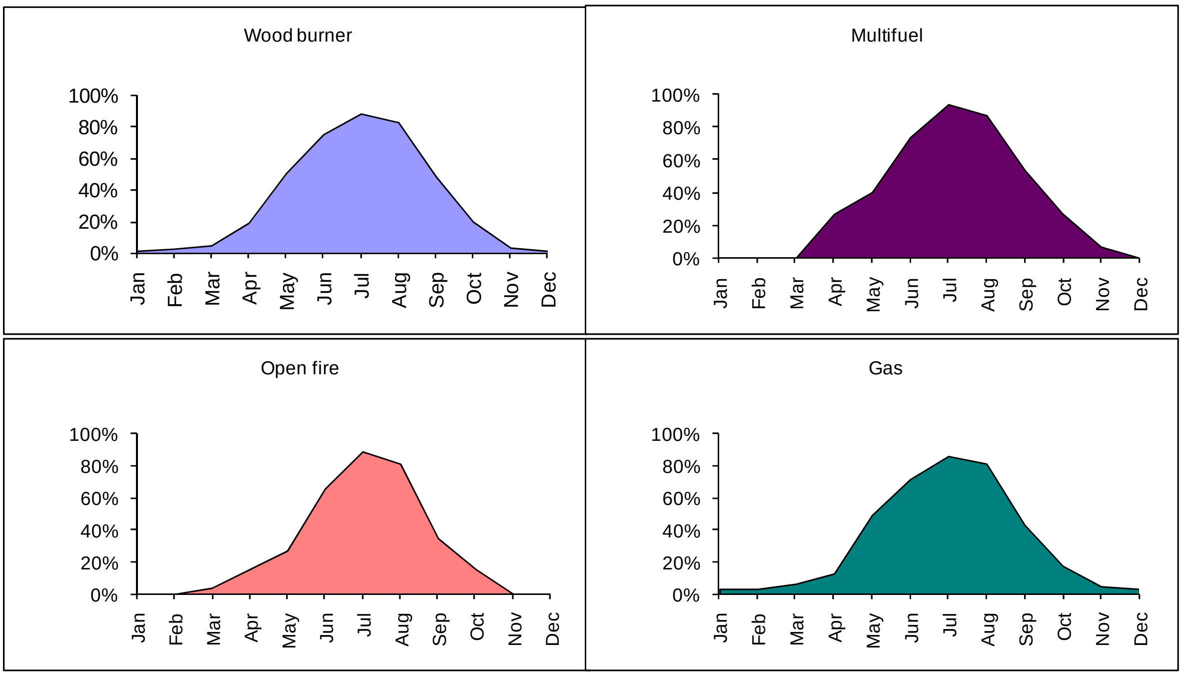

Figure 3-6: Monthly variations in appliance use in Te Kuiti

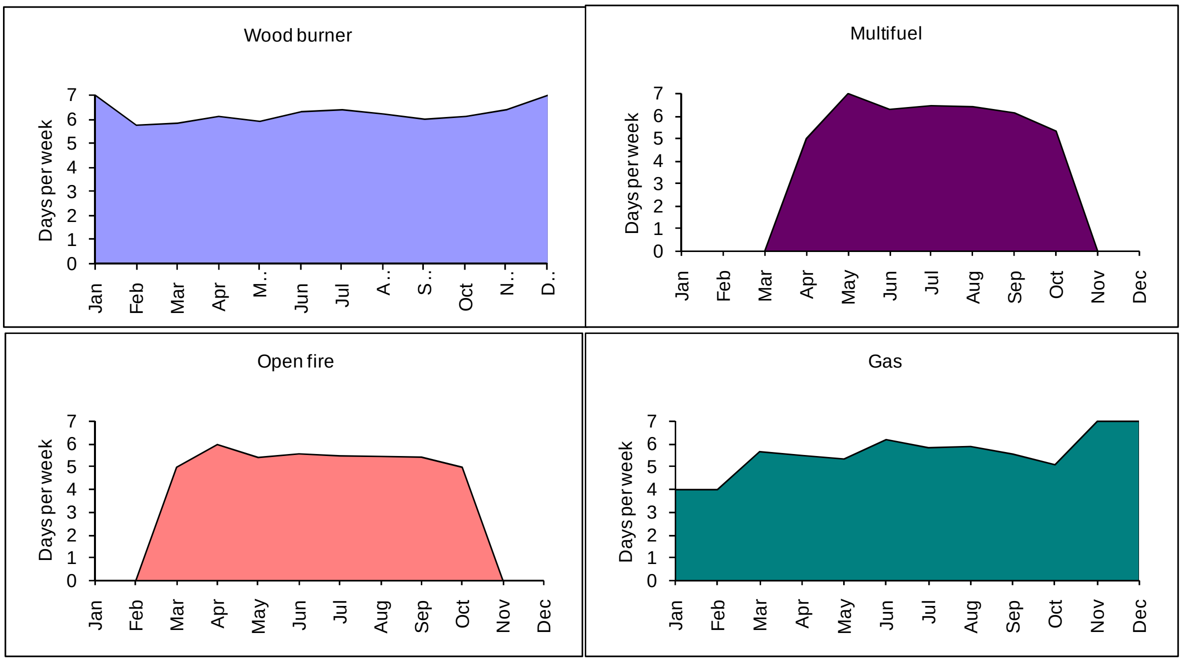

Figure 3-7: Average number of days per week that appliances are used in Te Kuiti

Table 3-8: Te Kuiti worst-case winter daily domestic heating emissions by appliance type

