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Whangārei and Kaitāia Air Emission Inventories for Particulate Matter - 2018

Northland Regional Council

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Whangārei and Kaitāia Air Emission Inventories for Particulate Matter - 2018

Prepared for

Northland Regional Council

October 2021

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Limitations:

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Northland Regional Council and others (not directly contracted by PDP for the work), including NZStats and Waka Kotahi. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

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Executive Summary

The key objective of Phase 1 of this project was to provide robust information which would enable the Northland Regional Council (NRC) to pinpoint and quantify the key PM_{10} and $PM_{2.5}$ sources in the Whangārei and Kaitāia airsheds. To meet the key project objective particulate matter emission inventories have been developed for the Whangārei and Kaitāia airsheds.

The emission inventories included four key source types; domestic fuel burning devices, road transport, industry and backyard burning. Emissions were calculated using best practice methods and the most robust/representative input data available was used to inform the calculations. Some limitations in the available data were identified and are discussed in Section 12.0. The emissions for both airsheds were based on the geospatial units used in the census and calculated for an annual total and a winter day.

In the Whangarei airshed, domestic and transport sources contribute 45% and 32% respectively to the annual total PM_{10} emissions of 171 tonnes. Hotspot geospatial units have been identified for both these sources. Home heating sources dominate (71%) the Whangarei airshed total PM_{10} emissions on winter days. Similar source type, temporal and spatial patterns are seen in the Whangarei airshed $PM_{2.5}$ emissions except for domestic emissions being slightly more prominent.

In the Kaitāia airshed, the domestic and industry sources contribute 15% and 76% respectively to the annual total PM_{10} emissions of 67 tonnes. Hotspot geospatial units have been identified for both these sources. The industrial sources dominate (59%) the Kaitāia airshed total PM_{10} emissions on a winter day with home heating contributing 35%. Similar source type, temporal and spatial patterns are seen in the Kaitāia airshed $PM_{2.5}$ emissions except for domestic emissions being more prominent.

A comparison of the 2006 and 2018 Whangarei airshed inventories has been undertaken to track changes in emissions of PM_{10} over the period 2006 to 2018. This comparison suggests a reduction in total winter day PM_{10} emissions in the Whangārei airshed of approximately 27% from 1.2 tonnes/day to 0.9 tonnes/day. This reduction reflects the trends observed in the key domestic and industrial emission sources. The comparison of the 2006 and 2018 Whangarei airshed inventories for transport and backyard burning PM_{10} emissions shows large changes over the 12-year period. These trends are not considered likely to reflect reality and are most likely artifacts due to the changes in the data sources used to calculate the emissions from these sources.

This information will be used in Phase 2 of the project which is to identify potential hotspots suitable for NESAQ PM_{10} and $PM_{2.5}$ monitoring in the Whangarei and Kaitāia airsheds.

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1.0 Introduction

Northland Regional Council's (NRC) responsibilities under the Resource Management Act include ensuring that air quality in its region is maintained within the requirements of National Environmental Standards for Air Quality (NESAQ).

The NRC's Regional Plan for Northland (RPN) (NRC 2016) has identified the following significant air quality issues in Northland:

- The desire to maintain Northland's high standard of air quality whilst also allowing the use and development of the region's resources
- The numerous sources of particulate matter in Northland include unsealed roads, quarries, sandblasting, port operations, coal fired boilers, open fires, rural burn offs, cement and fertilizer works and dairy factories. Particulate matter can cause adverse health effects and amenity and visibility effects.
- The cumulative effects of smoke from domestic fires for home heating, in combination with motor vehicle emissions over Northland's urban areas, particularly during calm winter nights, can have adverse health and amenity effects.

As part of its air quality management process NRC has established airsheds around specific towns in the region (Figure 1). NIWA (2020) identified that Whangārei and Kaitāia were the highest priority airsheds for the development of a particulate matter ($PM_{2.5}$) monitoring plan. NRC is now looking to develop a better understanding of the two of key airsheds. The intent of this project is to provide information to assist NRC to meet its regulatory functions, and to continue to manage air quality so that people in the region enjoy the benefits of clean air.

