Environment Waikato Technical Report 2001/17

# Taupo, Huntly, Putaruru and Matamata Domestic Heating Emission Inventory

Prepared by:
Emily Wilton
Environet Ltd
11 Lachie Griffin Rise
Governors Bay
Christchurch

For:
Environment Waikato
PO Box 4010
HAMILTON EAST

ISSN: 1172-4005

June 2001

Document #: 979630

Peer reviewed by:
Jeff Smith Initials ____________________ Date ______________

Approved for release by:
Dr. Vivienne Smith Initials ____________________ Date ______________

# Table of Contents



# List of Tables

# List of Figures

# Executive Summary

The burning of wood and coal for domestic home heating is the cause of air quality issues in many New Zealand towns. In the Waikato, air quality monitoring has already shown high concentrations of $PM_{10}$ in Te Kuiti. An earlier emission inventory for that area confirmed domestic fires were the main source of the $PM_{10}$ problem (Noonan, 1997).

The purpose of this emission inventory is to quantify the emissions to air from domestic space heating in the study areas of Taupo, Huntly, Matamata and Putaruru. These data can then be used to assist in prioritising future air quality monitoring and identifying contaminants that may be of concern. Emission inventories can also be an effective air quality management tool when used in conjunction with other data to determine the effectiveness of different management strategies in reducing emissions.

A survey of home heating methods and fuels was conducted in Taupo, Huntly, Matamata and Putaruru during winter of 2000. The burning of wood was the main method of home heating in Taupo, Matamata and Putaruru with around 50-60% of households using that fuel. In Huntly, the burning of wood, coal and gas were all common methods of home heating.

During the winter, 36 tonnes of wood and less than 0.5 tonne of coal is burnt in Taupo per day. This compares with 12, 26 and 14 tonnes of wood burnt in Huntly, Matamata and Putaruru, respectively. The greatest quantity of coal burnt per day is in Huntly – 26 tonnes. Other towns in the study area burn less than two tonnes of coal per day. Gas use ranges from one to five tonnes per day.

The greatest quantity of $PM_{10}$ emissions from domestic heating within the four towns occurs in Huntly where 860kg of $PM_{10}$ are discharged to air per day. This compares with 409kg in Taupo, 361kg in Matamata and 175kg in Putaruru. The majority of the $PM_{10}$ emissions from domestic heating in Huntly are from the burning of coal on open fires and enclosed burners. The burning of wood on open fires and older wood burners contributes the majority of the $PM_{10}$ domestic heating emissions in Taupo, Matamata and Putaruru.

Taupo has the lowest $PM_{10}$ emission rate relative to the size of the study area, emitting 409 g/ha per day compared with 1719, 657 and 438 g/ha in Huntly, Matamata and Putaruru, respectively. Carbon monoxide emission rates (g/ha) are highest in Matamata because of the predominance of wood use in that location. In Huntly, SOx emission rates are considerably higher than the other study areas reflecting the prevalence of coal burning in that location.

Emissions data from the four study areas were compared to results of the 1997 emission inventory for Hamilton, Te Kuiti and Tokoroa. The two studies show emission rates (g/ha) for $PM_{10}$ were highest in Huntly, Te Kuiti and Tokoroa. All areas, except Taupo and Putaruru, were found to have higher $PM_{10}$ emission rates than Christchurch, a city widely acknowledged as having a significant $PM_{10}$ problem. A monitoring schedule, based on emissions data alone, would therefore suggest giving priority to the monitoring of $PM_{10}$ in Huntly, Te Kuiti and Tokoroa. Monitoring of CO should also be considered in these towns, as should the monitoring of $SO_2$ in Huntly.

# 1 Introduction

The burning of wood and coal for domestic home heating has been found to be the cause of air quality issues in many New Zealand towns. In particular, concentrations of suspended particles ($PM_{10}$) in excess of ambient air quality guidelines have been attributed to that source in a number of locations. In Hamilton, $PM_{10}$ guidelines are within acceptable levels. However, elevated concentrations of $PM_{10}$ have been measured in other towns in the Waikato region, e.g., Te Kuiti, and it is possible that further areas within the region experience high concentrations of contaminants from domestic space heating.

The purpose of this study is to quantify the emissions to air from domestic space heating in the areas of Taupo, Huntly, Matamata and Putaruru. This type of study is referred to as an emission inventory and is the second investigation of this type carried out for the Waikato. The first emission inventory for the region, conducted in 1997 for the areas of Hamilton, Te Kuiti and Tokoroa, included emissions from domestic heating, motor vehicles and industry. Further work for Taupo, Huntly, Matamata and Putaruru may include an assessment of emissions from motor vehicles and industry.

Data from a domestic heating emission inventory can be used to identify areas that may require air quality monitoring and contaminants that may be of concern. Inventory data can assist with prioritising areas for monitoring, particularly when used in conjunction with data on meteorological conditions. It is not possible to assess whether an air quality problem exists based on emissions data alone, as the extent to which emissions in any area result in air quality problems will also depend on the impact of meteorology.

An emission inventory can also be used in conjunction with other data to determine the effectiveness of different management options in reducing concentrations of contaminants. For example, prohibiting the use of open fires may be an effective management strategy in a location where open fires make a significant contribution to emissions.

# 2 Inventory design

Limited information is available regarding key air quality issues in the towns of Taupo, Matamata, Putaruru and Huntly. While air quality monitoring is carried out in Huntly, the purpose of that programme is to assess the impact of industrial discharges, in particular the Huntly power station. Monitoring sites are thus located in areas that are unlikely to be representative of urban air pollution issues or general population exposure.

Air quality monitoring in other areas of the Waikato indicates concentrations of suspended particulate may be of concern in some smaller urban centres. For example, maximum $PM_{10}$ concentrations of 47 $\mu gm^{-3}$ (24-hour average) measured during a six-month monitoring period in Te Kuiti during 1998 were below the proposed ambient air quality guideline for $PM_{10}$ of 50 $\mu gm^{-3}$, but were within the Ministry for the Environment's "alert" environmental performance indicator (EPI) level (MfE, 2000). MfE (2000) recommends that air quality be enhanced when it falls within the "alert" category. Many other urban townships in New Zealand also experience high concentrations of $PM_{10}$ arising as a result of the burning of wood and coal for domestic space heating.

The main focus of this study is on daily wintertime emissions. This is because the $PM_{10}$ guideline is based on a 24-hour averaging period and because the highest concentrations of this contaminant are likely to occur during the wintertime, when wood and coal burning is at its peak.

## 2.1 Selection of sources

This report examines only the emissions from domestic space heating. Emissions from other sources (e.g., motor vehicles and industry) may be examined in the future to allow an assessment of the relative contribution of different sources. It is important, however, that an emission inventory relate to a particular point in time, in this case the year 2000, because emissions change with time. Consequently it will be necessary that the assessment of any additional sources for this inventory relate to emission rates from the year 2000.

## 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), and carbon dioxide ($CO_2$).

These contaminants were selected because of their potential for adverse effects and are the main contaminants surveyed in emission inventory investigations in New Zealand. A summary of guideline values for these contaminants, where applicable, and the types of impacts of concern are detailed in table 2.1. The inclusion of contaminants such as benzo(a)pyrene and $PM_{2.5}$ in future inventories should be considered, particularly in locations were $PM_{10}$ concentrations are of concern.