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	kg/ha	%	kg	g/ha	%
Open fire																							
Open fire - wood	2.3	11%	23	35	11%	234	350	13%	4	6	23%	0	1	5%	70	105	13%	4	6	10%	23	35	12%
Open fire – coal	0.5	3%	11	17	5%	43	65	2%	2	3	13%	3	4	27%	8	12	2%	1	2	4%	6	10	3%
Wood burner																							
Pre-997 wood burner	6.7	31%	74	110	35%	737	1102	39%	3	5	21%	1	2	13%	221	331	42%	11	16	30%	74	110	38%
1997-2002 wood burner	3.7	17%	26	38	12%	258	385	14%	2	3	11%	1	1	7%	77	115	15%	6	9	16%	26	38	13%
Post-2002 wood burner	5.5	26%	33	49	16%	331	495	18%	3	4	17%	1	2	11%	99	148	19%	9	13	24%	33	49	17%
Pellet Burner	0.0	0%	0	0	0%	1	1	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Multi fuel burner																							
Multi fuel burner – wood	1.0	5%	13	19	6%	128	191	7%	0	1	3%	0	0	2%	38	57	7%	2	2	4%	13	19	7%
Multi fuel burner – coal	1.2	5%	32	48	15%	139	207	7%	1	2	9%	3	5	35%	17	26	3%	3	4	8%	18	28	10%
Gas	0.4	2%	0	0	0%	0	0	0%	0	1	3%	0	0	0%	0	0	0%	1	1	3%	0	0	0%
Oil	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	19	90%	169	252	79%	1688	2524	90%	12	18	75%	4	6	38%	507	757	95%	31	46	85%	169	252	87%
Total Coal	2	8%	44	65	21%	182	272	10%	4	5	22%	6	9	62%	25	38	5%	4	7	12%	25	37	13%
Total	21		213	318		1870	2796		16	24		10	15		532	795		36	54		194	290	

Table 3-9: Te Kuiti average winter daily domestic heating emissions by appliance type

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	t	kg/ha	%	kg	g/ha	%
Open fire																							
Open fire - wood	1.4	9%	14	22	9%	144	216	11%	2	3	20%	0	0	4%	43	65	11%	2	3	9%	14	22	10%
Open fire - coal	0.3	2%	7	10	5%	27	40	2%	1	2	12%	2	2	23%	5	7	1%	1	1	3%	4	6	3%
Wood burner																							
Pre-1997 wood burner	5.0	32%	55	82	35%	546	816	40%	2	4	22%	1	1	14%	164	245	42%	8	12	30%	55	82	39%
1997-2002 wood burner	2.7	18%	19	29	12%	191	285	14%	1	2	12%	1	1	8%	57	86	15%	4	7	17%	19	29	14%
Post-2002 wood burner	4.1	26%	25	37	16%	245	367	18%	2	3	18%	1	1	11%	74	110	19%	7	10	25%	25	37	17%
Pellet Burner	0.0	0%	0.1	0	0%	1	1	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Multi fuel burner																							
Multi fuel burner – wood	0.8	5%	10	15	6%	98	147	7%	0	1	3%	0	0	2%	30	44	8%	1	2	5%	10	15	7%
Multi fuel burner – coal	0.9	6%	25	37	16%	107	160	8%	1	2	9%	3	4	37%	13	20	3%	2	3	9%	14	21	10%
Gas	0.3	2%	0	0	0%	0	0	0%	0	1	3%	0	0	0%	0	0	0%	1	1	3%	0	0	0%
Oil	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%	0	0	0%
Total Wood	14.0	90%	123	183	79%	1225	1832	90%	9	13	75%	3	4	39%	368	550	95%	22	34	85%	123	183	87%
Total Coal	1.2	8%	32	48	21%	134	200	10%	2	4	21%	4	6	60%	18	27	5%	3	5	12%	18	27	13%
Total	16		155	231		1359	2032		11	17		7	11		386	577		26	39		141	210	

Table 3-10: Monthly variations in contaminant emissions from domestic heating in Te Kuiti

	PM_{10} kg/day	CO kg/day	NOx kg/day	SOx kg/day	VOC kg/day	CO_2 t/day	$PM_{2.5}$ kg/day
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	2	0	0	1	0	0
April	11	103	1	0	30	2	10
May	7	53	1	1	14	1	6
June	27	197	3	2	51	4	22
July	59	399	6	5	98	8	45
August	51	346	5	4	84	7	39
September	43	395	3	1	114	8	40
October	8	71	1	0	20	1	7
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total (kg/year)	6312	47871	585	431	12567	959	5184

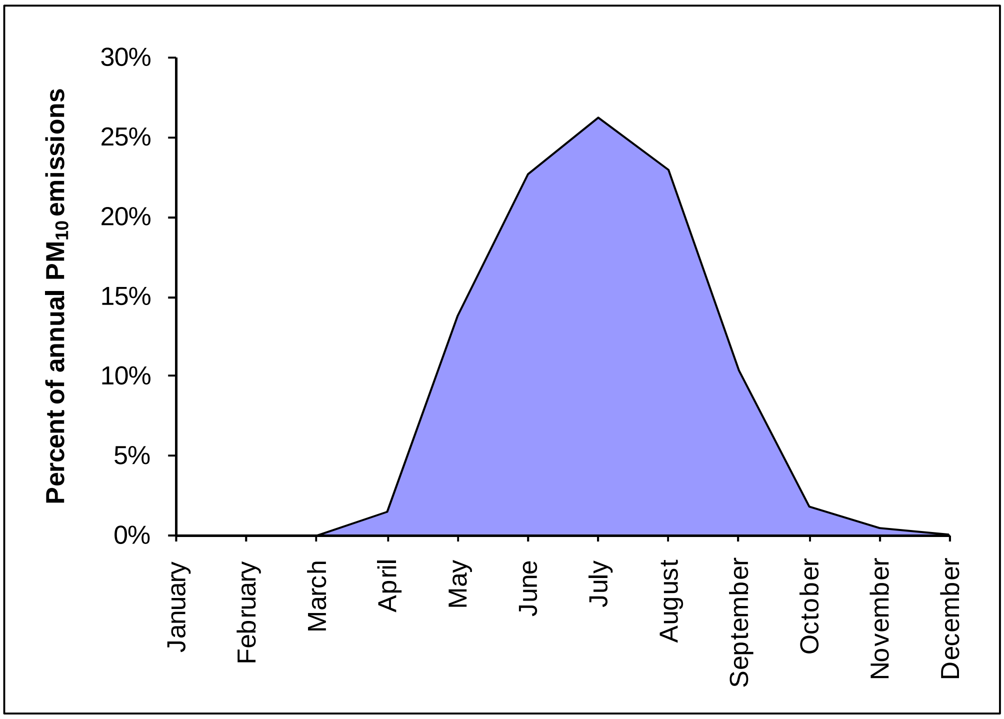

Figure 3-8: Proportion of annual PM10 emissions from domestic heating in Te Kuiti by month of year

4 Motor vehicles

Assessing emissions from motor vehicles involves collecting data on vehicle kilometres travelled (VKT) under different levels of congestion, and the application of emission factors to these data.

