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Air emission inventory – Taupo 2014

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Air Emission Inventory - Taupo 2014

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EXECUTIVE SUMMARY

The main air contaminant of concern in Taupo is PM_{10}, particles in the air less than 10 microns in diameter. Concentrations of PM_{10} have exceeded the National Environmental Standard (NES) of 50 µg/m^3 at the Taupo monitoring site. However a decrease in PM_{10} concentrations has been observed in more recent years and it now appears that the site may be close to compliance with the NES for PM_{10}. The purpose of this emission inventory is to evaluate changes in emissions to air and the contribution of different sources to these emissions over time to evaluate the extent of any decrease in emissions.

Sources included in the inventory are domestic heating, motor vehicle, industrial and commercial activities and outdoor burning. Natural source contributions (for example; sea salt and soil) are not included because the methodology to estimate emissions is less robust. While the evaluation focuses on PM_{10} other contaminants also evaluated include: carbon monoxide, nitrogen oxides, sulphur oxides, volatile organic compounds, carbon dioxide, benzene and benzo(a)pyrene.

A domestic home heating survey was undertaken to determine the proportions of households using different heating methods and fuels. The results show that wood burners and electricity are the most common method of heating the main living area each with 42% of households using them. This is similar to 2009 when around 45% of households were found to use wood burners.

Domestic heating is the main source of PM_{10} emissions in Taupo, accounting for 97% of daily winter emissions. Other sources included transport (2%) and outdoor burning (1%). The industrial contribution to PM_{10} emissions in Taupo was negligible as the industrial area to the north east of the urban area is excluded from the Taupo urban area inventory. On an average winter's night, around 561 kilograms of PM_{10} are discharged from these sources.

A previous emission inventory for Taupo conducted in 2009 estimated around 747 kilograms of PM_{10} were discharged on an average winters night of which 683 kilograms was from domestic home heating and 49 kilograms was motor vehicles. However, the latter is likely to have been overestimated by around 20 kilograms as a result of a likely overestimate of vehicle kilometres travelled (VKT). A revised motor vehicle estimate for 2009 is 29 kilograms making the 2009 total 727. This assessment indicates a reduction in total PM_{10} emissions in Taupo of around 23% from 2009 to 2014. The majority of this occurs as a result of a decrease in PM_{10} emissions from domestic heating. The estimated reduction in PM_{10} emissions over this time is consistent with an evaluation of trends in PM_{10} concentrations in Taupo which suggests a reduction in PM_{10} concentrations of around 24% occurring mostly between 2009 and 2010.

1 INTRODUCTION

The main air contaminant of concern in Taupo is PM_{10}, particles in the air less than 10 microns in diameter. Concentrations of PM_{10} have exceeded the National Environmental Standard (NES) limit of 50 µg/m^3 at the Taupo monitoring site since monitoring commenced in November 2000. However a decrease in PM_{10} concentrations has been observed in more recent years and it now appears that the site may be close to compliance with the NES for PM_{10}. An evaluation of trends in PM_{10} concentrations when data are adjusted for meteorological conditions shows a reduction in PM_{10} concentrations between 2009 and 2010 in Taupo of around 24% (Wilton, 2013). Management measures to further reduce PM_{10} by around 14% are recommended for on-going NES compliance.

The purpose of this emission inventory is to evaluate changes in emissions to air and the contribution of different sources to these emissions over time to evaluate the extent of any decrease in emissions. The sources that are included in emissions inventories in New Zealand are generally the domestic heating, motor vehicle, industrial and commercial and outdoor burning sector. Natural source contributions (for example; sea salt and soil) are not included because methodologies are less robust.

This report primarily focuses on emissions of particles (PM_{10}) from domestic heating, motor vehicles, industrial and commercial activities and outdoor burning in Taupo. Other contaminants included in this emission inventory are carbon monoxide, nitrogen oxides, sulphur oxides volatile organic compounds, carbon dioxide, benzene and benzo(a)pyrene. Previously an emission inventory for Taupo was carried out in 2009 (Wilton, 2009). Changes in PM_{10} emissions in Taupo since 2009 will be assessed and compared with the observed reduction in PM_{10} concentrations.

2 INVENTORY DESIGN

This emission inventory focuses on PM_{10} emissions as PM_{10} has been identified as the main contaminant of concern in urban New Zealand. It is unlikely that concentrations of other contaminants are likely to exceed national environmental standards (NES).

No NES exists for benzo(a)pyrene (BaP). However, concentrations of this contaminant have been found to be high and in excess of ambient air quality guidelines in Christchurch. A strong correlation was found with PM_{10} concentrations, which in Christchurch occur as a result of emissions from domestic home heating, and BaP concentrations (McCauley, 2005). In Hamilton, where PM_{10} concentrations rarely exceed 50 µg m^{-3} the annual average concentration for BaP was measured as 0.4 ng m^{-3} for the period March 2007 to March 2008. This result was statistically indistinguishable from the annual average guideline for BaP of 0.3 ng m^{-3}. However, the results reinforce the potential for high BaP concentrations within the Waikato Region in areas that have PM_{10} concentrations that are higher than Hamilton and result from domestic home heating.

2.1 Selection of sources

Estimates of emissions from the domestic heating, motor vehicles, industry and outdoor burning sector are included in the emissions inventory. The report also discusses PM_{10} emissions from a number of other minor sources.

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), benzene and benzo(a)pyrene (BaP). The latter contaminant has been included here because of the potential issues identified above.

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.) should detailed data on this source be required. Volatile organic compounds are typically included in emission inventory investigations because of their potential contribution to the formation of photochemical pollution. It is unlikely that ozone formation from emissions within Taupo, Thames or Huntly would cause ozone problems. However, ozone formation as a result of emissions from Auckland could impact on areas such as Thames. 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

Taupo is located on the shores of Lake Taupo, New Zealand's largest lake, north east of where the Waikato River begins. It is located in the centre of a volcanic and geothermal area. Mount Tauhara lies six kilometres to the east of Taupo and the area is surrounded by forestry. Taupo is located 53 kilometres north of Turangi. The Taupo airshed (Figure 2.1) is unusual in having two distinct areas, one being predominantly urban and the other, to the northeast, being mainly industrial. Under most circumstances, contributions from one area to the other are expected to be minimal. The main focus of this emissions inventory is the urban part of the Taupo airshed, which will be referred to as urban Taupo. However, as part of this work, total PM_{10} emissions from the five significant industrial sources that are located within the industrial part of the Taupo airshed were also estimated. The Taupo inventory study area is based on census area unit (CAU) boundaries.

The census area units used in the emission inventory for Taupo are: Lakewood, Rangatira, Nukuhau, Taupo Central, Tauhara, Hilltop, Waipahihi and Richmond Heights.

Figure 2.1 shows the Airshed boundaries for Taupo, including the industrial area to the northeast of the Taupo urban area. The red numbers on the map depict the location of air discharge resource consents.