## 2.3 Selection of study areas

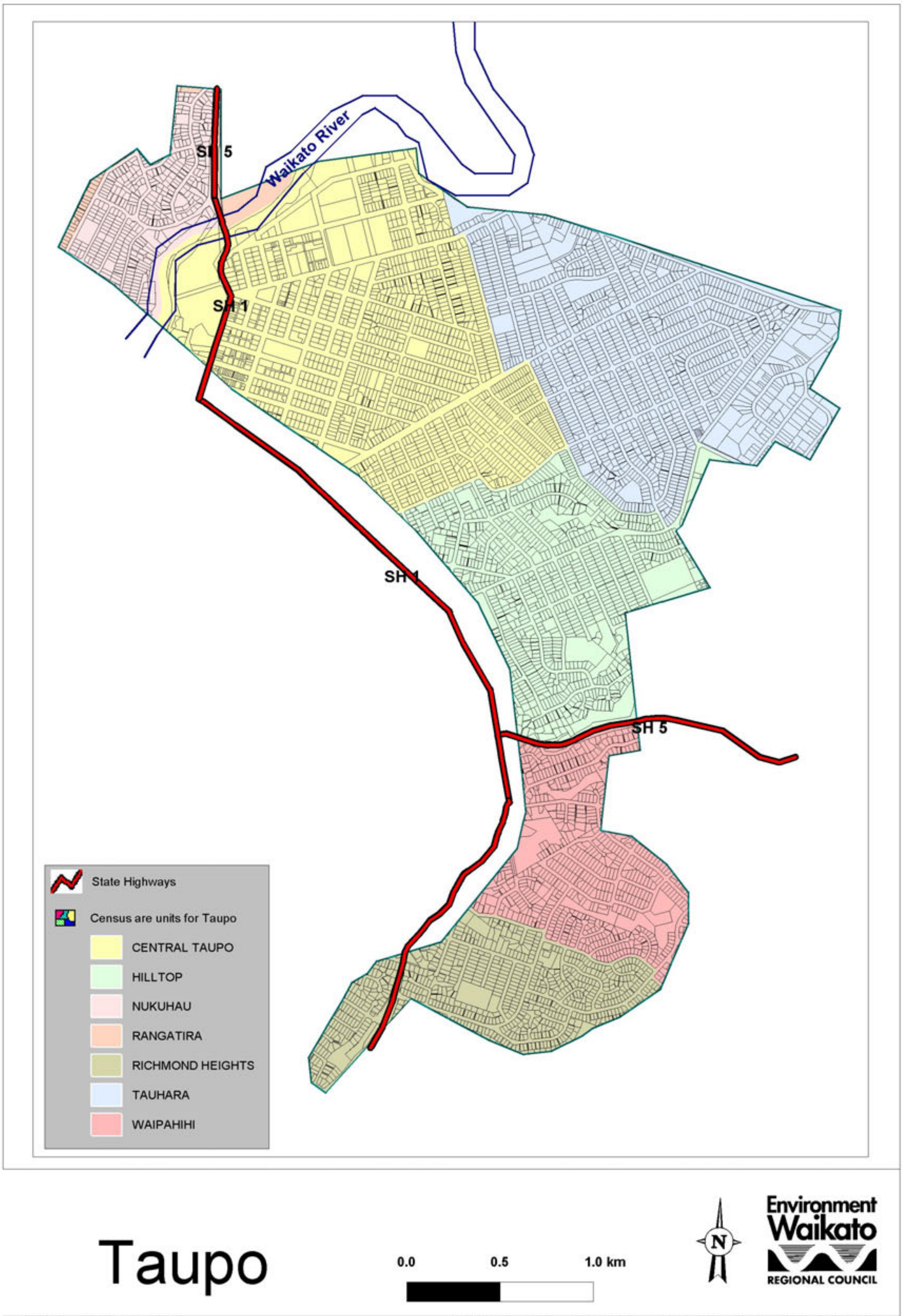
The study areas of Taupo, Huntly, Matamata and Putaruru were selected because of their size, density of dwellings and potential for air quality problems, based on topographical and meteorological characteristics.

Of the four study areas, Taupo has the highest housing density, with an average of 7 households per hectare of land, and the greatest number of total dwellings (6973). However, this area is used by many as a holiday location and the number of usually resident households is likely to be less than this.

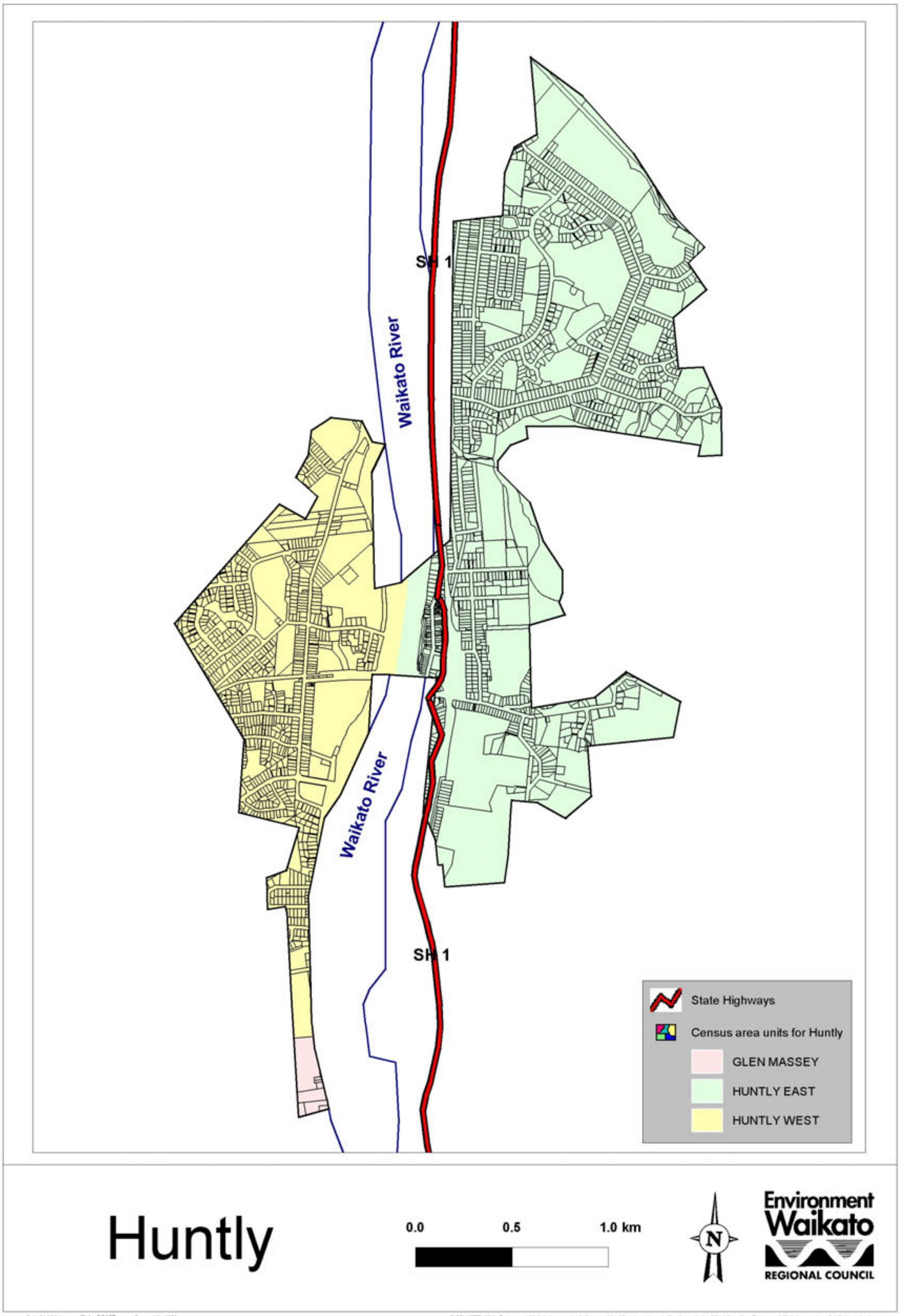
The following illustrations of each study area provide an indication of the distribution of households and main features within each location. The shape of the urban area will have some impact on variations in concentrations of air contaminants within each area. For example, the high density housing area of Matamata is very compact, potentially giving a high density of emissions, whereas Huntly is spread out over both sides of the Waikato River, potentially reducing the emission density.