The 2007 emission factors used to estimate motor vehicle emissions for PM_{10}, CO, NOx and VOC were taken from the New Zealand Traffic Emission Rates (NZTER) database based on a vehicle fleet profile derived from motor vehicle registrations for

Hamilton data (Table 4.1). The NZTER database was developed by the Ministry of Transport (MOT) based on measured emissions rates from actual vehicle emissions tests on New Zealand vehicles under various road and traffic conditions. Emission rates for SOx and CO_2 are not included in the NZTER database and were selected based on emission rates derived by the Fuel and Energy Group for the national vehicle fleet profile.

The emission factors for $PM_{2.5}$ were based on estimates of PM_{10} emissions using data from the British Columbia Lower Fraser Valley adjusted for the Hamilton vehicle fleet profile. This indicated that around 57 per cent of the PM_{10} tailpipe emissions would be in the $PM_{2.5}$ size fraction. In addition to tailpipe emissions, PM_{10} from the wearing of brakes and tyres were also included in the emissions assessments. Emission factors for PM_{10} and $PM_{2.5}$ from these sources were also derived from the British Columbia Lower Fraser Valley data adjusted for the Hamilton vehicle fleet profile. However, the extent to which these conversions based on overseas data are applicable to New Zealand vehicle emissions is uncertain. Consequently, emission estimates for $PM_{2.5}$ from motor vehicles and PM_{10} from the wearing of tyre and brakes should be treated as indicative only.

Table 4-1: Vehicle registrations in Hamilton for the year ending July 2007

	Petrol	Diesel	LPG	Other	Total
Cars	82,502	6,408	22	11	88,943
LCV	3,736	6,152	17	2	9,907
Bus	642	94	1	26	763
MCV	101	1,887	-	-	1,989
HCV	28	1,625	-	-	1,653
Miscellaneous	984	814	71	9	1,878
Motorcycle	2,412	-	-	-	2,412
Total	90,405	16,981	111	48	107,545

For the purpose of assessing emissions from motor vehicles, VKTs are typically differentiated into three different driving conditions called Levels Of Service (LOS) and a fourth category representing emissions under cold running conditions. The LOS categories include free flow conditions (LOS category A-B), interrupted flow conditions (LOS category C-D) and congested flow conditions (LOS category E-F). The number of VKTs occurring under different LOS is usually determined on a road network model by the number of vehicles on a particular road relative to the capacity of the road. No road network model exists for Tokoroa or Te Kuiti so total VKTs for each area was based on the average number of VKTs per household for Taupo, which was obtained from road network modelling for the 2004 Taupo air emission inventory. Because of the relatively uncongested nature of vehicle movements in Te Kuiti and Tokoroa, all VKTs were assumed to occur under free flowing conditions.

Table 4.2 shows the estimated number of VKTs under the free flowing (A-B) category for Tokoroa and Te Kuiti for 2007.

Table 4-2: VKT by time of day for Tokoroa and Te Kuiti

	Total VKT	Time of day			
		6am-10am	10am-4pm	4pm-10pm	10pm-6am
Tokoroa	391,601	74,981	163,465	129,846	23,309
Te Kuiti	139,542	26,718	58,249	46,269	8,306

The emission factor for each contaminant is shown in Table 4.3. These are based on the Hamilton vehicle fleet composition and the assumption that 30 per cent of the VKTs occur under cold start conditions.

Table 4-3: Emission factors for 2007 for Hamilton based on a suburban driving regime

Driving Conditions	CO g/VKT	CO_2 g/VKT	VOC g/VKT	NOx g/VKT	SOx g/VKT	PM_{10} g/VKT	$PM_{2.5}$ g/VKT
Free flow - A-B	11.59	365.65	1.97	1.56	0.216	0.09	0.052

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) = A-B Emission Rate (g/VKT) * VKT (A-B) + C-D Emission Rate (g/VKT) * VKT (C-D) + E-F Emission Rate (g/VKT) * VKT (E-F)

4.1 Motor vehicle emissions

4.1.1 Tokoroa

The method estimates around 391,600 VKTs per day on for Tokoroa, and assumes that all occur under free flowing conditions. This is likely to be an upper estimate for Tokoroa because the VKT to Households ratio for Taupo is higher than most urban areas of New Zealand with road network modelling. Thus, the following emission estimates are likely to represent upper limit motor vehicle contributions.

Around 42 kilograms per day of PM_{10} are estimated to occur from motor vehicle emissions in Tokoroa. Around 17 per cent of this is estimated to occur as a result of the wearing of brakes and tyres.

Other contaminant emissions from motor vehicles in Tokoroa include around 4540 kilograms of CO, 610 kilograms of NOx and 84 kilograms of SOx (Table 4.4). By 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.

4.1.2 Te Kuiti

Around 139,542 VKTs are estimated per day on average in Te Kuiti, and all are assumed to occur under free flowing conditions. As with Tokoroa, this is likely to represent an upper limit estimate.

Estimated emissions to air include 40 kilograms per day of PM_{10}. Around 17 per cent of this is estimated to occur as a result of the wearing of brakes and tyres. Other contaminant emissions from motor vehicles in Te Kuiti include around 1618 kilograms of CO, 217 kilograms of NOx and 30 kilograms of SOx.

Table 4.4 shows emissions from motor vehicles in Tokoroa and Te Kuiti by weight and grams per hectare. Grams per hectare emissions are likely to be lower than previous inventories for these areas because the airshed areas for both Te Kuiti and Tokoroa include more rural land than the previous inventory study areas.