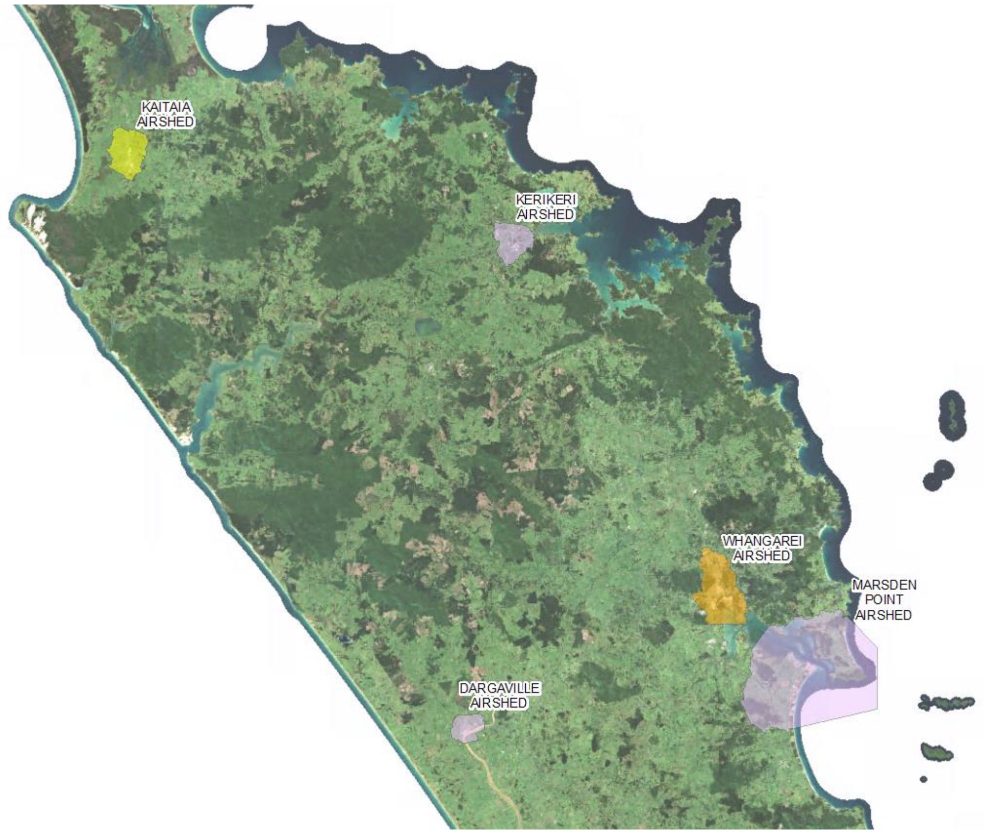

Figure 1: Location and extent of Northland Region Airsheds

2.0 Project Objective

The key objective of Phase 1 of this project is to provide robust information enabling NRC to pinpoint and quantify the key PM_{10} and $PM_{2.5}$ sources in the Whangārei and Kaitāia airsheds. To meet the key project objective Pattle Delamore Partners (PDP) has developed particulate matter emissions inventories for the Whangārei and Kaitāia airsheds. Given the current NESAQ focus on Particulate Matter less than 10 microns in size (PM_{10}) and the Ministry for the Environment's (MfE) proposed amendment to the NESAQ to include $PM_{2.5}$, both pollutants are included in the scope of the investigation.

This information will be used in Phase 2 of the project which is to Identify potential hotspots suitable for NESAQ PM_{10} and Particulate Matter less than 2.5 microns in size ($PM_{2.5}$) monitoring in the Whangārei and Kaitāia airsheds.