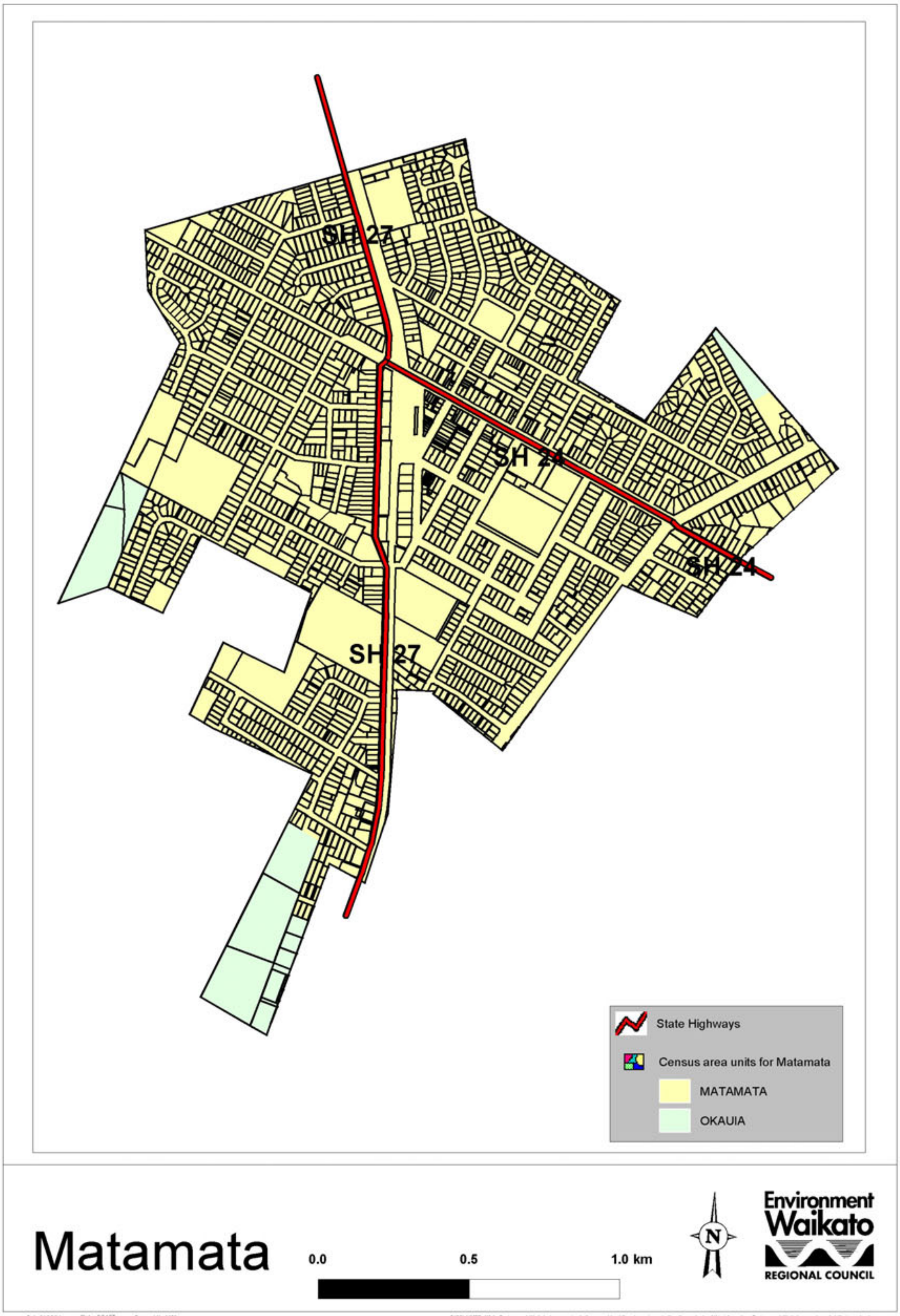
Table 2.1 Summary of the contaminants, guidelines and adverse effects

| Contaminant | Guideline | Averaging period and source | Adverse Effect |
|---|---|---|---|
| Particulates<br>$PM_{10}$ | 50 $\mu g/m^3$ | 24-hour proposed MfE (2000) | Health effects range from throat irritation, chronic cough, bronchitis, increased asthma symptoms, reduced lung function and death (Wilton, 1999). |
| Carbon monoxide<br>CO | 30 $mg/m^3$<br>10 $mg/m^3$ | 1 hour MfE (1994)<br>8 hour MfE (1994) | Health effects range from headaches and dizziness to loss of consciousness and death (MfE, 1994). |
| Carbon dioxide $CO_2$ | | | A "greenhouse" gas that contributes to global warming |
| Nitrogen dioxide<br>$NO_2$ | 200 $\mu g/m^3$<br>100 $\mu g/m^3$ | 1 hour proposed MfE (2000)<br>24 hour MfE (1994) | $NO_2$ increases susceptibility to asthma and bacterial infections in the lungs. $NO_2$ also causes reduced visibility and damages plants (MfE, 1994). |
| Sulphur dioxide<br>$SO_2$ | 500 $\mu g/m^3$<br>350 $\mu g/m^3$<br>125 $\mu g/m^3$<br>50 $\mu g/m^3$ | 10 min MfE (1994)<br>1 hour MfE (1994)<br>24 hour MfE (1994)<br>Annual MfE (1994) | Causes irritation in the upper respiratory tract and can trigger bronchitis and tracheitis. At higher concentrations can cause a bronchospasm in asthmatics (MfE, 1994). The proposed revised MfE guidelines (2000) suggest the removal of the 10-minute and annual guideline values. |
| Volatile Organic Carbons<br>VOC | | | VOCs collectively, have typically been included in emission inventories because they are a precursor to photochemical smog. |

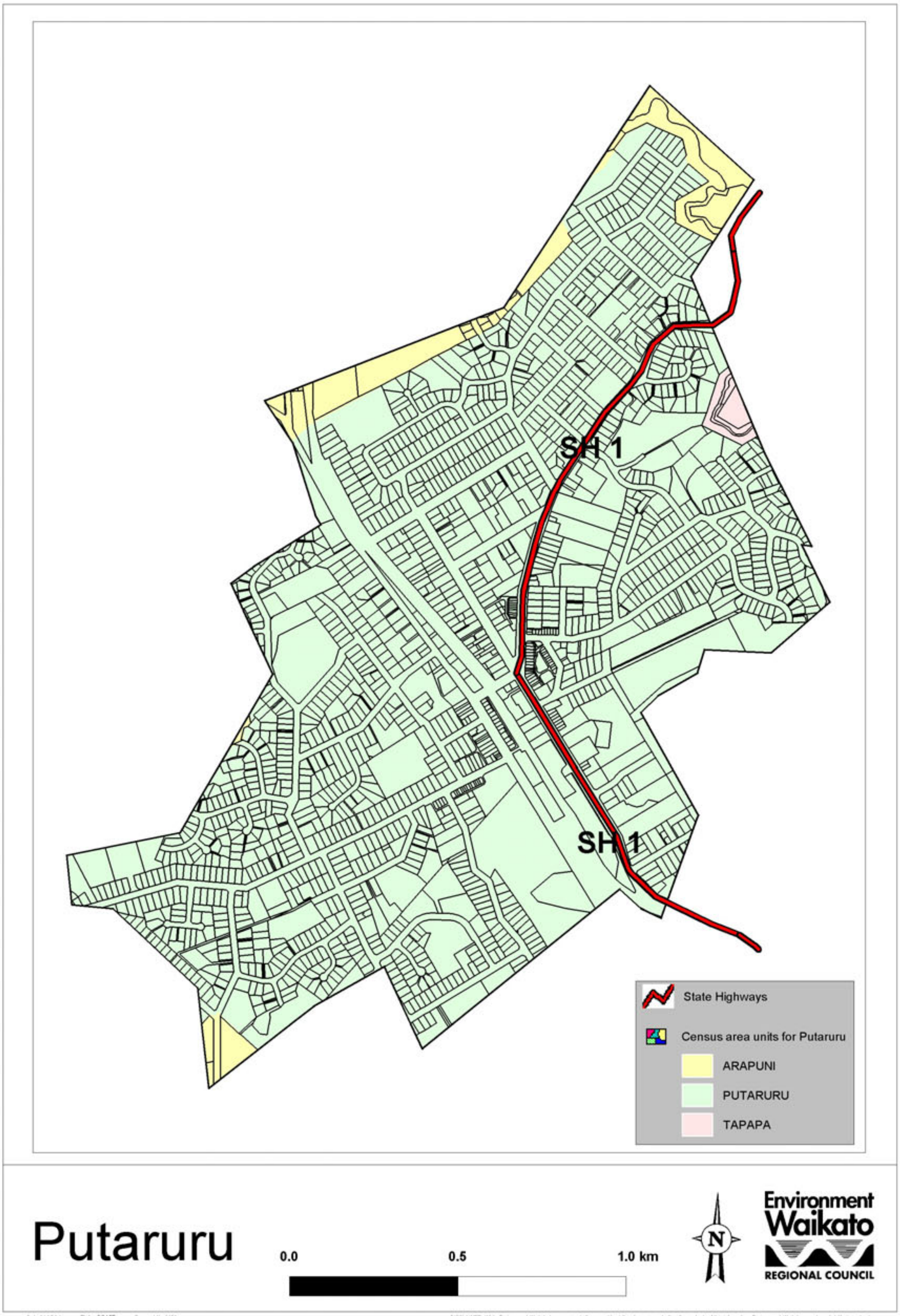



Status DRAFT


SH 1
Waikato River
Waikato River
SH 1
State Highways
Census area units for Huntly
GLEN MASSEY
HUNTLY EAST
HUNTLY WEST
Huntly
0.0
0.5
1.0 km
N
Environment Waikato
REGIONAL COUNCIL




Status DRAFT




Digital boundaries derived from Statistics New Zealand's Digital Meshblock Database (DMDB). Crown Copyright Reserved, DOSLI and Statistics 1994. License Number DDL08. Cadastral information derived from the Land Information New Zealand's Digital Cadastral Database (DCDB). CROWN COPYRIGHT RESERVED. License No. TL/ENV02/1. Digital Terrain Information obtained from the Department of Survey and Land Information. Digital License Number TD093603/92. CROWN COPYRIGHT RESERVED.