Table 4-4: Summary of daily motor vehicle emissions in Tokoroa and Te Kuiti

		PM_{10}		CO		NOx		SOx	
	Hectares	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Tokoroa	1049	42	40	4540	4328	610	581	84	81
Te Kuiti	669	15	23	1618	2418	217	325	30	45
		VOC		CO_2		$PM_{2.5}$			
	Hectares	kg	g/ha	t	kg/ha	kg	g/ha		
Tokoroa	1049	770	734	143	136	23	21		
Te Kuiti	669	274	410	51	76	8	12		

5 Industrial and commercial

5.1 Methodology

An evaluation of potential discharges to air from industrial and commercial sources in Tokoroa and Te Kuiti was undertaken to identify activities that discharge PM_{10} to air. Environment Waikato staff provided information on consented activities and an internet and Yellow Pages search was undertaken to identify key industries.

All schools in Tokoroa and Te Kuiti were also surveyed by phone to determine the source of their heating. The results showed that only two schools (Tokoroa High School and Te Kuiti Primary School) use coal boilers. The remaining schools use natural gas or electricity for heating. Emissions from gas boilers were not included in the inventory as the PM_{10} emissions from them are negligible for small to medium size boilers. A total of 41 industrial and commercial premises were surveyed. Because of the small scale of a number of discharges, only nine industrial activities were included.

The selection of industries for inclusion in this inventory was based primarily on potential for PM_{10} emissions. Industrial activities such as spray painting or dry cleaning operations, which discharge primarily VOCs, 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. Activity data was collected using a phone survey or data provided by Environment Waikato staff. Data were collected for winter, autumn, spring and summer.

Combustion emissions were estimated using emission factor data as indicated in Equation 5.1.

Equation 5.1 Emissions (kg) = Emission factor (kg/tonne) x Fuel use (tonnes)

The emission factors used to estimate the quantity of emissions discharged are shown in Table 5.1. The coal fired boiler emission factors for PM_{10} are based on New Zealand specific emission factors as described in Wilton et. al. 2007. 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 are based on factors derived by NIWA for the Christchurch 1996 emission inventory (NIWA, 1998). Gas emission factors are based on AP-42 for a small boiler.

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

Table 5-1: Emission factors for industrial discharges

	PM_{10} g/kg	CO g/kg	NOx g/kg	SOx g/kg	VOC g/kg	CO2 g/kg	$PM_{2.5}$ g/kg
Chain grate	1.0	3.0	3.8	18.0	0.1	2400	0.7
Spreader and Vekos	3.8	2.5	5.0	18.0	0.1	2400	3.1
Overfeed stokers	1.5	3.0	3.8	18.0	0.1	2400	3.1
Underfeed stokers	2.0	5.5	4.8	13.5	0.1	2400	3.1
Low Ram	2.0	3.0	5.0	18.0	0.1	2400	1.8
Wood boiler	1.6	6.8	0.8	0.0	0.1	1069	3.3
Diesel boiler	0.2	0.7	3.2	10.5	0.2	3194	0.3
Light fuel oil	1.3	0.7	6.3	3.9	0.2	3194	.1
LPG	0.1	0	3	0	0	1716	0
Lime burning	0.26	1.1	1.7				0.03
Crushing and pulverising minerals.	0.032						
Abrasive blasting	0.69						
Concrete batching	0.01						
	kg/m^3	kg/m^3	kg/m^3	kg/m^3	kg/m^3	kg/m^3	kg/m^3
Natural gas AP42	0.00012	0.00134	0.00160	0.00001	0.00009	1.92000	0.00012

5.2 Industrial and commercial emissions

5.2.1 Tokoroa

Discharges from five industrial and commercial activities were included in the assessment. These included coal fired boilers, abrasive blasting, concrete production and the zeolite processing plant.

Around five kilograms of PM_{10} are discharged to air from industrial and commercial activities in Tokoroa. The main source of these emissions is the hospital coal boiler, which contributes around three kilograms of PM_{10} per day during the winter. Figure 5.1 shows the relative contributions of different fuels and sources to PM_{10} emissions in Tokoroa during the winter months.

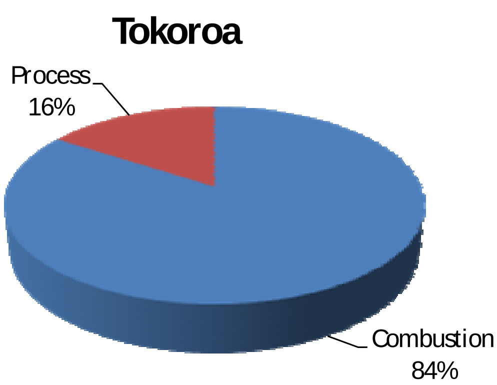

Figure 5-1: Contribution of different combustion versus process industrial PM10 emissions in Tokoroa

5.2.2 Te Kuiti

Discharges from five industrial and commercial activities were included in the assessment.

Around 47 kilograms of PM_{10} are discharged to air from industrial and commercial activities in Te Kuiti. The highest estimated emissions were estimated for McDonald's Lime Ltd (28 kilograms of PM_{10} per day), although there is some uncertainty surrounding the applicability of the emission factors used[2]. The other two major contributors to PM_{10} emissions in Te Kuiti were Waitete Sawmills located to the south of Te Kuiti (14 kilograms per day) and Tregoweth Sawmill to the north (four kilograms per day). Although lower in absolute emissions, the latter industry has greater potential for contributing to PM_{10} emissions during high pollution episodes because of its upwind location relative to the Te Kuiti urban area and air quality monitoring site. Thus, the main industries with potential for contributions to elevated daily PM_{10} are McDonald's Lime and Waitete Sawmill. Figure 5.2 shows the relative contributions of different fuels and sources to PM_{10} emissions in Te Kuiti during winter months.