3.0 Structure and Content of the Report

To achieve the project objective the report presents:

- **An overview of the Inventory Design** (Section 4.0)
- **Domestic heating emissions** (Section 5.0)
  - Methodology (Section 5.1and 5.2);
  - Results (Section 5.3 (Whangārei) and 5.2 (Kaitāia);
- **Road transport emissions** (Section 6.0)
  - Methodology (Section 6.1)
  - Results (Section 6.2 (Whangārei) and 6.3(Kaitāia);
- **Industrial emissions** (Section7.0)
  - Methodology (Section 7.1)
  - Results (Section 7.2 (Whangārei) and 7.3 (Kaitāia);
- **Backyard burning emissions** (Section 8.0)
  - Methodology (Section 8.1)
  - Results (Section 8.2 (Whangārei) and 8.3 (Kaitāia);
- **Total emissions** (Section 9.0)
  - Whangārei (Section 9.1.1 (PM_{10}) and 9.1.2 ($PM_{2.5}$);
  - Kaitāia (Section 9.2.19.1.1 (PM_{10}) and 9.2.2 ($PM_{2.5}$);
- **Summary of findings and conclusions** (Section 10.0);
- **Limitations** (Section 12.0); and
- **Recommendations for further work (**Section 12.0)

4.0 Inventory Design

4.1 Introduction

The development of the emission inventories follows the relevant MfE guidance (Wilton, 2001) and incorporates current best practices. NRC has previously developed an inventory for the Whangārei airshed 'Air Emission Inventory – Whangārei 2006' (Wilton, 2007), and this document has been used as the starting point to develop the current PM_{10} and $PM_{2.5}$ emission inventories for the Whangārei and Kaitāia airsheds. PDP has provided a comparison and track changes in emissions between the 2006 and current inventories present (Section 10.0).

4.2 Base year 2018

The New Zealand census data is a key input for this inventory, specifically for defining the number, type and location of domestic heating units. The most recent census was undertaken in 2018. For this reason, 2018 has been adopted as the base year for the inventory.

4.3 Emission sources and Input Data

Data used to inform the 2018 inventories has been taken from existing sources, and the best available data has been used. Where necessary, assumptions on emission and/or activity data have been made. No new data has been generated to inform the 2018 inventories.

Details of the data used and assumptions made are provided in the method section of each of the emission types (see Sections 5.0 to 8.0). The key emission sources considered, and data inputs used in the inventory are:

- Domestic heating: Census home heating data, age of burners, fuel use and emission factors;
- Road Transport: Vehicle Kilometres Travelled (VKT) and vehicle fleet composition and emission factors;
- Industry: NRC and Territorial Local Authority consent data, and representative fuel use/activity data and emission factors; and,
- Backyard burning of rubbish: number of fires, amount of material burned and emission factors.

The following sources have been excluded from the inventories

- Natural sources such as sea salt or soil particles;
- Aviation, rail and marine transport;
- Dust from unsealed roads; and,
- Permitted industrial activities or smaller commercial discharges.

These four sources may contribute particulate emissions into the airsheds but it is likely they are relatively small contributors. At a future date the inventories could be refined to include these sources.

4.4 Spatial Extent and Resolution of Inventories

NRC have gazetted five airsheds in the region:

- Whangārei;
- Marsden Point;
- Dargaville;

- Kerikeri; and
- Kaitāia.

Marsden Point airshed has been defined with a view of managing sulphur dioxide (SO_2) emissions – mainly from the Marsden Point Oil Refinery. The other four airsheds have been defined with a view of managing PM_{10} emissions. When considering the relative populations of the four PM_{10} airsheds and current PM_{10} concentrations experienced in those airsheds, Whangarei and Kaitāia stand out as the two airsheds which have the highest potential to benefit from an improved understanding and management of PM_{10} and $PM_{2.5}$ emission sources.