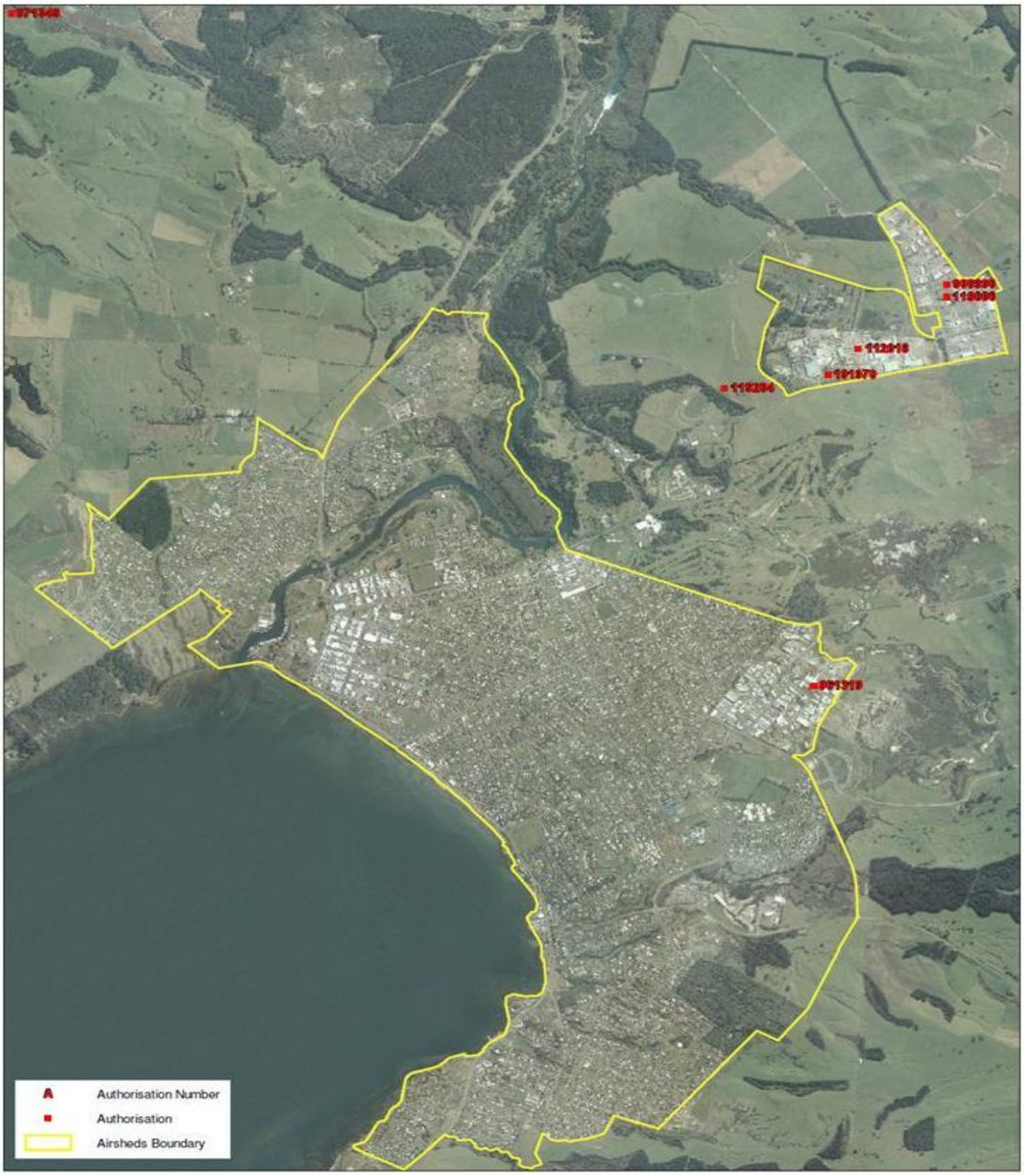

Figure 2.1: Taupo Airshed (source Waikato Regional Council).

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.

3 DOMESTIC HEATING

3.1 Methodology

Domestic heating methods and fuel use used by households in Taupo was collected using a household survey carried out by Digipol during June 2014 (Appendix A). Table 3.1 shows the number of households based on 2013 census data for the Airshed area and survey details.

Table 3.1: Summary household, area and survey data for the Taupo Airsheds.

	Households by census area unit 2013	Sample size	Area (ha)	Sample error
Taupo	8028	360	1669	5%

Home heating methods were classified as; electricity, open fires, wood burners 10 years or older (pre 2004), wood burners five to 10 years old (2005-2009), wood burners less than five years old (post 2009), pellet fires, multi fuel burners, gas burners and oil burners. The post 2005-2009 and post 2009 wood burner categories would contain wood burners meeting the NES design criteria, although the latter was introduced in September 2005 and so the 2005-2009 wood burner category may therefore include some burners installed early 2005 that do not comply with the NES.

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.

	PM_{10} g/kg	CO g/kg	NOx g/kg	SO_2 g/kg	VOC g/kg	CO_2 g/kg	Benzene g/kg	BaP g/kg
Open fire - wood	10	100	1.6	0.2	30	1600	0.97	0.002
Open fire - coal	21	80	4	5.0	15	2600	0.00065	2.70E-06
Pre 2004 burners	9	90	0.5	0.2	24	1600	0.97	0.003
Post 2004 burners	4.5	45	0.5	0.2	12	1600	0.97	0.003
Pellet burners	2	20	0.5	0.2	12	1600	0.97	0.003
Multi-fuel[1] - wood	13	130	0.5	0.2	39	1600	0.97	0.002
Multi-fuel[1] – coal	28	120	1.2	3.0	15	2600	0.97	2.70E-06
Oil	0.3	0.6	2.2	3.8	0.25	3200	0.00065	
Gas	0.03	0.18	1.3	7.6E-09	0.2	2500	2.16E-05	

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

The average weight for a log of wood is one of the assumptions required for this inventory to convert householder's estimates of fuel use in logs per evening to a mass measurement required for estimating emissions. 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. More recently a similar study was carried out in Nelson, Rotorua and Taumaranui.

Results of fuel use from that study indicated an average fuel weight of 1.7 kilograms per log. The previous inventory for Taupo (Wilton, 2009) used 1.6 kg and it is recommended that this value is used for this inventory.

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

3.2 Home heating methods

Table 3.3 shows wood burners and electricity were the main heating methods in Taupo with 42% of households using each method to heat their main living area. Heat pumps were the most common type of electric heating method with 60% of households using electricity using them (Figure 3.1). Around 16% of households used gas for home heating. Open fires were used by only three percent of Taupo residents and no houses surveyed reporting using coal as fuel. Table 3.3 also shows that households rely on more than one method of heating their main living area during the winter months.

Around 72 tonnes of wood is burnt per typical winters night in Taupo. This compares with around 87 tonnes of wood during 2009.

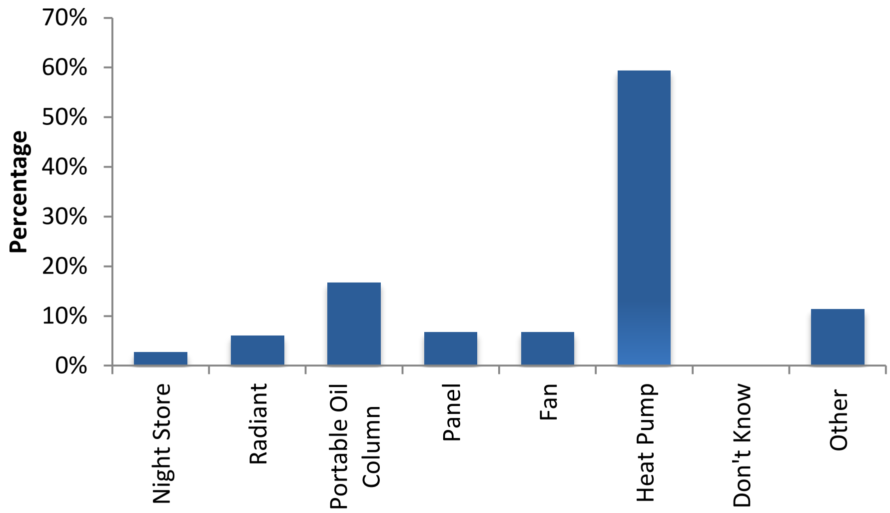

Figure 3.1: Electric heating options for Taupo households (main living area).