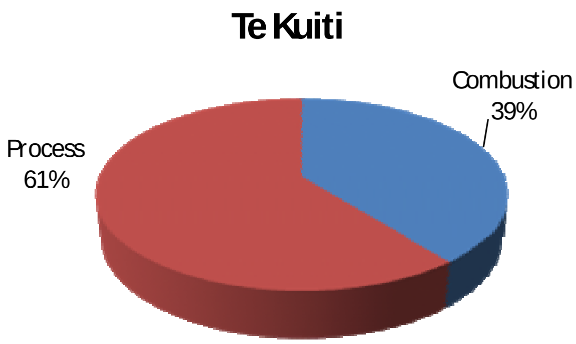

Figure 5-2: Contribution of different combustion versus process industrial PM10 emissions in Te Kuiti

Table 5-2: Summary of industrial emissions (daily winter) in Tokoroa and Te Kuiti

		PM_{10}		CO		NOx		SOx	
	Hectares	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**
Tokoroa	1049	5	5	11	11	10	9	28	26
Te Kuiti	669	47	70	258	386	201	300	1	2
		VOC		**CO2**		**PM2.5**			
	Hectares	**kg**	**g/ha**	**T**	**kg/ha**	**kg**	**g/ha**		
Tokoroa	1049	0.1	0.1	5	5	4	4		
Te Kuiti	669	3.0	4.4	22	33	44	65		

6 Outdoor burning

Emissions from outdoor burning can contribute to PM_{10} and $PM_{2.5}$ concentrations. In some urban areas of New Zealand outdoor burning is prohibited because of the adverse health and nuisance effects associated with these emissions. Outdoor burning includes any backyard burning of household or garden wastes in a drum, incinerator or open air.

[2] McDonald's Lime control equipment includes a wet scrubber whereas the AP42 classifications had only a gravel bed scrubber or electrostatic precipitator. The former was used to estimate emissions.

The Waikato Regional Plan permits outdoor burning of specified materials including untreated wood, vegetative matter, paper and cardboard and other similar materials subject to a number of conditions (Rule 6.1.13.1). The conditions include ensuring that the effects of the discharge do not go beyond the boundary of the property and are sourced from the property where the burning occurs.

6.1 Methodology

Outdoor burning emissions for the winter months were estimated for Tokoroa, based on data collected for the 2007 Tokoroa domestic home heating emission survey. The survey showed 11 per cent of households in Tokoroa and 20 per cent in Te Kuiti burnt rubbish in the outdoors during the winter. In both areas, these households burnt an average of around four fires per winter per household. Emissions were calculated based on the assumption of an average weight of material per burn of 150 kilograms and using the emission factors in Table 6.1. This was based on an average fires size of 2 m^3 across the two areas and an estimated average weight of 75 kg/m^3.

Table 6-1: Outdoor burning emission factors (AP42, 2002)

	$PM_{2.5}$ g/kg	PM_{10} g/kg	CO g/kg	NOx g/kg	SOx g/kg	VOC g/kg	CO_2 g/kg
Outdoor burning	8	8	42	3	0.5	4	1470

6.2 Tokoroa

Outdoor burning emission estimates for Tokoroa (Table 6.2) indicate that around 37 kilograms of PM_{10} from outdoor burning could be expected per day during the winter months. Outdoor burning also produces around 196 kilograms of carbon monoxide and around seven tonnes of carbon dioxide per day during winter.

Table 6-2:Outdoor burning emission estimates for Tokoroa

	PM10 kg/ day	CO kg/ day	NOx kg/ day	SOx kg/ day	VOC kg/ day	CO2 t/ day	PM2.5 kg/ day
Summer (Dec-Feb)	32	170	12	2	16	6	32
Autumn (Mar-May)	27	141	10	2	13	5	27
Winter (June-Aug)	37	196	14	2	19	7	37
Spring (Sept-Nov)	26	135	10	2	13	5	26

6.3 Te Kuiti

Outdoor burning emission estimates for Te Kuiti (Table 6.3) indicate that around 15 kilograms of PM_{10} from outdoor burning could be expected per day during the winter months. Outdoor burning also produces around 79 kilograms of carbon monoxide and around three tonnes of carbon dioxide per day during winter.

Table 6-3: Outdoor burning emission estimates for Te Kuiti

Outdoor burning	PM10 kg/ day	CO kg/ day	NOx kg/ day	SOx kg/ day	VOC kg/ day	CO2 t/ day	PM2.5 kg/ day
Summer (Dec-Feb)	16	86	6	1	8	3	16
Autumn (Mar-May)	20	106	8	1	10	4	20
Winter (June-Aug)	15	79	6	1	7	3	15
Spring (Sept-Nov)	16	85	6	1	8	3	16

It should be noted, however, that there are a number of uncertainties relating to this estimation and the Tokoroa estimation. In particular, it is assumed that burning is carried out evenly throughout the winter, whereas in reality it is highly probable that a disproportionate 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.

7 Other sources of emissions

This inventory includes all likely major sources of PM_{10} that can be adequately estimated using inventory techniques. Other sources of emissions not included in the inventory that may contribute to measured PM_{10} concentrations at some times during the year include dusts (a portion of which occur in the PM_{10} size fraction) and sea spray.

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 one kilogram per day[3].

8 Total emissions

8.1 Tokoroa

Around 602 kilograms of PM_{10} is discharged to air in Tokoroa on an average winter's day. Domestic home heating is the main source, contributing 86 per cent of the daily wintertime PM_{10} (Figure 8.1). Other sources include transport (seven percent), outdoor burning (six percent) and industry (one percent).

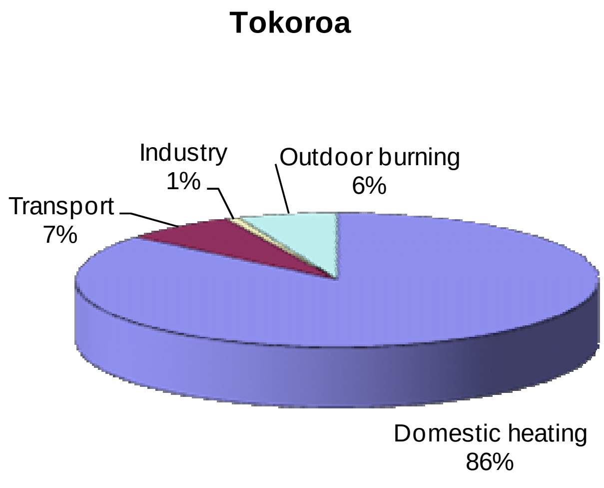

Figure 8-1: Relative contribution of sources to daily winter PM10 emissions in Tokoroa

Domestic home heating is also the main source of CO, $PM_{2.5}$ and VOCs and contributes just over a third of the CO_2 in Tokoroa. Motor vehicles are the main source of NOx, SOx and CO_2 (Figure 8.2).