## 2.4 Temporal distribution

Domestic heating data were broken down into the following time of day categories:

| 6am - 10am | 10am - 4pm | 4pm - 10pm | 10pm - 6am |
|---|---|---|---|

These categories were selected to coincide with variations in meteorological conditions typical of high pollution incidents in other locations. Assessment of the meteorological data for each of the areas included in this study was not possible because of the limited data available. However, it is likely that this breakdown will be appropriate for these locations.

The collection of data for different time of day breakdowns allows for subsequent assessment of the contribution of different sources to concentrations, as opposed to emissions. The latter calculation requires details on the impact of meteorological conditions on contaminant concentrations at different times of the day.

## 2.5 Domestic heating survey

Home heating methods and fuels were assessed by a telephone survey conducted by DigiPol during winter, 2000. Between 170 and 200 households were randomly surveyed in each of the study areas. The actual number of households in those areas ranges from about 1400 in Putaruru to just less than 7000 in Huntly (table 3.1). The sample error for the survey for each area was around 7%.

There were some limitations with the survey design, in particular when households were asked about their home heating methods. The question, “what percentage of the following energy sources do you use to heat your main living area in winter?” was ambiguous. For example, respondents could interpret the question based on the amount of time spent using each method or the proportion of heat provided by different methods or some proportion based on cost or the amount of fuel used. There are also some inconsistencies in the way this question was analysed. For example, in an earlier inventory for Hamilton, Tokoroa and Te Kuiti the survey analysis indicated that many households used multiple methods. However, the analysis for Taupo, Huntly, Matamata and Putaruru, showed the proportions of households using each method adding up to 100%, indicating that either the households in this area only use one method of heating or that data were analysed differently. Because of the uncertainties associated with these data, only limited time of day analyses has been undertaken.

Table 3.1: Sample size and error and study area size

| | Households in sample | Total households in urban area[1] | Sample error | Study area size Ha |
|---|---|---|---|---|
| Taupo | 183 | 6973 | 7.1% | 810 |
| Huntly | 202 | 2354 | 6.6% | 492 |
| Matamata | 174 | 2297 | 7.1% | 315 |
| Putaruru | 189 | 1405 | 6.6% | 313 |

The survey collected data relating to the type of home heating methods used in the main living area during the winter months. Heating methods were classified as one or more of the following:

- Electricity
- Gas burners
- Oil burners
- Open fires
- Wood burners -- pre 1989
- Wood burners – 1990-1993
- Wood burners – post 1993
- Multi-fuel burners
- Potbelly stoves
- Incinerators

Data on fuel use were gathered by requiring households to estimate their daily fuel consumption. These data were estimated as the number of split logs, sawmill off-cuts, timber off-cuts, buckets, or in the case of gas, the amount of money spent, per day. Assumptions relating to the conversion of these data to weights of fuel use are detailed in table 3.2.

Table 3.2: Estimated weight of fuel per unit (kg)

| | **Split logs** | **Sawmill off cuts** | **Timber off cuts** | **Bucket** | **Dollars** |
|---|---|---|---|---|---|
| Wood | 1.6 | 0.5 | 0.5 | 8 | - |
| Coal | - | - | - | 10 | - |
| Gas | - | - | - | - | 1.59 |

## 2.6 Home heating methods

Wood burning is the most commonly used form of home heating in Taupo, Putaruru and Matamata. In Huntly, wood and gas are the most predominant methods (table 3.1). However, the use of coal is also prevalent with 23% of households using that method. This proportion is greater than in the other urban centres but is not surprising given the high profile of coal in Huntly.

[1] Census 1996

Table 3.3: Percentage of households using different heating methods

| | Electricity % | Gas % | Coal % | Wood % | Oil % |
|---|---|---|---|---|---|
| Taupo | 23 | 21 | 1 | 55 | 0 |
| Huntly | 17 | 29 | 23 | 31 | 0 |
| Putaruru | 16 | 21 | 2 | 59 | 1 |
| Matamata | 29 | 19 | 2 | 49 | 1 |

A reasonable proportion of households rely on the use of gas for domestic space heating. The proportion of these households that used flued versus unflued gas was not determined in the survey. This is of interest as the indoor emissions of contaminants from unflued gas appliances are of concern. These appliances emit nitrogen oxides, carbon monoxide and other toxic contaminants into the indoor environment and can result in adverse health impacts.

# 3 Domestic heating emissions

## 3.1 Method used to calculate emissions

Assessing emissions from domestic heating involves the collection of data on home heating methods and fuel use, referred to as activity data, and the application of emission factors to these data.

As detailed in the previous section, data on home heating methods and fuel use were obtained through a domestic heating survey of the study areas. The total quantity of each type of fuel burnt on each type of appliance was used to calculate the emissions from that appliance and fuel type. Because the use of electricity does not result in any discharges to air, no emissions from that source are included. The generation of electricity using combustion does result in discharges to air, however, for the purpose of an emission inventory these are treated as an industrial point source discharge.

Emission factors for the emission inventory were selected by Environment Waikato staff and were based on those used in the 1996 Christchurch emission inventory. These emission factors have been used widely throughout New Zealand. However, emission test data for the derivation of emission factors applicable to New Zealand domestic heating appliances and fuels are limited and existing emission factors are indicative only. The wood burner age categories and associated emissions variations were derived based on appliance test standards unique to Christchurch and the applicability of these categories in the Waikato is uncertain. Table 3.1 shows the emission factors used to estimate emissions for the areas of Huntly, Matamata, Putaruru and Taupo.

Table 4.1: Emission factors for domestic home heating appliances

| | $PM_{10}$ g/kg | CO g/kg | NOx g/kg | SOx g/kg | VOC g/kg | $CO_2$ g/kg |
|---|---|---|---|---|---|---|
| Gas burner | 0.1 | 0.4 | 2 | 0.01 | 0.2 | 2500 |
| Oil burner | 1.3 | 0.6 | 2.2 | 3.8 | 0.25 | 3200 |
| Open fire – wood | 15 | 120 | 1.6 | 0.2 | 30 | 1700 |
| Open fire – coal | 33 | 60 | 1.5 | 18 | 15 | 2800 |
| Old (10yr +) burner - wood | 12.8 | 104 | 1.4 | 0.2 | 26 | 1700 |
| Newer (< 10 yr) burner - wood | 6.4 | 51 | 0.7 | 0.2 | 13 | 1700 |
| Enclosed coal burner - wood | 14.3 | 114 | 1.6 | 0.2 | 29 | 1700 |
| Enclosed coal burner - coal | 31 | 57 | 1.4 | 18 | 14 | 2800 |
| Multi-fuel burner - wood | 6.4 | 51 | 0.7 | 0.2 | 13 | 1700 |
| Multi-fuel burner - coal | 14.3 | 26 | 0.6 | 18 | 6 | 2800 |
| Potbelly - wood | 14.3 | 114 | 1.6 | 0.2 | 31 | 1700 |
| Potbelly - coal | 31.5 | 57 | 1.4 | 18 | 14 | 2800 |

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

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

*where*

*CE = contaminant emission*
*EF = emission factor*
*FB = fuel burnt*

# 3.2 Total domestic heating emissions

Emissions of $PM_{10}$, CO, NOx, SOx, VOC and $CO_2$ were estimated for each study area. Results are presented in tables 4.4 to 4.9 as total emissions and presented in grams per hectare (g/ha) in table 4.2. The latter units allow a comparison of the relative discharge rates across different sized study areas. For example, the area of Putaruru is much smaller in size (313 ha) than Taupo (810 ha) so total emissions (table 4.4) appear much smaller. However, the quantity of emissions produced in each hectare is similar for both areas (table 4.2).

Another way of presenting results, which provides an indicator of the relative cleanliness of home heating methods in each area, is grams of emissions per household. For example, table 4.3 shows that, overall, home heating methods used in Huntly are more polluting than those used in Taupo, Putaruru and Matamata.