The geospatial resolution of within each airshed inventory has been aligned with the available Stats New Zealand 2018 census data which uses a geospatial unit named Statistical Area 2 (SA2). SA2s in city council areas generally have a population of 2,000–4,000 residents while SA2s in district council areas generally have a population of 1,000–3,000 residents. In rural areas, many SA2s have fewer than 1,000 residents because they are in conservation areas or contain sparse populations that cover a large area.

The 2006 Whangarei inventory and NRC airshed boundaries were based on Census Area Units (CAUs) which were used by Stats NZ as the standard geospatial until they were replaced by SA2s in 2018. The current airshed boundaries do not exactly align with SA2s. Where needed, assumptions have been made to allocate and/or exclude relevant SA2 census data to the airsheds.

4.5 Focus on Particulate Matter

The RPN has identified that particulate matter is a key contaminant of concern in Northland's urban airsheds. The NESAQ provides a national ambient air quality standard PM_{10} and MfE has proposed an amendments to the NESAQ to include an ambient air quality standard for $PM_{2.5}$. Therefore, both these particulate size fractions are included in the scope of this investigation.

5.0 Domestic Heating

This section covers estimation of emissions from domestic heating sources such as wood fires, pellet fires, gas heaters, and coal burners.

5.1 Method and Data Used to Calculate Emissions

The method used to calculate emissions from domestic heating sources is:

Emissions (g/day) = Activity data (number of households) x fuel use (kg/day) x emission factor (g particulate/kg of fuel burned).

The information needed to estimate the emissions from domestic heating includes household heating types and numbers, burner age data, fuel use rates, and emission factors for each type of heating used. This data was obtained from the following sources:

- National PM_{10} emission inventory – as produced for and used in the 2014 *Air Domain – State of the Environment Report and 2015 Environment Aotearoa 2015 Report* (Emission Impossible , 2015);
- Stats NZ data – Density of solid fuel home heating devices and breakdown of types within a SA2 (StatsNZ, 2021);
- Emission factor estimates in line with the Napier, Hastings 2015, National 2013, Nelson 2014 Inventories; (Environet Limited - Air Quality Specialists, 2015)
- Fuel use data from the MfE Home heating emission inventory and other sources evaluation, 2015 (Environet Limited - Air Quality Specialists, 2015); and,
- Wood burner ages and therefore performance was estimated using the previous Whangarei inventory and the building consents database of new burner installations from Kaitāia 2006 – 2021 (Environet Limited - Air Quality Specialists , 2007) (Far North District Council , 2021).

5.1.1 Home Heating Device Types

The Stats NZ data in the 2018 New Zealand census showed the breakdown of heating types from the 22,761 and 3,045 households in Whangārei and Kaitāia (Figure 2 and Figure 3 respectively).