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

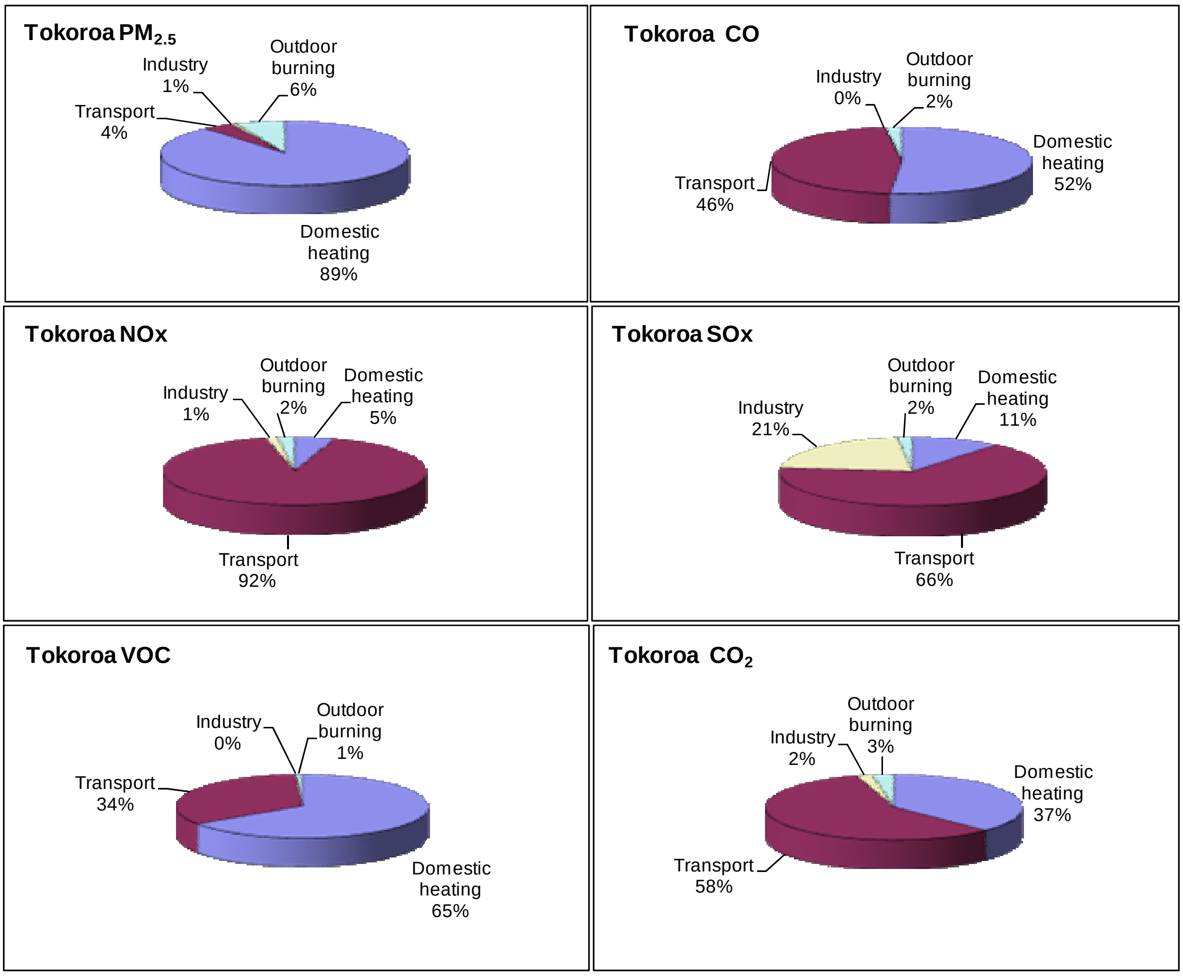

Figure 8-2: Relative contribution of sources to contaminant emissions in Tokoroa.

Daily wintertime emissions of PM_{10} and other contaminants (kg/day and kg/day/ha) are shown in Table 8.1. It should be noted that the airshed study areas used in this inventory are larger than the previous study areas and incorporate more rural (low emission density) areas. Thus, the emission results expressed as kg/day/ha are likely to appear lower than for previous inventories for Tokoroa.

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.

Table 8-1: Daily contaminant emissions from all sources in Tokoroa (winter average)

	PM_{10}		CO		NOx		SOx	
	kg	kg/ha	kg	kg/ha	kg	kg/ha	kg	kg/ha
Domestic home heating	517	493	5036	4801	33	31	14	13
Transport	42	40	4540	4328	610	581	84	81
Industry	5	5	11	11	10	9	28	26
Outdoor burning	37	36	196	186	14	13	2	2
Total	602	574	9783	9326	667	635	128	122
	VOC		**CO_2**		**$PM_{2.5}$**			
	kg	kg/ha	t	kg/ha	kg	kg/ha		
Domestic home heating	1494	1424	93	89	507	483		
Transport	770	734	143	136	23	21		
Industry	0	0	5	5	4	4		
Outdoor burning	19	18	7	7	37	36		
Total	2282	2176	248	236	571	544		

Table 8-2: Monthly variations in daily PM10 emissions in Tokoroa

	Domestic Heating		Outdoor Burning		Industry		Motor vehicles		Total
	kg/day	%	kg/day	%	kg/day	%	kg/day	%	kg/day
January	0	0%	32	42%	3	3%	42	55%	77
February	0	0%	32	42%	3	3%	42	55%	77
March	0	0%	27	37%	3	5%	42	58%	72
April	31	30%	27	26%	3	3%	42	41%	104
May	280	79%	27	8%	3	1%	42	12%	353
June	477	85%	37	7%	5	1%	42	8%	561
July	534	86%	37	6%	5	1%	42	7%	618
August	467	85%	37	7%	5	1%	42	8%	551
September	218	75%	26	9%	4	1%	42	15%	290
October	37	34%	26	24%	4	3%	42	39%	109
November	10	12%	26	32%	4	4%	42	52%	82
December	1	1%	32	41%	3	3%	42	54%	78
Total kg year	62947		11154		1324		15439		90863

8.2 Te Kuiti

Around 231 kilograms of PM_{10} is discharged to air in Te Kuiti on an average winter's day. Domestic home heating is the main source contributing 67 per cent of the daily wintertime PM_{10} (Figure 8.3). Industry is the next largest contributing at 20 per cent, with motor vehicles and outdoor burning contributing seven percent and six percent respectively. The industrial contribution to measured PM_{10} concentrations may be less because of the additional dispersion associated with the higher discharge heights of most industrial chimneys and the locations of industry on the outskirts of the Te Kuiti township.