Table 4.2: Domestic heating emission rate (g/ha) in each study area

| | $PM_{10}$ g/ha | CO g/ha | NOx g/ha | SOx g/ha | VOC g/ha | $CO_2$ g/ha |
|---|---|---|---|---|---|---|
| Taupo | 505 | 3993 | 84 | 20 | 999 | 94083 |
| Huntly | 1747 | 4737 | 136 | 1255 | 1219 | 189488 |
| Matamata | 1147 | 8382 | 145 | 183 | 1976 | 167633 |
| Putaruru | 560 | 4750 | 73 | 83 | 976 | 95001 |

Table 4.3: Domestic heating emissions per household in each study area

| | $PM_{10}$ g/hh | CO g/hh | NOx g/hh | SOx g/hh | VOC g/hh | $CO_2$ g/hh |
|---|---|---|---|---|---|---|
| Taupo | 59 | 464 | 10 | 2 | 116 | 10929 |
| Huntly | 365 | 990 | 28 | 262 | 255 | 39604 |
| Matamata | 157 | 1149 | 20 | 25 | 271 | 22988 |
| Putaruru | 125 | 1058 | 16 | 19 | 217 | 21164 |

Table 4.4: Summary of total domestic heating emissions in each study area

| | $PM_{10}$ kg | CO kg | NOx kg | SOx Kg | VOC kg | $CO_2$ kg |
|---|---|---|---|---|---|---|
| Taupo | 409 | 3235 | 68 | 16 | 809 | 76208 |
| Huntly | 860 | 2331 | 67 | 618 | 600 | 93228 |
| Matamata | 361 | 2640 | 46 | 58 | 622 | 52804 |
| Putaruru | 175 | 1487 | 23 | 26 | 306 | 29735 |

Table 4.5: Domestic heating emissions by appliance type - Taupo

| | Fuel kg | $PM_{10}$ kg | CO kg | NOx kg | SOx kg | VOC kg | $CO_2$ kg |
|---|---|---|---|---|---|---|---|
| Open fire - wood | 11393 | 171 | 1367 | 31 | 5 | 342 | 19368 |
| Open fire - coal | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Woodburner - pre 89 wood | 11660 | 149 | 1194 | 16 | 2 | 298 | 19822 |
| Woodburner - pre 89 coal | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Woodburner - 90-93 wood | 4153 | 29 | 229 | 3 | 1 | 57 | 7061 |
| Woodburner - 90-93 coal | 381 | 6 | 11 | 0 | 7 | 3 | 1067 |
| Woodburner - post 93 wood | 9145 | 54 | 432 | 6 | 2 | 108 | 15546 |
| Woodburner - post 93 coal | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Enclosed coal burner | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Potbelly wood | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Potbelly coal | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Incinerator | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total wood | 36351 | 403 | 3222 | 57 | 10 | 805 | 61797 |
| Total coal | 381 | 6 | 11 | 0 | 7 | 3 | 1067 |
| Gas heater | 5449 | 1 | 2 | 11 | 0 | 1 | 13622 |
| Oil burner | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | 42181 | 409 | 3235 | 68 | 16 | 809 | 76486 |

Table 4.6: Domestic heating emissions by appliance type - Huntly

| | **Fuel kg** | **$PM_{10}$ kg** | **CO kg** | **NOx kg** | **SOx kg** | **VOC kg** | **$CO_2$ kg** |
|---|---|---|---|---|---|---|---|
| Open fire - wood | 4277 | 64 | 513 | 12 | 2 | 128 | 7271 |
| Open fire - coal | 9579 | 316 | 575 | 24 | 345 | 144 | 26822 |
| Woodburner - pre 89 wood | 3566 | 46 | 365 | 5 | 1 | 91 | 6062 |
| Woodburner - pre 89 coal | 8099 | 228 | 415 | 10 | 146 | 104 | 22678 |
| Woodburner - 90-93 wood | 1270 | 9 | 70 | 1 | 0 | 18 | 2159 |
| Woodburner - 90-93 coal | 233 | 4 | 6 | 0 | 4 | 2 | 653 |
| Woodburner - post 93 wood | 2797 | 17 | 132 | 2 | 1 | 33 | 4755 |
| Woodburner - post 93 coal | 1748 | 23 | 41 | 1 | 31 | 10 | 4894 |
| Enclosed coal burner | 4894 | 154 | 280 | 7 | 88 | 70 | 13705 |
| Potbelly wood | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Potbelly coal | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Incinerator | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total wood | 11910 | 135 | 1081 | 20 | 3 | 270 | 20247 |
| Total coal | 24554 | 724 | 1317 | 43 | 614 | 329 | 68751 |
| Gas heater | 2436 | 0 | 1 | 5 | 0 | 0 | 6089 |
| Oil burner | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | 38899 | 860 | 2399 | 67 | 618 | 600 | 95087 |

Table 4.7: Domestic heating emissions by appliance type - Matamata

| | Fuel kg | $PM_{10}$ kg | CO kg | NOx kg | SOx kg | VOC kg | $CO_2$ kg |
|---|---|---|---|---|---|---|---|
| Open fire – wood | 6099 | 91 | 732 | 17 | 2 | 183 | 10368 |
| Open fire – coal | 568 | 19 | 34 | 1 | 20 | 9 | 1589 |
| Woodburner - pre 89 wood | 12515 | 160 | 1281 | 18 | 3 | 320 | 21275 |
| Woodburner - pre 89 coal | 924 | 26 | 47 | 1 | 17 | 12 | 2587 |
| Woodburner - 90-93 wood | 1320 | 9 | 73 | 1 | 0 | 18 | 2244 |
| Woodburner - 90-93 coal | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Woodburner - post 93 wood | 6020 | 36 | 284 | 4 | 1 | 71 | 10233 |
| Woodburner - post 93 coal | 264 | 3 | 6 | 0 | 5 | 2 | 739 |
| Enclosed coal burner | 528 | 17 | 30 | 1 | 10 | 8 | 1479 |
| Potbelly wood | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Potbelly coal | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Incinerator | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total wood | 25953 | 296 | 2370 | 39 | 6 | 593 | 44121 |
| Total coal | 2284 | 65 | 118 | 4 | 51 | 29 | 6395 |
| Gas heater | 1373 | 0 | 1 | 3 | 0 | 0 | 3432 |
| Oil burner | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | 29610 | 361 | 2489 | 46 | 58 | 622 | 53948 |

Table 4.8: Domestic heating emissions by appliance type - Putaruru

| | Fuel kg | $PM_{10}$ kg | CO kg | NOx kg | SOx kg | VOC kg | $CO_2$ kg |
|---|---|---|---|---|---|---|---|
| Open fire – wood | 2855 | 43 | 343 | 8 | 1 | 86 | 4853 |
| Open fire – coal | 335 | 11 | 20 | 1 | 12 | 5 | 937 |
| Woodburner - pre 89 wood | 5382 | 69 | 551 | 8 | 1 | 138 | 9150 |
| Woodburner - pre 89 coal | 223 | 6 | 11 | 0 | 4 | 3 | 624 |
| Woodburner - 90-93 wood | 2639 | 18 | 146 | 2 | 1 | 36 | 4486 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Woodburner - 90-93 coal | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Woodburner - post 93 wood | 2736 | 16 | 129 | 2 | 1 | 32 | 4651 |
| Woodburner - post 93 coal | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Enclosed coal burner | 372 | 12 | 21 | 1 | 7 | 5 | 1041 |
| Potbelly wood | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Potbelly coal | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Incinerator | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total wood | 13611 | 146 | 1168 | 19 | 3 | 292 | 23139 |
| Total coal | 929 | 29 | 53 | 2 | 23 | 13 | 2602 |
| Gas heater | 1063 | 0 | 0 | 2 | 0 | 0 | 2658 |
| Oil burner | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | 15604 | 175 | 1222 | 23 | 26 | 306 | 28399 |

## 3.3 Domestic heating emissions in Taupo

Taupo is situated on the edge of Lake Taupo in the centre of the north island and is the largest of the four study areas both in terms of size (approximately 810 hectares) and number of households (6973).

The emission rates of $PM_{10}$ and CO in Taupo are the lowest per hectare of the four towns examined. Emission rates of SOx, NOx, VOCs and $CO_2$ are also low, with g/ha emission rates just slightly higher than Putaruru. About half of the households in Taupo use solid fuel burning for domestic heating, and coal use is rare.

The burning of wood is the main contributor to emissions of all contaminants included in the study (figure 4. 1). The burning of gas contributes 16% and 18% of the NOx and $CO_2$ emissions respectively and coal burning contributes 42% of the SOx emissions.