Table 3.3: Home heating methods and fuels in Taupo.

	Heating methods		Fuel Use	
	%	HH	t/day	%
Electricity	42%	3,345		
Total Gas	16%	1,249	0.5	1%
Flued gas	11%	872		
Unflued gas	5%	377		
Oil	0%	22	0.1	0%
Open fire	3%	223		
Open fire - wood	3%	223	2.8	4%
Open fire - coal	0%	0		0%
Total Woodburner	42%	3,390	68.2	93%
Pre 2004	21%	1,695	34.1	47%
2004-2008 wood burner	11%	888	17.9	24%
Post-2008 wood burner	10%	807	16.2	22%
Multi-fuel burners	1%	112		
Multi-fuel burners-wood	1%	89	1.5	2%
Multi-fuel burners-coal	0%	0	0.0	0%
Pellet burners	0%	0		0.0%
Total wood	46%	3,702	73	99.2%
Total coal	0%	0	0	0.0%
Total		8,028	73	100%

3.3 Emissions from domestic heating

Around 60% of the daily PM_{10} emissions from domestic heating during the winter are from pre 2004 wood burners (Figure 3.2). Wood burners installed during the years 2004 to 2008 contribute to 16% of domestic heating PM_{10} emissions and burners less than five years old contribute 14%. Multi fuel burners and open fires collectively contribute 10% of PM_{10} from domestic heating.

Tables 3.4 and 3.5 show the estimates of emissions for different heating methods under average and worst-case scenarios. Average daily wintertime PM_{10} emissions are around 542 kilograms per day. Days when households may not be using specific home heating methods are accounted for in this method[1]. Under the worst-case scenario around 626 kilograms of PM_{10} are discharged from all households using solid fuel burners on a particular night.

Figures 3.3 and 3.4 show the monthly variation in appliance use and average days per week used. The seasonal variation in contaminant emissions is shown in Table 3.6. Figure 3.5 indicates that the majority of the annual PM_{10} emissions from domestic home heating occur during June, July and August.

[1] Total fuel use per day is adjusted by the average number of days per week wood burners are used (e.g.,6/7) and the proportion of wood burners that are used during July (e.g.,95%).

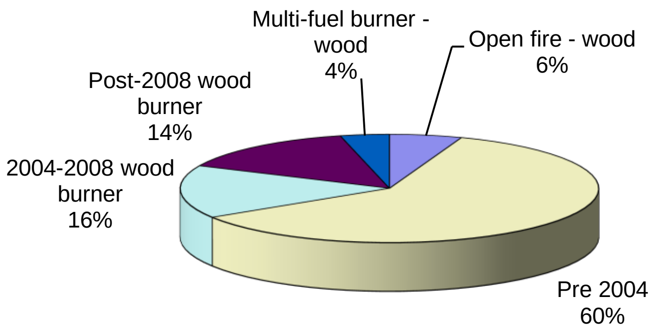

Figure 3.2: Relative contribution of different heating methods to average daily PM_{10} (winter average) from domestic heating in Taupo.

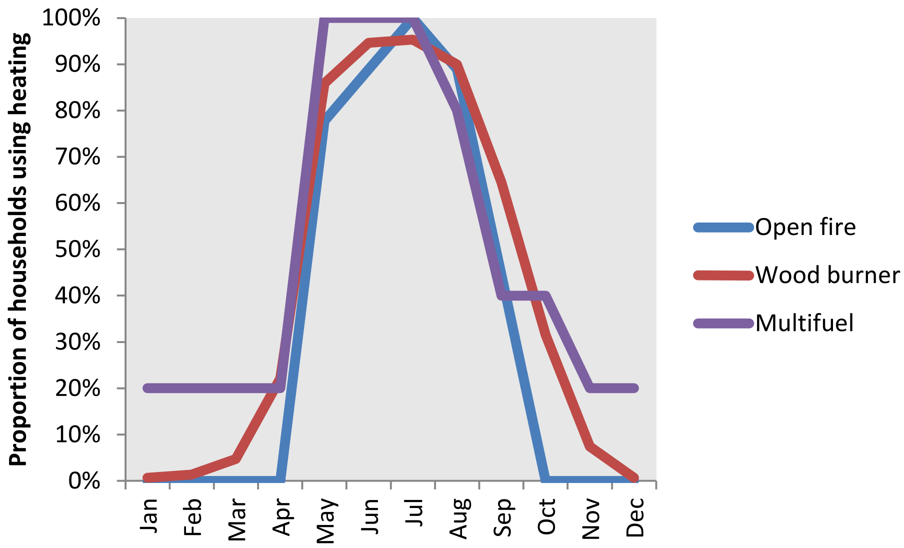

Figure 3.3: Monthly variations in appliance use in Taupo.

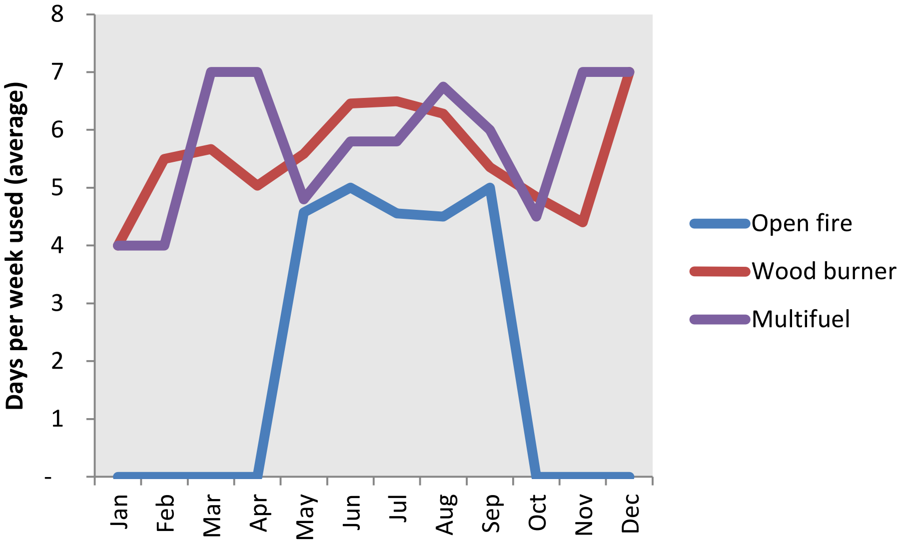

Figure 3.4: Average number of days per week appliances are used in Taupo.

Table 3.4: Taupo winter daily domestic heating emissions by appliance type (winter average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			BaP		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%	kg	g/ha	%	kg	g/ha	%
Open fire																										
Open fire - wood	2.8	4%	28	17	5%	284	170	5%	5	3	11%	1	0	4%	85	51	6%	5	3	4%	3	2	4%	0.0	0	3%
Open fire - coal	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.0	0	0%
Wood burner	68.2																									
Pre 2004 wood burner	34.1	47%	341	204	63%	3410	2043	59%	17	10	42%	7	4	46%	818	490	60%	55	33	46%	33	20	47%	0.1	0	48%
2004-2008 wood burner	17.9	24%	80	48	15%	1250	749	22%	9	5	22%	4	2	24%	214	128	16%	29	17	24%	17	10	25%	0.1	0	25%
Post 2008 wood burner	16.2	22%	73	44	13%	650	389	11%	8	5	20%	3	2	22%	195	117	14%	26	16	22%	16	9	22%	0.0	0	23%
Pellet Burner	0.0	0%	0.0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.0	0	0%
Multi fuel burner																										
Multi fuel– wood	1.5	2%	19	12	4%	192	115	3%	1	0	2%	0	0	2%	58	35	4%	2	1	2%	1	1	2%	0.0	0	1%
Multi fuel – coal	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.0	0	0%
Gas	0.5	1%	0	0	0%	0	0	0%	1	0	2%	0	0	0%	0	0	0%	1	1	1%	0	0	0%	0.0	0	0%
Oil	0.1	0%	0	0	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	72.5	99%	542	325	100%	5787	3467	100%	39	24	98%	15	9	99%	1371	821	100%	116	70	99%	70	42	100%	0.2	0	100%
Total Coal	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.0	0	0%
Total	73		542	325		5787	3467		40	24		15	9		1371	821		117	70		70	42		0.2	0	