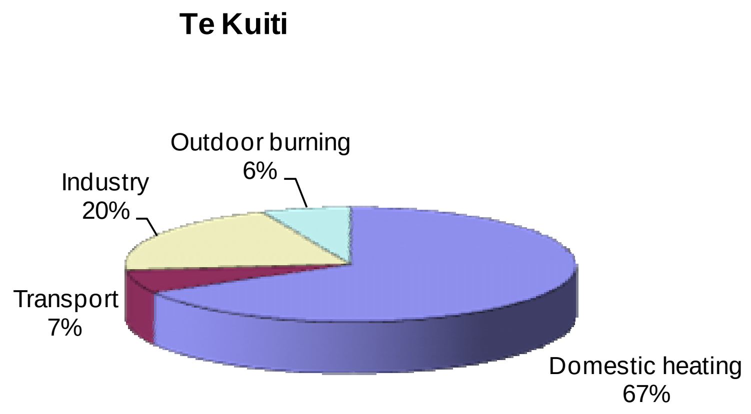

Figure 8-3: Relative contribution of sources to daily winter PM10 emissions in Te Kuiti

Domestic home heating is also the main source of $PM_{2.5}$ and VOCs and contributes around a quarter of the CO. Industry is the main source of NOx emissions and motor vehicles are the main source of SOx, CO and contribute half of the CO_2 emissions (Figure 8.4).

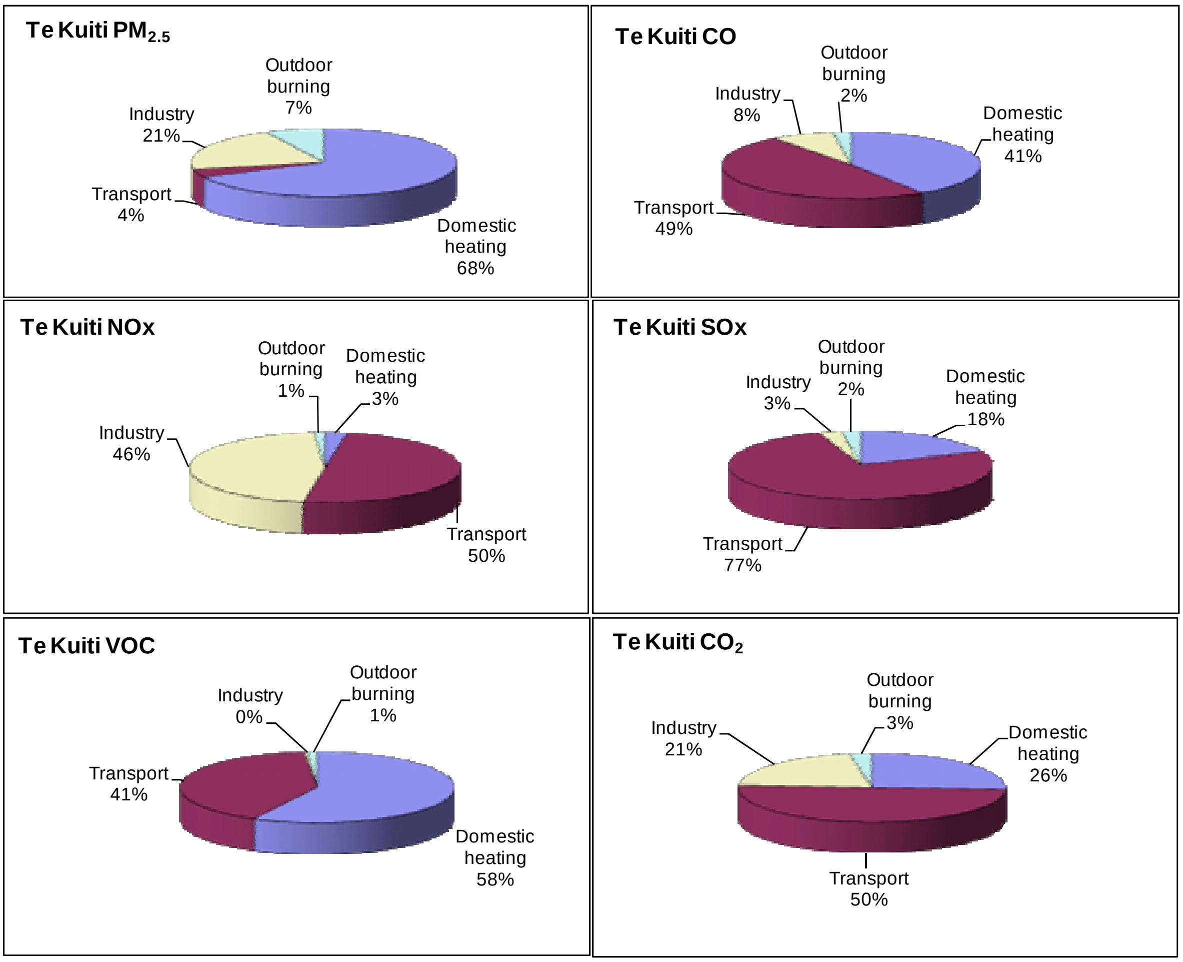

Figure 8-4: Relative contribution of sources to contaminant emissions in Te Kuiti

Daily wintertime emissions of PM_{10} and other contaminants (kg/day and kg/day/ha) are shown in Table 8.3. Table 8.4 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, industry is the dominant contributor to PM_{10} emissions.