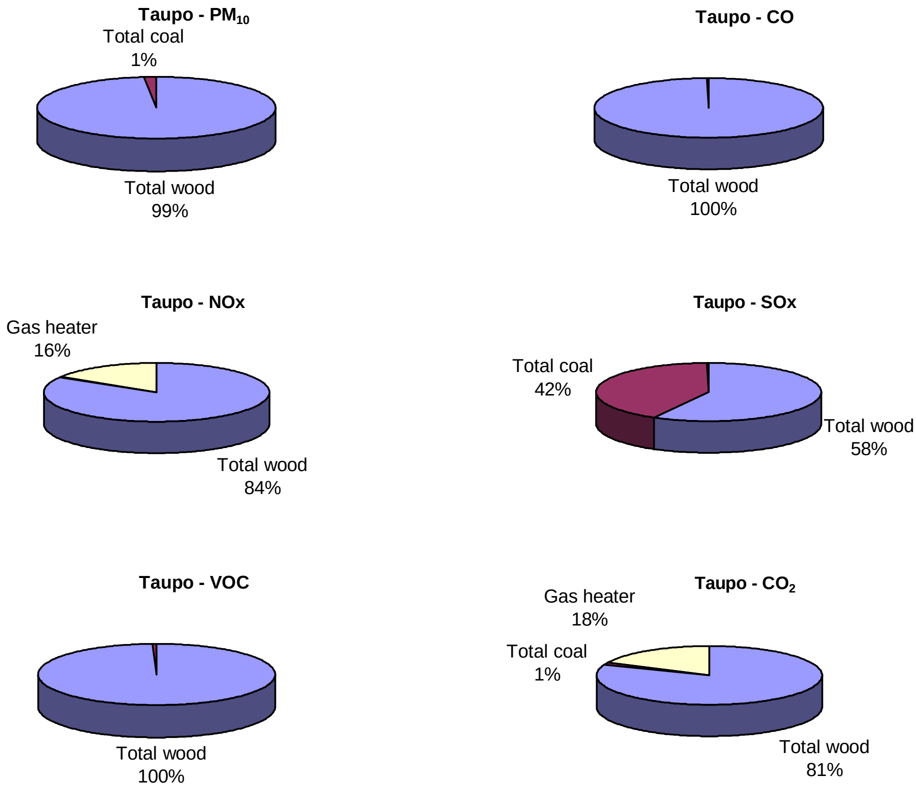



Figure 4.1: Contribution of different fuel types to contaminant emissions in Taupo

The contaminant most likely to be of concern in Taupo is $PM_{10}$. Domestic heating is a major source of $PM_{10}$ in many urban areas of New Zealand, particularly in locations where the burning of solid fuel for domestic heating is prominent. In Taupo, the total $PM_{10}$ emissions per winter's day from domestic heating is 409 kg or 505 g/ha. Of this, 99% comes from the burning of wood and 1% from the burning of coal. Figure 4.2 illustrates the proportion of $PM_{10}$ emissions from domestic heating from different appliance types.

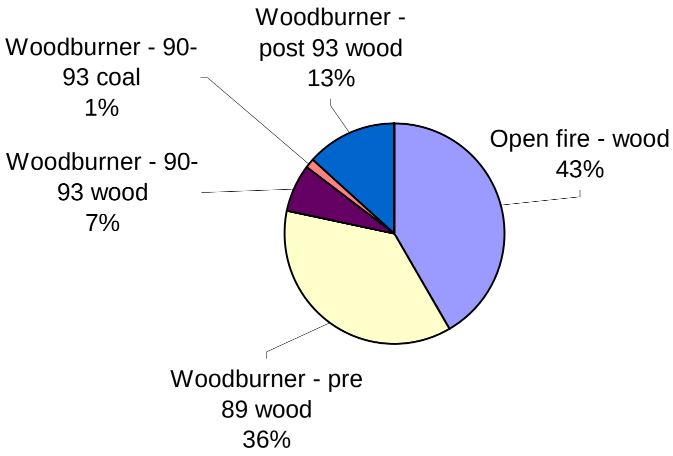



Figure 4.2: Contribution of appliance types and fuels to PM10 emissions in Taupo

Older wood burners and open fires contribute the majority of the $PM_{10}$ emissions from domestic heating in Taupo.

# 3.4 Domestic heating emissions in Huntly

Huntly is an urban township located on the Waikato River and state highway one, to the north west of Hamilton. The mining of coal in and around Huntly and the coal fired Huntly power station are major sources of employment in the town. The prominence of coal within Huntly also has implications for domestic home heating emissions.

The main contaminants likely to be of concern in Huntly are $PM_{10}$ and potentially $SO_2$. During the winter approximately 860kg of $PM_{10}$ are discharged to air from domestic heating in Huntly per day. This compares with 409kg in Taupo, 361kg in Matamata and 175kg in Putaruru. The majority of the $PM_{10}$ emissions from domestic heating in Huntly are from the burning of coal on open fires and enclosed burners. These higher emissions arise because a greater proportion of households use coal and because the quantity of coal burnt on open fires in Huntly is greater than in other areas. For example, the average amount of coal burnt on an open fire in Huntly per 24-hour period is about 26 kg, compared to around 11 kg in Matamata. In total, approximately 24.5 tonnes of coal is burnt per night in Huntly, compared to between 0.38 to 1.8 tonnes in the other study areas. The quantity of wood burnt per night is about 12 tonnes compared to between 13 to 36 tonnes in the other areas.

Of the four study areas, Huntly also emits the greatest amount of $SO_2$ and $CO_2$ and also has the highest emission rate of these contaminants both on a gram per hectare and grams per household basis. However, the suitability of the emission factor used for SOx emissions from coal, which is based on coal sulphur content of about 1%, has not been assessed.

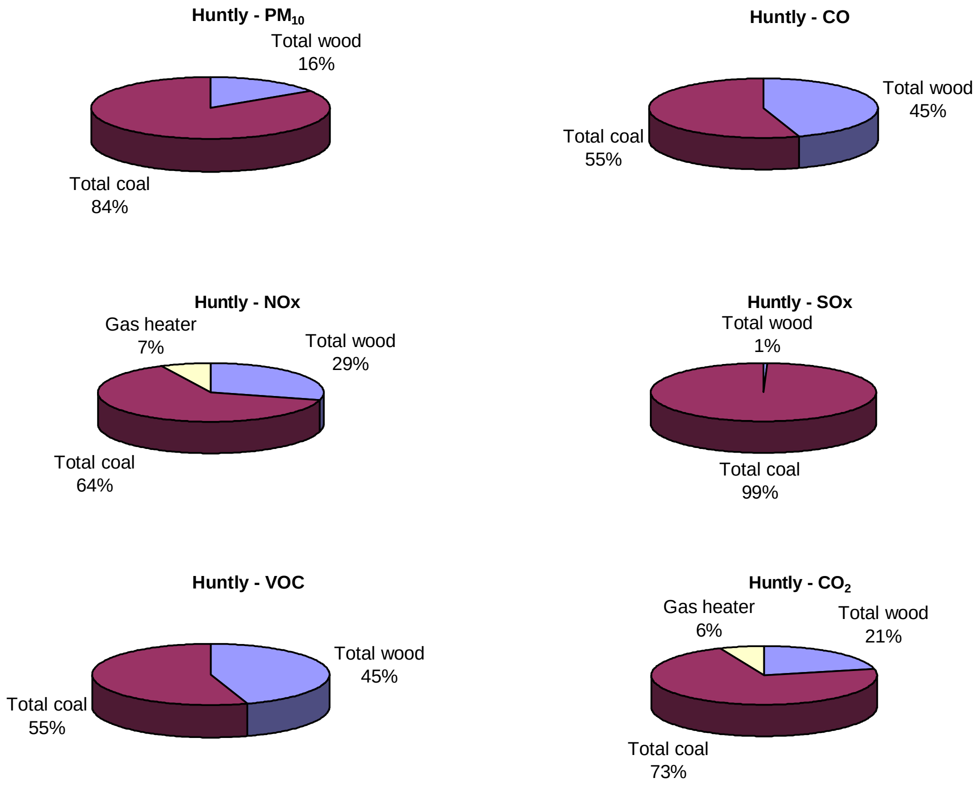



Figure 4.3: Contribution of different fuel types to contaminant emissions in Huntly

The relative contribution of coal and wood to emissions of different contaminants in Huntly is illustrated in figure 4.3. Coal burning contributes more than wood burning to emissions of all contaminants and results in over 80% of the $PM_{10}$ emissions. Open fires burning coal contribute 37% of the $PM_{10}$ emissions, while older wood burners and enclosed coal burners emit 27% and 18% respectively (figure 4.4).