Table 3.5: Taupo winter daily domestic heating emissions by appliance type (worst case average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			BaP		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%	kg	g/ha	%	kg	g/ha	%
Open fire																										
Open fire - wood	4.4	5%	44	26	7%	437	262	7%	7	4	15%	1	1	5%	131	79	8%	7	4	5%	4	3	5%	0.0	0	4%
Open fire - coal	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.0	0	0%
Wood burner	77																									
Pre 2004 wood burner	39	46%	386	231	62%	3856	2310	58%	19	12	41%	8	5	46%	925	554	58%	62	37	46%	37	22	46%	0.1	0	47%
2004-2008 wood burner	20	24%	91	54	15%	1414	847	21%	10	6	21%	4	2	24%	242	145	15%	32	19	24%	20	12	24%	0.1	0	25%
Post 2008 wood burner	18	22%	83	50	13%	734	440	11%	9	6	19%	4	2	22%	220	132	14%	29	18	22%	18	11	22%	0.1	0	23%
Pellet Burner		0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.0	0	0%
Multi fuel burner																										
Multi fuel– wood	1.8	2%	23	14	4%	232	139	3%	1	1	2%	0	0	2%	70	42	4%	3	2	2%	2	1	2%	0.0	0	1%
Multi fuel – coal	0.0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.0	0	0%
Gas	0.6	1%	0	0	0%	0	0	0%	1	0	2%	0	0	0%	0	0	0%	2	1	1%	0	0	0%	0.0	0	0%
Oil	0.0548 361	0%	0	0	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	83	99%	626	375	100%	6673	3998	100%	46	28	98%	17	10	99%	1589	952	100%	133	80	99%	81	48	100%	0.2	0	100%
Total Coal	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.0	0	0%
Total	84		626	375		6673	3998		47	28		17	10		1589	952		135	81		81	48		0.2	0	

Table 3.6: Monthly variations in contaminant emissions from domestic heating in Taupo.

	PM_{10} kg/day	CO kg/day	NOx kg/day	SOx kg/day	VOC kg/day	CO_2 t/day	Benzene kg/day	BaP kg/day
January	4	40	0	0	11	1	0	0.0
February	7	73	0	0	18	1	1	0.0
March	21	225	1	1	54	4	3	0.0
April	77	822	5	2	193	17	10	0.0
May	421	4495	31	11	1065	91	55	0.2
June	535	5710	40	15	1352	116	69	0.2
July	542	5787	40	15	1371	117	70	0.2
August	494	5275	36	13	1249	107	64	0.2
September	243	2596	18	7	612	53	32	0.1
October	105	1124	7	3	263	23	14	0.0
November	25	266	2	1	64	5	3	0.0
December	7	70	0	0	19	1	1	0.0
Total (kg/year)	76013	811385	5562	2045	192138	16443	9856	30

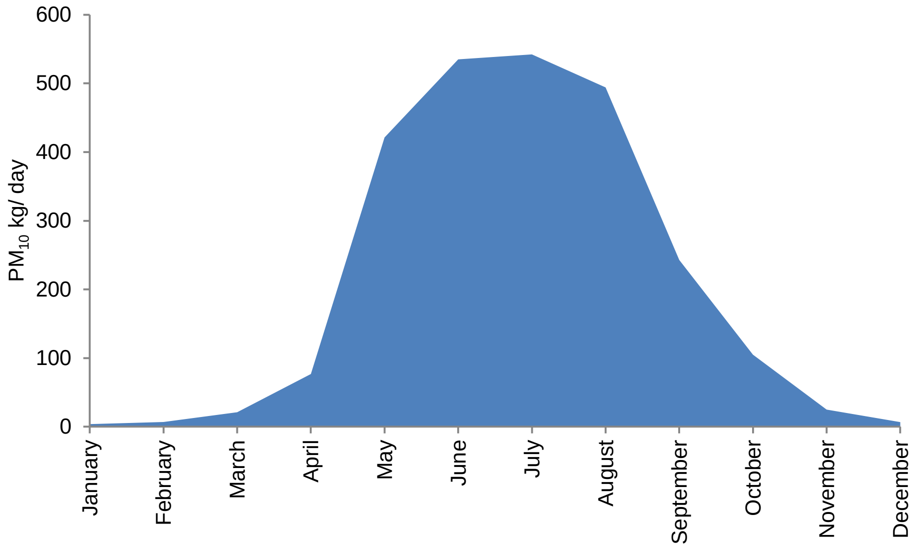

Figure 3.5: Monthly variations in PM_{10} emissions from domestic heating in Taupo as a proportion of annual emissions.

4 MOTOR VEHICLES

4.1 Methodology

Motor vehicle emissions to air include tailpipe emissions and particulate emissions occurring as a result of the wear of brakes and tyres. Assessing emissions from motor vehicles involves collecting data on vehicle kilometres travelled (VKT) and the application of emission factors to these data.

Historically the emission factors used for motor vehicle emissions assessments in New Zealand were taken from the New Zealand Traffic Emission Rates (NZTER) database using local vehicle fleet profiles derived from motor vehicle registrations. The NZTER database was developed by the Ministry of Transport (MOT) based on measured emission rates from actual vehicle emissions tests on New Zealand vehicles under various road and traffic conditions. However, assumptions underpinning the model were not documented. As a result, the Auckland Regional Council developed the Vehicle Emission Prediction Model (VEPM 3.0). Emission factors for PM_{10}, CO, NOx, VOCs and CO_2 for this study have been based on VEPM 3.0. Default settings were used for all variables except for the vehicle fleet profile which was based on Taupo vehicle registration data for the year ending 31 May 2014 (Table 4.1) and the annual average temperature was based on temperature data for Taupo. Resulting emission factors are shown in Table 4.2.

Emission factors for SOx were estimated for diesel vehicles based on the sulphur content of the fuel (0.01%) and the assumption of 100% conversion to SOx. Total VKT for diesel vehicles were estimated based on the proportion of diesels in the vehicle fleet.

No emission factor data for BaP are available for motor vehicle emissions in New Zealand. Emission factors for BaP used here have been taken from USEPA - emission factors for estimating mobile source PAH emissions in the National Toxics Inventory (www.epa.gov/ttn/chief/nti/index.html#info). These are based on a proportion of the PM_{10} and was estimated at 0.0008 x PM for this study based on the proportion of heavy versus light vehicles. This estimate will be highly approximate because of differences in fuel composition and should therefore be treated with caution.

The number of vehicle kilometres travelled (VKT) for the airshed was estimated using the New Zealand Transport Authority VKT data for 2013 available at the census area unit level. The total was extrapolated (scaled up) based on the additional households in the airshed as opposed to historical inventory area defined by CAUs. Table 4.3 shows the estimated VKTs distributed by time of day splits from the Taupo transport model.

Table 4.1: Vehicle registrations in Taupo for the year ending May 2014.