Table 8-3: Daily contaminant emissions from all sources in Te Kuiti (winter average)

	PM_{10}		CO		NOx		SOx	
	kg	kg/ha	kg	kg/ha	kg	kg/ha	kg	kg/ha
Domestic home heating	155	231	1359	2032	11	17	7	11
Transport	15	23	1618	2418	217	325	30	45
Industry	47	70	258	386	201	300	1	2
Outdoor burning	15	22	79	118	6	8	1	1
Total	231	346	3314	4953	435	650	39	59
	VOC		CO_2		$PM_{2.5}$			
	kg	kg/ha	t	kg/ha	kg	kg/ha		
Domestic home heating	386	577	26	39	141	210		
Transport	274	410	51	76	8	12		
Industry	3	4	22	33	44	65		
Outdoor burning	7	11	3	4	15	22		
Total	671	1003	102	152	208	310		

Table 8-4: Monthly variations in daily PM10 emissions in Te Kuiti

	Domestic Heating		Outdoor Burning		Industry		Motor vehicles		Total
	kg/day	%	kg/day	%	kg/day	%	kg/day	%	kg/day
January	0	0%	16	21%	47	60%	15	19%	79
February	0	0%	16	21%	47	60%	15	19%	79
March	0	0%	20	25%	46	56%	15	18%	82
April	11	12%	20	22%	46	50%	15	16%	92
May	64	44%	20	14%	46	32%	15	10%	146
June	117	60%	15	8%	47	24%	15	8%	194
July	166	68%	15	6%	47	19%	15	6%	243
August	149	66%	15	7%	47	21%	15	7%	226
September	43	35%	16	13%	47	39%	15	13%	120
October	8	9%	16	19%	47	54%	15	18%	86
November	0	0%	16	21%	47	60%	15	19%	78
December	0	0%	16	21%	47	60%	15	19%	78
Total kg year	17113		6196		16991		5502		45801

References

Dasch, J. M. 1982: Particulate and gaseous emissions from wood burning fireplaces, *Environment, Science and Technology*, Volume 16, Number 10:639-645.

Environment Australia, 2001: National Pollutant Inventory, http://www.environment.gov.au/epg/npi/handbooks/aedmanuals/aedmanuals.html

ESR 1999: Otago inventory of domestic emissions. Unpublished report prepared for Otago Regional Council.

GVRD 1998, 1995: Emission inventory for the Lower Fraser Valley Airshed: Technical Appendix: Detailed Listing of Methodology and Results. Greater Vancouver Regional District and Fraser Valley Regional District.

Hennessy, W. 1999: Statement of evidence – Hearing on proposed coal ban for Christchurch. Environment Canterbury unpublished.

Kim, N. 2007: Meeting the Air NES – general methodology and reappraisal for Tokoroa following 2007 instrument calibration. Unpublished Environment Waikato Memo dated 3 September 2007.

Lamb, C. 1999, *Christchurch Home Heating Survey: A survey of domestic home heating methods and fuels in the Christchurch metropolitan area.* Environment Canterbury Report U00/34.

Ministry for the Environment. 1994: *Ambient Air Quality Guidelines.* Ministry for the Environment, Wellington.

Ministry for the Environment. 2002: *Ambient Air Quality Guidelines for New Zealand.* Ministry for the Environment.

Ministry of Transport. 1998: *Vehicle fleet emission control strategy – final report*. Ministry of Transport.

NIWA. 1998: *Christchurch inventory of Total Emissions.* Environment Canterbury Report R98/20.

NIWA. 1999: *Natural emissions for the Waikato Region.* NIWA report AK98154.

Scott, A. 2004: Impact of strategies to reduce residential heating emissions in Christchurch - an update, Unpublished, draft Environment Canterbury Report.

Stern, C. H.; Jaasma, D.R.; Shelton, J.W. and Satterfield G. 1992: Parametric study of fireplace particulate matter and carbon monoxide emissions. *Journal of the Air Waste Management Association* Vol 42, Number 6:777-783.

USEPA AP42, 2001, Emissions Database http://www.epa.gov/ttn/chief/ap42/

Wilton, E. 2005: *Hamilton Emission Inventory.* Environment Waikato Report TR2005/52.

Wilton, E. 2005a: *Management options for air quality in Hamilton and Te Kuiti, An assessment of management options to achieve National Environmental Standards.* Environment Waikato report 2005/53.

Wilton, E., 2005b: *Management options for air quality in Tokoroa and Taupo, An assessment of management options to achieve National Environmental Standards.* Environment Waikato Report TR2004/29.

Wilton, E. 2005: *Tokoroa Emission Inventory 2004*. Environment Waikato Report TR05/11.

Wilton, E. *Seasonal Variations in PM10 Emissions in Tokoroa 2005.* Report TR 2005/55.

Wilton, E. 2007: *Hamilton, Taupo, Te Kuiti and Tokoroa: an Assessment of Management Options to Achieve National Environmental Standards.* Environment Waikato Report TR 2007/15.

Wilton, E. and Smith J. 2006: *Real Life Emissions Testing of Pre 1994 Woodburners in New Zealand.* Environment Waikato Report TR2006/05.

Wilton and Simpson, 2001: Nelson emission inventory – 2001, Unpublished Nelson City Council Report.

Wilton. E. 2002a: Improving air quality in Nelson, An assessment of the effectiveness of management options for reducing PM10 concentrations in Nelson - Stage One. Unpublished Nelson City Council Report.

Wilton. E. 2002b: Briefing paper for addressing PM_{10} emissions in the Tahunanui/ Airport area. Unpublished report prepared for Nelson City Council.

Wilton. E. 2004: National Environmental Standards for air quality – implications for PM_{10} concentrations in Nelson. Unpublished report prepared for Nelson City Council.

Wilton. E., Anderson B. and Iseli.J. 2007: Cost effectiveness of policy options for boilers – Rangiora. Unpublished report prepared for Environment Canterbury.

Appendix A: 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. 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.

D4 How many people live at your address?

D5 Do you own your home or rent it?

D6 Approximately how old is your home?

D7 How many bedrooms does your home have?

D8 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 B: 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 21 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-1997 wood burner categories were based on data collected in Nelson on burner types in different age categories. 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).

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.