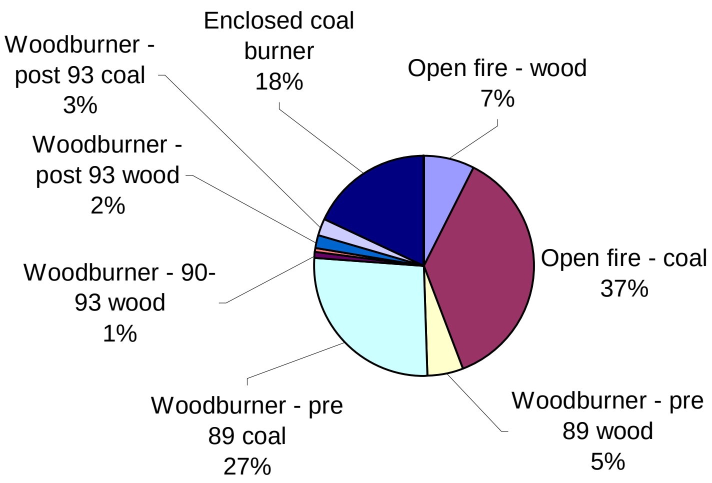



Figure 4.4: Contribution of appliance types and fuels to PM10 emissions in Huntly

## 3.5 Domestic heating emissions in Matamata

Matamata is an urban township located to the east of Hamilton on state highway 27.

The total quantities of emissions from domestic heating discharged into the air above Matamata are considerably smaller than in Huntly and less than Taupo. However, the emission rate e.g., $PM_{10}$, as indicated by the gram per hectare and grams per household data, indicate that the density of emissions are greater than in Taupo and Putaruru. Emission density provides a better indicator of the potential for air quality problems. As discussed previously, it is not possible to assess the potential for high concentrations of contaminants based on these data, as the impact of meteorological conditions will vary between locations.

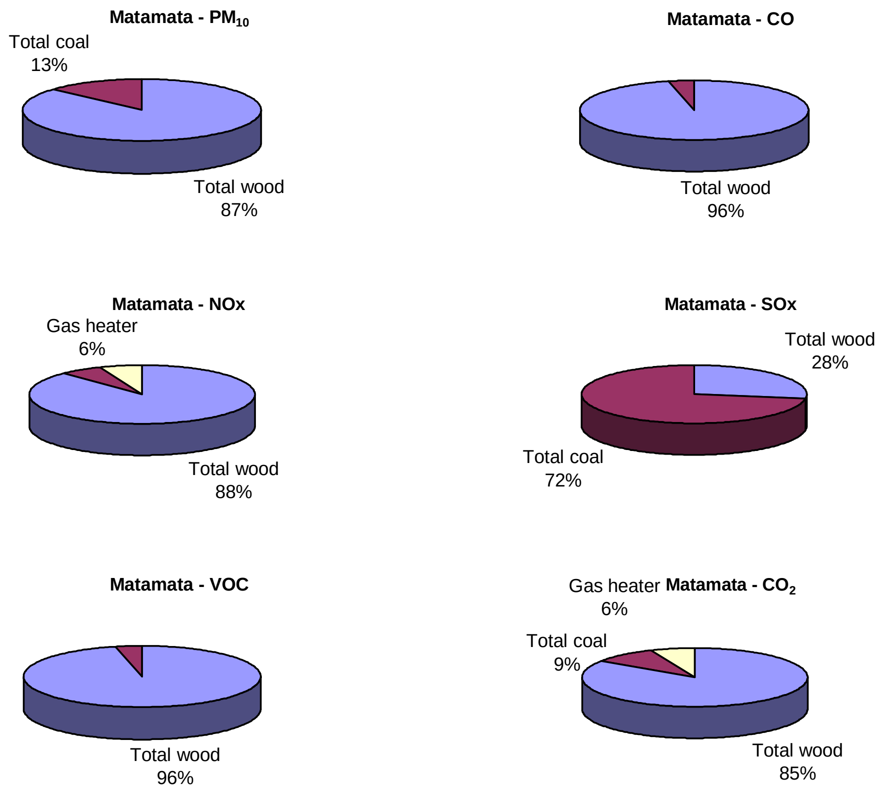



Figure 4.5: Contribution of different fuel types to contaminant emissions in Matamata

The majority of the domestic heating emissions in Matamata are from the burning of wood. The exception is emissions of $SO_2$, which result from the burning of coal.

Like other areas, the contaminant with the greatest potential for air quality problems from domestic heating in Matamata is particulate. Carbon monoxide emissions are also higher in Matamata than the other study areas and monitoring of that contaminant may also be warranted. The main source of $PM_{10}$ domestic heating emissions is older wood burners, which contribute 44% of the emissions. Open fires contribute about 25% of the domestic heating $PM_{10}$ emissions in Matamata (figure 4.6).

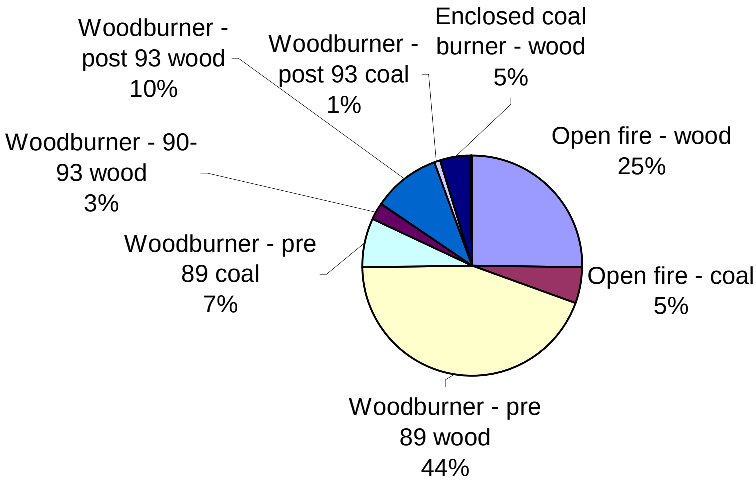



Figure 4.6: Contribution of appliance types and fuels to PM10 emissions in Matamata

## 3.6 Domestic heating emissions in Putaruru

Putaruru is located along state highway one, north of Tokoroa, and is the smallest of the four study areas, comprising 1405 households located within 313 hectares.

Just under 14 tonnes of wood and less than one tonne of coal are burnt per night during the winter in Putaruru. This is less than half the amount burnt in Taupo, Huntly and Matamata, and reflects the smaller size of the town. The emission density in Putaruru is also lower than in Huntly and Matamata for most contaminants, and similar to Taupo. The proportion of households that use solid fuel burning for domestic heating in Putaruru is also similar to Taupo, (approximately half), with almost all of these relying on wood as opposed to coal.

While the emissions are lower in Putaruru than in the other study areas, it is still possible for high concentrations of contaminants to occur in this area. This will depend on the prevalence and extent of meteorological conditions conducive to high pollution. The contaminant most likely to be of concern is $PM_{10}$.

The burning of wood results in the majority of the emissions from domestic heating in Putaruru and contributes over 80% of the $PM_{10}$ emissions. Coal burning contributes the majority of the sulphur dioxide emissions and 17% of the $PM_{10}$ emissions. Open fires and older wood burners are responsible for 70% of the domestic heating $PM_{10}$ emissions.

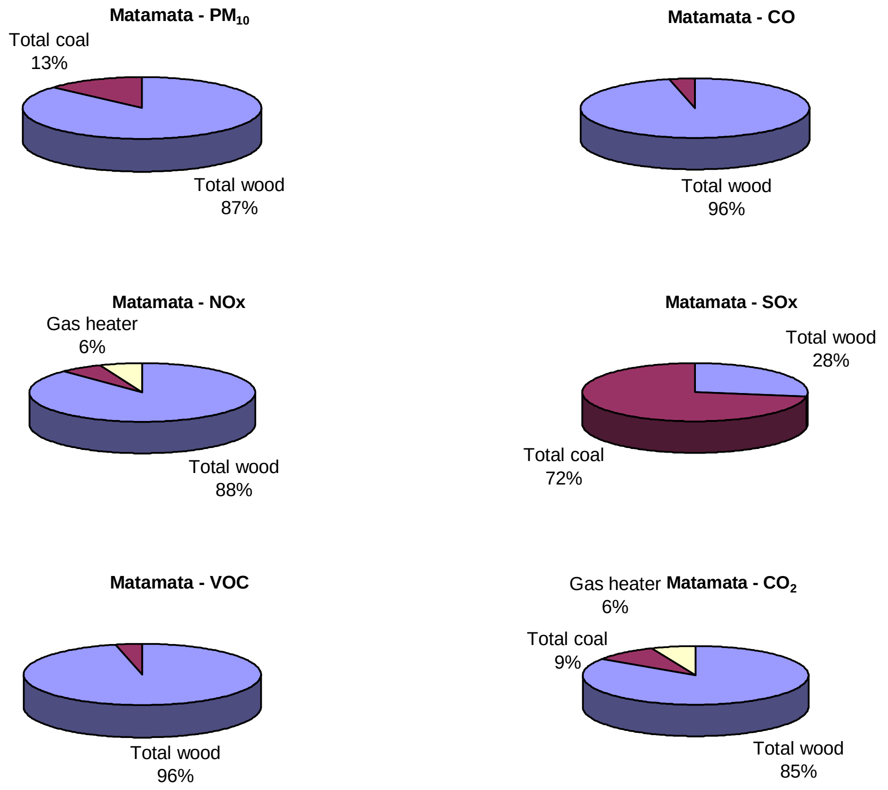



Figure 4.7: Contribution of different fuel types to contaminant emissions in Putaruru