Taupo	Petrol	Diesel	LPG	Other	Total
Cars	18,909	2,631	6	0	21,546
LCV	1,363	3,172	4	0	4,539
Bus	53	184			237
HCV		2,203			2,203
Miscellaneous	414	358	7	0	779
Motorcycle	1,046				1,046
Total	21785	8548	17	0	30,350

Table 4.2: Emission factors for 2014 for Taupo vehicle fleet

Driving Conditions	CO g/VKT	CO_2 g/VKT	VOC g/VKT	NOx g/VKT	PM_{10} g/VKT	PM brake & tyre g/VKT	Benzene g/VKT
Taupo	4.22	250.11	0.27	0.72	0.04	0.01	0.01

Table 4.3: VKT by time of day for Taupo for 2013.

	Total VKT	Time of day			
		6am-10am	10am-4pm	4pm-10pm	10pm-6am
Taupo	171829	40646	86437	69951	12597

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/VKT) * VKT

4.2 Motor vehicle emissions

Around 10 kilograms per day of PM_{10} are estimated to occur from motor vehicle emissions in Taupo. This compares with around 49 kilograms per day in 2009. The main cause of the difference is a reduction in VKTs and improved tailpipe emissions. The road network model used previously to estimate VKTs gives a high estimate relative to the NZTA estimates, although the latter approach also suggests a reduction in VKT of around 40% since 2010. This is likely to have occurred as a result of the opening of the East Taupo Arterial in October 2010. A re-estimate of 2009 emissions based on NZTA VKTs suggest around 29 kilograms of PM_{10} per day is more realistic for 2009 indicating a reduction in PM_{10} of 19 kilograms from motor vehicle emissions since 2009.

Around 21% of the PM_{10} from motor vehicles is estimated to occur as a result of the wearing of brakes and tyres.

Other contaminant emissions from motor vehicles in Taupo include around 885 kilograms of CO, 151 kilograms of NOx and one kilogram of SOx (Table 4.4).

Table 4.4: Summary of daily motor vehicle emissions in Taupo

		PM10		CO		NOx		SOx	
	Hectares	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Taupo	1669	10	6	885	530	151	90	1	0
		VOC		CO_2		Benzene		BaP	
	Hectares	kg	g/ha	t	kg/ha	kg	g/ha	kg	g/ha
Taupo	1669	56	33	52	31	3	2	0.0006	0

5 INDUSTRIAL AND COMMERCIAL

5.1 Methodology

Information on activities discharging to air in Taupo were provided by the Waikato Regional Council.

Schools in Taupo were also surveyed by phone or email to determine the source of their heating. The results showed that only one school uses a coal boiler in Taupo. The remaining schools use natural gas, electricity or geothermal power for heating. Emissions from gas boilers were not included in the inventory as the PM10 emissions from them are negligible for small to medium size boilers. Seven industrial and commercial premises were included in the inventory.

The selection of industries for inclusion in this inventory was based 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.

For most industries included in the assessment, site specific emissions data was available from the resource consent application. Emissions were estimated based on equation 5.1.

Equation 5.1 Emissions (kg/day) = Emission rate (kg/hr) x hrs per day (hrs)

Where site specific emissions data were not available, emissions were estimated using activity data and emission factor information, as indicated in Equation 5.2. 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 were collected using a phone survey or data provided by Waikato Regional Council staff. Data were collected for winter, autumn, spring and summer.

Equation 5.2 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. Other emission factors are from the USEPA AP42 database[2].

Fugitive dust emissions from industrial and commercial activities were not included in the inventory assessment because of difficulties in quantifying the emissions.

Table 5.1: Emission factors for industrial discharges.

	PM_{10} g/kg	CO g/kg	NOx g/kg	SOx g/kg	VOC g/kg	CO_2 g/kg	BaP g/kg
Underfeed stokers	2.0	5.5	4.8	13.5	0.1	2400	0.00002

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

5.2 Industrial and commercial emissions

5.2.1 Urban Airshed

Three industrial activities with discharges to air significant enough to require resource consent were found in the Taupo urban area. However, one activity was still under construction and another did not discharge PM_{10} except in backup situations. Emission estimates were made based on the remaining industrial activity plus school boilers in the area. Less than 1 kilogram of PM_{10} is estimated to be discharged to air from industrial and commercial activities in the Taupo urban airshed (Table 5.2). This is similar to the 2009 emission inventory which also showed negligible PM_{10} from industry within the urban area.

5.2.2 Industrial Airshed

An estimate of PM_{10} emissions was made for the industrial airshed area of Taupo and was based on activities holding discharge to air resource consents. It is noted, that other sources, for example, domestic heating and motor vehicles in that airshed have not been examined, but are likely to be minimal. Results indicate that around 102 kilograms of PM_{10} per day could be expected from the five industries in the area that are operational during 2014. This is less than one third of the 380 kg/day estimated in 2009. The main reasons for the decrease in PM_{10} emissions are a fire at the Laminex Group which has rendered some parts of the plant unusable and improvements in the particulate emission rates from the dryers at Solid Energy.

Table 5.2: Summary of industrial emissions (daily winter) in Taupo within the main urban part of the Airshed.

		PM_{10}		CO		NOx		SOx	
	Hectares	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Taupo	1669	0.1	0.1	0.0	0.0	0.4	0.2	0.0	0.0

		VOC		CO_2		Benzene	
	Hectares	kg	g/ha	t	kg/ha	kg	g/ha
Taupo	1669	0.0	0.0	0.3	0.2	0.0	0.0

Table 5.3: Summary of industrial emissions (daily winter) in the Taupo industrial Airshed

		PM_{10}		CO		NOx		SOx	
	Hectares	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Industrial	132	102	777	1839	13945	203	1538	0	0

		VOC		CO_2		Benzene	
	Hectares	kg	g/ha	t	kg/ha	kg	g/ha
Industrial	132	40	300	289	2193	5	36

6 OUTDOOR BURNING

Outdoor burning of green wastes or household material can contribute to PM_{10} concentrations and also discharge other contaminants to air. 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 burning in a drum, incinerator or open air on residential properties in the study area.

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 Taupo, were estimated for the winter months based on data collected during the 2014 domestic home heating survey. The survey showed 4% of households in Taupo burnt rubbish in the outdoors during the winter. On average there are around nine fires per day during winter. Emissions were calculated based on the assumption of an average weight of material per burn of 75 kilograms and using the emission factors in Table 6.1 with an average fire size of 1 m^3. Emission factors of benzene and BaP were based on wood burning for domestic heating and are indicative only. Emissions of these contaminants will be largely influenced by the material burnt, in particular the inclusion of household rubbish and plastics.

Estimates of PM_{10} and other emissions are detailed in sections 6.2 to 6.4. It should be noted, however, that there are a number of uncertainties relating to the calculations. 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.

Table 6.1: Outdoor burning emission factors (AP42, 2002).

	PM10 g/kg	CO g/kg	NOx g/kg	SOx g/kg	VOC g/kg	CO2 g/kg	Benzene g/kg	BaP g/kg
Outdoor burning	8	42	3	0.5	4	1470	0.97	0.003

6.2 Outdoor burning emissions

Around nine kilograms of PM_{10} from outdoor burning could be expected per day during the winter months on average in Taupo. Outdoor burning also produces around 28 kilograms of carbon monoxide and around one tonne of carbon dioxide on average per day during winter.

Table 6.2: Outdoor burning emission estimates for Taupo.

	PM10 kg/ day	CO kg/ day	NOx kg/ day	SOx kg/ day	VOC kg/ day	CO2 t/ day	Benzene kg/day	BaP kg/day
Summer (Dec-Feb)	8	28	2	0	3	1	0.3	0.002
Autumn (Mar-May)	10	32	2	0	3	1	0.4	0.000
Winter (June-Aug)	9	29	2	0	3	1	0.3	0.002
Spring (Sept-Nov)	12	41	3	0	4	1	0.5	0.001

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. These sources are not typically included because the methodology used to estimate the emissions is less robust.

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].

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

8 TOTAL EMISSIONS

In the urban area of the Taupo airshed, around 561 kilograms of PM_{10} is discharged to air on an average winter's day. This compares with an estimated 727 kilograms per day for 2009 (after taking into account differences in VKT methods) indicating a reduction in emissions of around 23% since 2009. Figure 8.1 shows that domestic home heating is the main source of PM_{10} emissions contributing 97% of the daily wintertime emissions. Transport contributes two percent, outdoor burning contributes one percent and industry has a negligible contribution to total wintertime PM_{10} emissions.

It has been noted that the Taupo airshed (**Error! Reference source not found.**) is unusual in having two distinct areas, one being predominantly urban and the other, to the northeast, being mainly industrial. If the industrial emission contribution of 102 kg of PM_{10} per day from the industrial area of the airshed to the northeast was added to the urban contributions then the industrial contribution would increase to around 15%. However, under most circumstances, contributions from one area to the other are expected to be minimal based on previous air dispersion modelling evidence[4]. Therefore it is not considered appropriate to add the northeastern industrial emissions to the urban emissions.

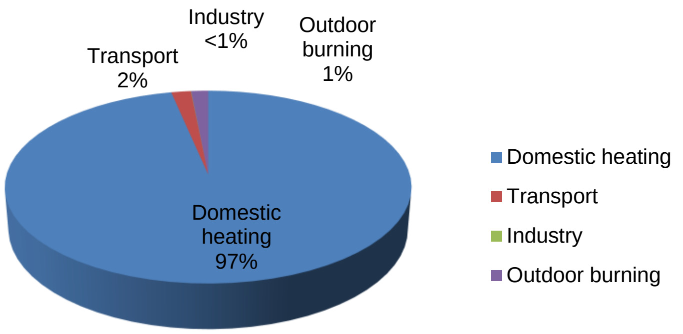

Figure 8.1: Relative contribution of sources to daily winter PM_{10} emissions in the urban area of the Taupo airshed.

An estimate of the spatial distribution of PM_{10} emissions from all sources in Taupo are shown in Figure 8.2. The estimate of spatial distribution is based on the location of households burning wood and coal from the 2013 census combined with the 2014 emission inventory estimates for domestic heating. Emissions from other sources are included but are assumed to be spatially uniform across the study area.

[4] *Resource Consent Application and Assessment of Effects on the Environment – Proposed Wood Pellet Manufacturing Facility Discharges to Air*, dated October 2008 and prepared by Golder Associates (NZ) Ltd.

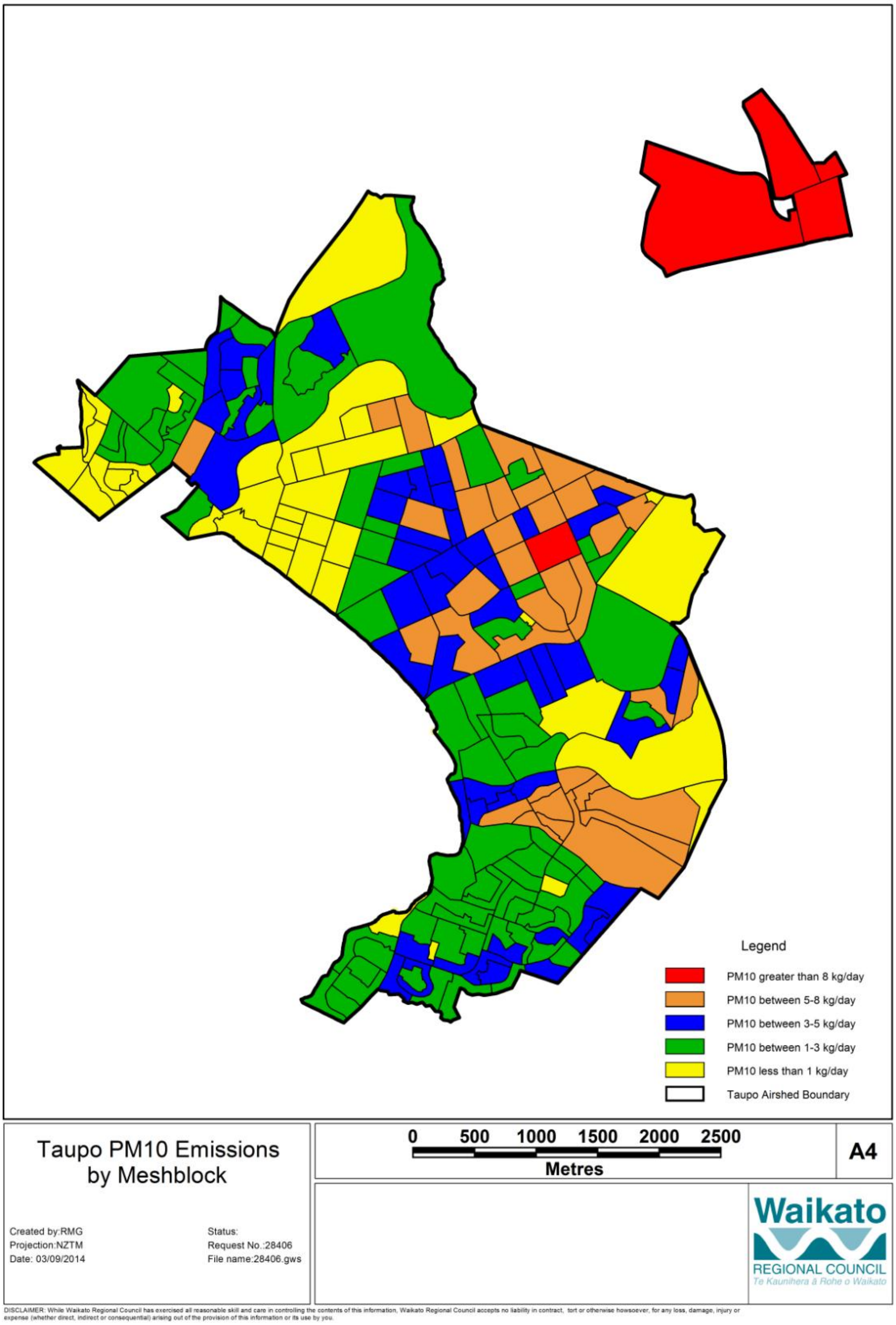

Figure 8.2: Estimate of the spatial distribution of PM_{10} emissions from all sources in Taupo

The reduction in PM_{10} emissions in the Taupo Airshed from 2009 to 2014 is illustrated in Figure 8.3 and similar changes in industrial emissions in the industrial Airshed are shown in Figure 8.4. Domestic home heating is also the main source of BaP, CO, SOx, VOCs and CO_2 in Taupo. Motor vehicles are the main source of NOx (Figure 8.5).