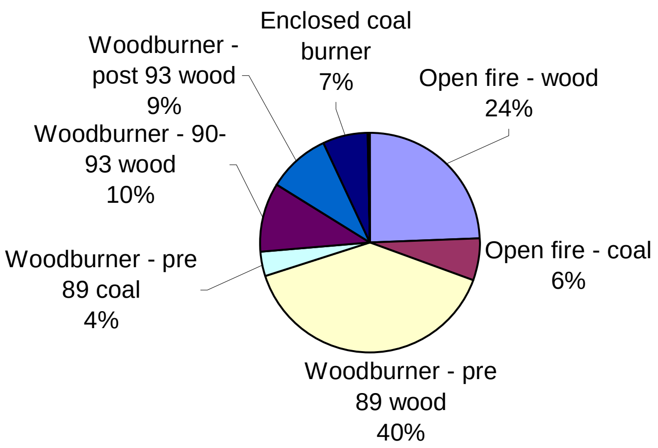



Figure 4.8: Contribution of appliance types and fuels to PM10 emissions in Putaruru

## 3.7 Domestic heating emissions by time of day

Table 4.7 illustrates the proportion of solid fuel burners that are used in the study areas during different times of the day for weekdays. This shows that at least a third of the Taupo burners are used during the morning and daytime periods compared to around 20% in Huntly and Matamata. Around 60% of households burn during the evening period and a smaller proportion (20-30%) burn overnight. The overnight burn is of interest as it is common for households to stoke up a fire in the evening and turn down the air, allowing a slow burn throughout the night, making it possible to restart the fire in the morning without relighting. This type of operation results in increased $PM_{10}$ emissions, although it is not common practice to factor this into an emission inventory assessment because of difficulties in assessing operational aspects.

Table 4.9. Percentage of solid fuel burners used during different times on a weekday

| | **Morning (6am - 10am)** | **Daytime (10am - 4pm)** | **Evening (4pm - 10pm)** | **Overnight (10pm - 6am)** |
|---|---|---|---|---|
| Taupo | 33 | 40 | 57 | 30 |
| Huntly | 22 | 21 | 61 | 22 |
| Matamata | 22 | 19 | 58 | 26 |
| Putaruru | 28 | 25 | 64 | 28 |

The proportion of households that use their solid fuel burners at different times of the day during the weekend is illustrated in table 4.8. The main differences between weekend and weekday are observed in Taupo where fewer households use their burners in the daytime and overnight periods during the weekend.

Table 4.10. Percentage of solid fuel burners used during different times on a weekend

| | **Morning (6am - 10am)** | **Day time (10am - 4pm)** | **Evening (4pm - 10pm)** | **Overnight (10pm - 6am)** |
|---|---|---|---|---|
| Taupo | 34 | 10 | 45 | 9 |
| Huntly | 26 | 29 | 62 | 25 |
| Matamata | 32 | 25 | 49 | 19 |
| Putaruru | 30 | 36 | 64 | 30 |

# 4 Comparison to other urban centres

A survey of domestic home heating methods and fuels was carried out in Hamilton, Tokoroa and Te Kuiti during the winter of 1997. Results from that survey found that solid fuel burning was a predominant home heating method in both Tokoroa and Te Kuiti, with about 50% of households burning wood or coal compared to less than 20% in Hamilton (Noonan, 1997). The study areas included in this inventory, Taupo, Huntly, Matamata and Putaruru were more similar to Tokoroa and Te Kuiti in the proportion of households depending on solid fuel burning for domestic home heating, with 50-60% of the households using solid fuel burning in these areas.

The use of coal for home heating is most prominent in Huntly where 23% of households rely on that fuel. Te Kuiti has the next highest coal use, with 5% of households using that method. In Hamilton less than 2% of households use coal. However, because of the larger size of that city total coal use per day/ night is 25 tonnes, about the same amount as used in Huntly. Less than three tonnes of coal is burnt in Te Kuiti on a winter's day/ night.

Table 5.2 compares the total emissions and the emission rate per hectare in the study areas to the areas of Hamilton, Tokoroa and Te Kuiti. With the exception of SOx emissions, total emissions are greatest in Hamilton simply because there are significantly more houses in Hamilton. The SOx emissions are slightly higher in Huntly, however, because of the higher use of coal in that area.

Perhaps a better indicator of the potential for ambient air quality issues is the representation of emissions in grams per hectare (g/ha). While this provides an indicator of the emission density, it is also not an ideal expression, as the housing density within the study areas will vary (table 5.1). For example, some of the town boundaries will include quantities of rural land that will reduce the overall grams per hectare emission rate.

The areas of Huntly, Te Kuiti and Tokoroa have the highest area adjusted emission rates (g/ha), with Huntly boasting the highest for $PM_{10}$ at 1747 g/ha and SOx at 1255 g/ha and Te Kuiti the highest for CO at 11164 g/ha. These are high compared to locations outside of the Waikato with air quality problems. For example, $PM_{10}$, CO and SOx emissions from domestic heating in Christchurch in 1996 were 618 g/ha, 3489 g/ha and 140 g/ha respectively (CRC, 1998). In Christchurch, guidelines concentrations for both $PM_{10}$ and CO are regularly breached during the winter months. The extent to which emissions of these contaminants will result in guideline exceedences in these Waikato locations will depend on meteorological conditions.

Based on emissions data alone, priority should be given to the monitoring of $PM_{10}$ in Huntly, Te Kuiti and Tokoroa. Monitoring of CO should also be considered in the latter towns, as should the monitoring of $SO_2$ in Huntly.

Table 5.1: Housing densities within the study areas, compared to Hamilton, Te Kuiti and Tokoroa.

| | **Number of Households HH** | **Study Area Size Ha** | **Housing Density HH/Ha** |
|---|---|---|---|
| Taupo | **6973** | **810** | **8.6** |
| Huntly | **2354** | **492** | **4.8** |
| Matamata | **2297** | **315** | **7.3** |
| Putaruru | **1405** | **313** | **4.5** |
| Hamilton | **37250** | **6680** | **5.6** |
| Te Kuiti | **4918** | **870** | **5.7** |
| Tokoroa | **1596** | **420** | **4** |

Table 5.2: Comparison of Taupo, Huntly, Matamata and Putaruru emission to Hamilton, Te Kuiti and Tokoroa 1997 emissions

| | $PM_{10}$ | | CO | | NOx | | SOx | | VOC | | $CO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg | g/ha | kg | g/ha | kg | g/ha | kg | g/ha | kg | g/ha | kg | g/ha |
| Taupo | 409 | 505 | 3235 | 3993 | 68 | 84 | 16 | 20 | 809 | 999 | 76208 | 94083 |
| Huntly | 860 | 1747 | 2331 | 4737 | 67 | 136 | 618 | 1255 | 600 | 1219 | 93228 | 189488 |
| Matamata | 361 | 1147 | 2640 | 8382 | 46 | 145 | 58 | 183 | 622 | 1976 | 52804 | 167633 |
| Putaruru | 175 | 560 | 1487 | 4750 | 23 | 73 | 26 | 83 | 306 | 976 | 29735 | 95001 |
| Hamilton | 4188 | 627 | 28513 | 4268 | 453 | 68 | 514 | 77 | 7131 | 1067 | 578134 | 86547 |
| Te Kuiti | 652 | 1552 | 4689 | 11164 | 68 | 162 | 58 | 139 | 1172 | 2791 | 91172 | 217077 |
| Tokoroa | 986 | 1202 | 7532 | 9186 | 109 | 133 | 49 | 60 | 1883 | 2297 | 138942 | 169442 |

# References

CRC, 1998, *Christchurch inventory of total emissions.* Canterbury Regional Council report R98/20.

Ministry for the Environment, 1994, *Ambient air quality guidelines*. Ministry for the Environment, Wellington.

Ministry for the Environment, 2000, *Proposal for Revised and New Ambient Air Quality Guidelines*. Ministry for the Environment, Wellington.

Noonan, M., 1997, Hamilton, Te Kuiti and Tokoroa, Home heating and motor vehicle emissions inventory. Environment Waikato Report.