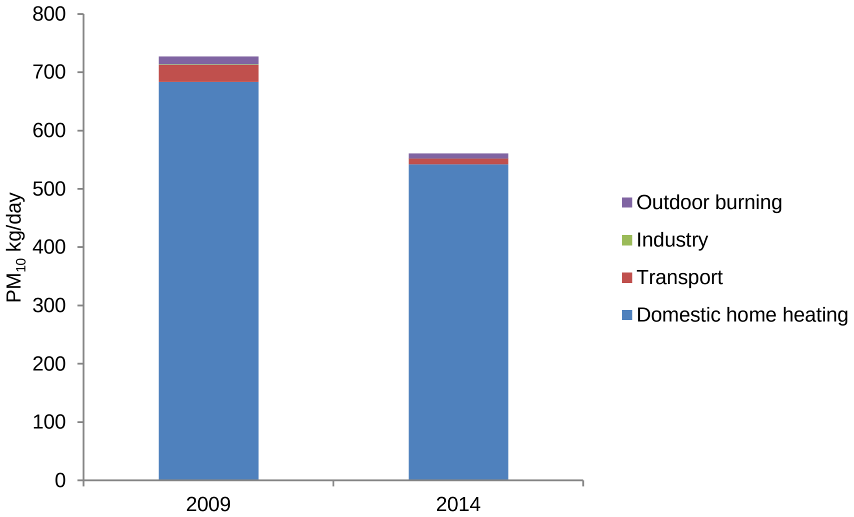

Figure 8.3: Comparison of estimated changes in PM_{10} emissions in the urban area of the Taupo airshed from 2009 to 2014.

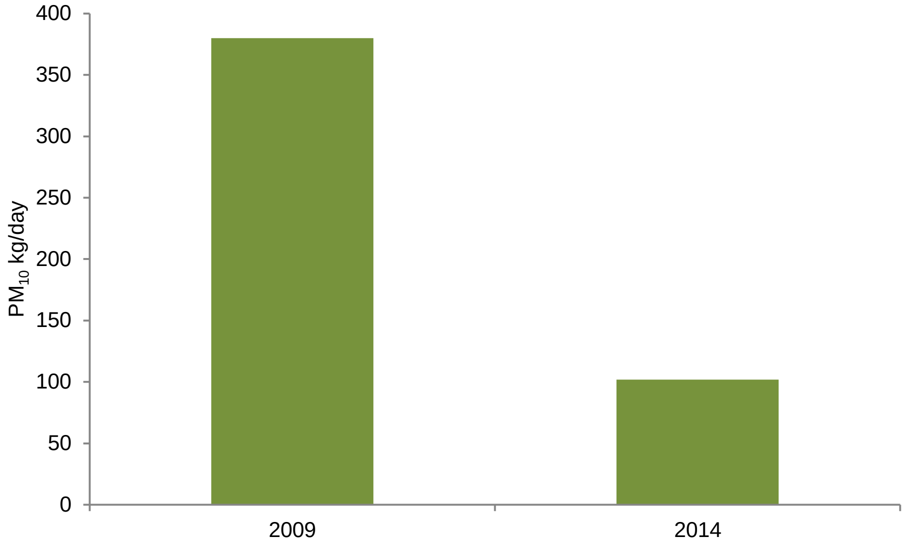

Figure 8.4: Comparison of estimated changes in PM_{10} emissions in the industrial airshed 2009 to 2014.

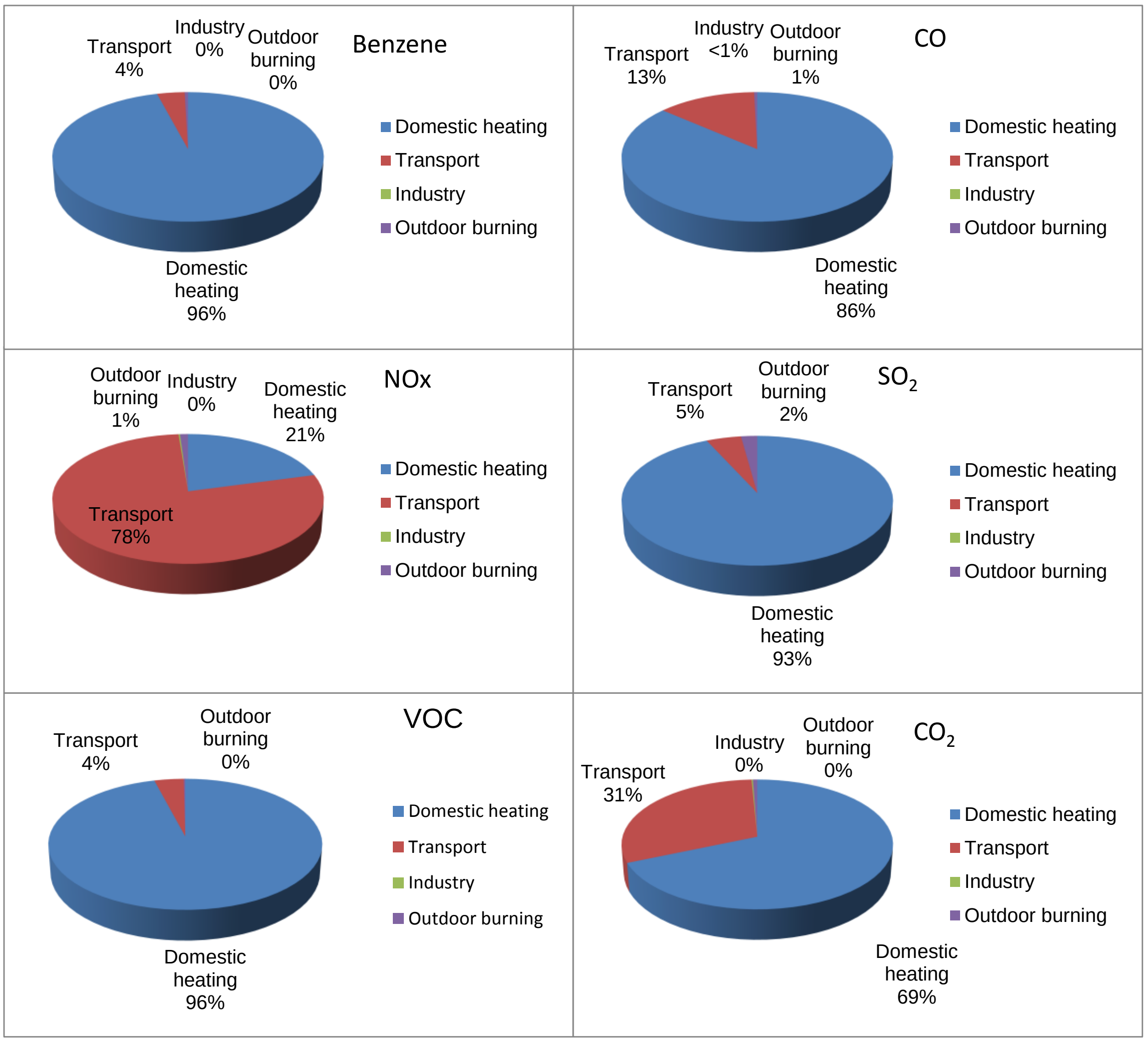

Figure 8.5: Relative contribution of sources to contaminant emissions in the urban area of the Taupo airshed.

Table 8.1 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, domestic heating, motor vehicles and outdoor burning are all contributors to PM_{10} emissions. Daily wintertime emissions of PM_{10} and other contaminants (kg/day and g/day/ha) are shown in Table 8.2.

Table 8.1: Monthly variations in daily PM_{10} emissions in Taupo.

	Domestic Heating		Outdoor Burning		Industry		Motor vehicles		Total
	kg/day	%	kg/day	%	kg/day	%	kg/day	%	kg/day
January	4	17%	8	37%	0.1	1%	10	45%	22
February	7	28%	8	33%	0.2	1%	10	39%	25
March	21	52%	10	24%	0.1	0%	10	24%	41
April	77	80%	10	10%	0.1	0%	10	10%	96
May	421	96%	10	2%	0.1	0%	10	2%	441
June	535	97%	9	2%	0.1	0%	10	2%	554
July	542	97%	9	2%	0.1	0%	10	2%	561
August	494	96%	9	2%	0.1	0%	10	2%	513
September	243	92%	12	5%	0.1	0%	10	4%	265
October	105	82%	12	10%	0.1	0%	10	8%	127
November	25	53%	12	26%	0.1	0%	10	21%	47
December	7	27%	8	33%	0.1	1%	10	39%	25
Total kg year	76013		3540		51		3608		

Table 8.2: Daily contaminant emissions from all sources in Taupo (winter average).

	PM_{10}		CO		NOx		SOx	
	Kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Domestic home heating	542	325	5787	3467	40	24	15	9
Transport	10	6	885	530	151	90	1	0
Industry	0.1	0.1	0.0	0.0	0.4	0.2	0.0	0.0
Outdoor burning	9	5	29	17	2	1	0	0
Total	561	336	6700	4015	193	116	16	9
	VOC		CO_2		BaP		Benzene	
Domestic home heating	1371	821	117	70	73	44	0.2	0.1
Transport	56	33	52	31	3	2	0.0	0.0
Industry	0.0	0.0	0.3	0.2	0.0	0.0	0.0	0.0
Outdoor burning	3	2	1	1	0	0	0.0	0.0
Total	1429	856	171	103	76	45	0.2	0.1

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9 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 decade/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?

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 wood burners 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 and with adjustments made to account for more recent real life testing of pre 1994 and NES compliant wood burners (Wilton & Smith, 2006; Smith, et. al., 2008) and burners meeting the NES design criteria for wood burners (Bluett, Smith, Wilton, & Mallet, 2009; Smith, Bluett, Wilton, & Mallet, 2009) .

The Christchurch 1999 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% to 20% figures quoted by Hennessy (1999). 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.

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. The burner age category for the latter testing is older (pre 1994) than the category included here (pre 2004). However, the main difference in burner design is between the older burners and those meeting the NES design criteria of 1.5 g/kg so the older emission factor has only been adjusted slightly to allow for some more modern burners that may have been installed pre 2004. Post 2006 emission factors were based on an emission factor of 4.5 g/kg based on an analysis by Wilton (2013).

The gas and oil PM_{10} emission factors were based on testing in New Zealand (Scott, 2004).

Domestic heating emission factors for CO, NOx, SOx and CO_2 were also based on the Christchurch 1999 emission factor revisions with adjustments made for relationships with PM_{10} where appropriate.

Emissions factors for BaP were based on AP42 factors for conventional wood burners (no baffles) for open fires and on phase II burners (with baffles, non catalytic) for wood burners. Benzene emission factors were based on AP42 for conventional wood burners. Benzene emission factors for coal burning was based on AP42 coal fired boiler data because no domestic information was available. Emission factors for BaP for coal burning was based on AP42 factors for burning anthracite coal on open fires as no data were available for bituminous or sub bituminous coals.

APPENDIX C – MESHBLOCK DATA PM_{10} EMISSIONS

meshbock no	kg/day	meshbock no	kg/day	meshbock no	kg/day	meshbock no	kg/day
MB 1279004	0	MB 1272700	4	MB 1269702	7	MB 1267600	3
MB 1279006	0	MB 1272800	8	MB 1269800	6	MB 1267701	3
MB 1279023	2	MB 1272900	4	MB 1269900	3	MB 1267703	3
MB 1279024	0	MB 1273000	1	MB 1270000	6	MB 1267704	3
MB 1275105	4	MB 1273100	4	MB 1270100	8	MB 1267705	0
MB 1275108	1	MB 1273200	2	MB 1270200	10	MB 1267800	2
MB 1275109	3	MB 1273300	3	MB 1270300	5	MB 1267900	5
MB 1275110	2	MB 1273400	2	MB 1270400	6	MB 1268000	4
MB 1275111	4	MB 1273500	0	MB 1270501	3	MB 1268100	4
MB 1275112	1	MB 1273600	2	MB 1270503	1	MB 1268205	5
MB 1275113	4	MB 1273700	1	MB 1270504	7	MB 1268206	1
MB 1275114	4	MB 1273800	0	MB 1270600	1	MB 1268207	7
MB 1275115	2	MB 1273900	1	MB 1270700	2	MB 1268208	2
MB 1275116	3	MB 1274000	0	MB 1270800	1	MB 1268209	4
MB 1275117	4	MB 1274100	0	MB 1270900	0	MB 1268210	3
MB 1275200	6	MB 1274200	0	MB 1271000	7	MB 1268211	3
MB 1275301	4	MB 1274300	0	MB 1271100	8	MB 1268212	5
MB 1279602	3	MB 1274400	1	MB 1271200	7	MB 1268501	3
MB 1268300	2	MB 1274500	0	MB 1271300	3	MB 1268502	5
MB 1268400	4	MB 1274600	0	MB 1271400	1	MB 1268600	3
MB 1269000	4	MB 1274700	5	MB 1271500	2	MB 1268700	7
MB 1269100	4	MB 1274800	5	MB 1271600	6	MB 1268801	5
MB 1269200	5	MB 1274900	1	MB 1271700	6	MB 1268803	0
MB 1269300	4	MB 1275000	0	MB 1271800	5	MB 1268804	3
MB 1269400	7	MB 1275400	0	MB 1271900	2	MB 1268900	4
MB 1272000	4	MB 1275500	0	MB 1272100	6	MB 1279908	6
MB 1272300	4	MB 1275600	1	MB 1272200	5	MB 1266801	2
MB 1272400	4	MB 1269500	2	MB 1278802	0	MB 1266803	2
MB 1272500	3	MB 1269600	7	MB 1267400	2	MB 1266805	2
MB 1272600	5	MB 1269701	8	MB 1267500	3	MB 1266806	2

meshbock no	kg/day	meshbock no	kg/day	meshbock no	kg/day
MB 1266903	1	MB 1266616	3	MB 1279035	1
MB 1266904	2	MB 1266617	3	MB 1279036	1
MB 1266905	3	MB 1266618	2	MB 1279037	0
MB 1266906	3	MB 1266619	3	MB 1279038	1
MB 1266907	3	MB 1266620	5	MB 1279039	1
MB 1267010	3	MB 1266621	5	MB 1279040	0
MB 1267011	5	MB 1266701	2	MB 1279041	1
MB 1267101	4	MB 1266702	1	MB 1279042	2
MB 1267102	5	MB 1266703	3	MB 1279601	0

MB 1267200	3	MB 1266704	1	MB 1277501	4
MB 1267301	3	MB 1267004	3	MB 1277502	0
MB 1267302	1	MB 1267005	2	MB 1277601	3
MB 1267303	3	MB 1267006	4	MB 1277602	3
MB 1267304	1	MB 1267007	1	MB 1277700	3
MB 1280002	0	MB 1267008	4	MB 1277800	3
MB 1266403	2	MB 1267009	3	MB 1277900	0
MB 1266404	3	MB 1279014	0	MB 1278500	0
MB 1266405	3	MB 1279015	3	MB 1278801	34
MB 1266406	2	MB 1279016	2	MB 1279300	0
MB 1266407	2	MB 1279017	5	MB 1279700	0
MB 1266501	1	MB 1279018	2	MB 1279801	34
MB 1266502	1	MB 1279026	1	MB 1279802	34
MB 1266503	2	MB 1279027	1	MB 1279905	2
MB 1266609	4	MB 1279028	2		
MB 1266610	0	MB 1279029	2		
MB 1266611	4	MB 1279030	2		
MB 1266612	1	MB 1279031	0		
MB 1266613	3	MB 1279032	0		
MB 1266614	3	MB 1279033	1		
MB 1266615	4	MB 1279034	0		