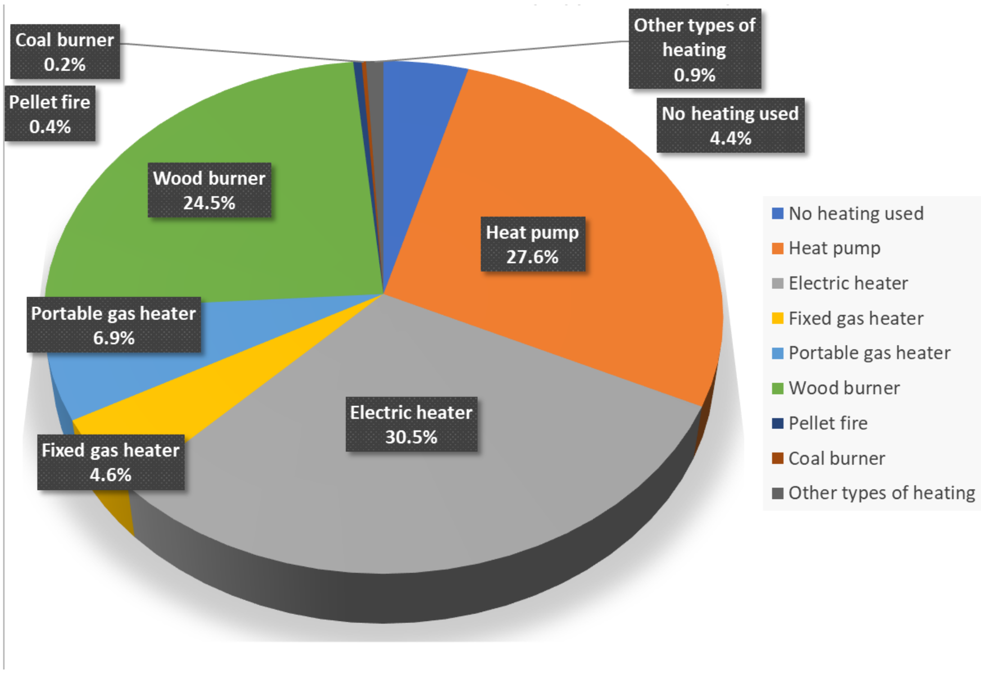

Figure 2: Breakdown of heating types in each household in Whangārei

From Figure 2 it can be seen that in Whangārei most households rely on electric heaters (31%) and heat pumps (28%). The largest fuel-based contributor to home heating emissions are wood burners (24%) followed by with gas heating (12% total) and minor contributions from pellet fires and coal fires to particulate matter.

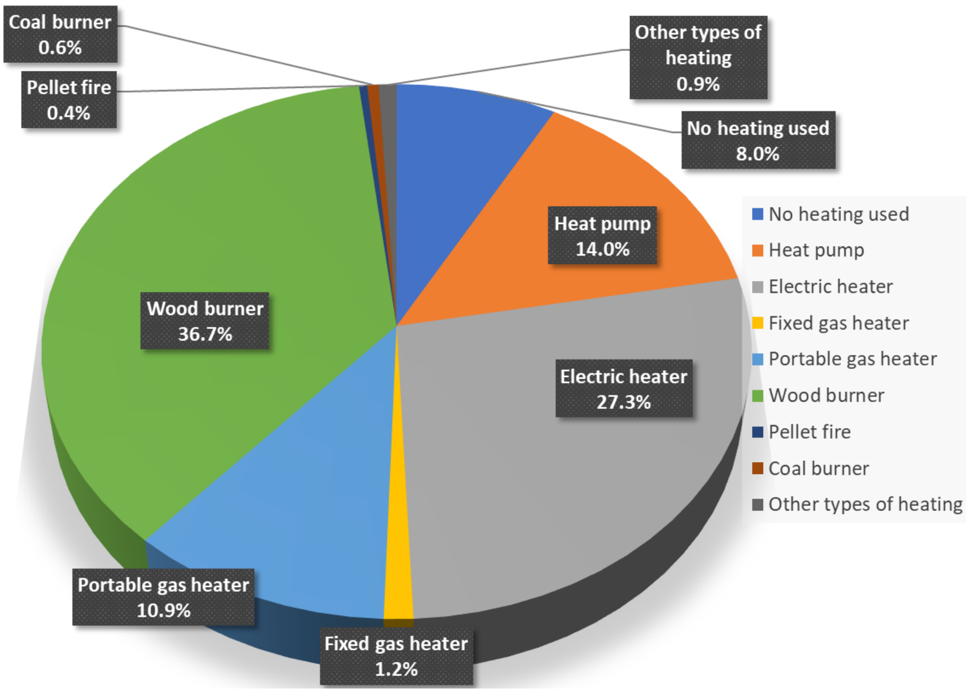

Figure 3: Breakdown of heating types in each household in Kaitāia

From Figure 3 it can be seen that wood burners (37%) are the most common source of heating in Kaitāia followed by electric heaters (27%) and heat pumps (14%). The largest contributor to home heating emissions are therefore expected to be wood burners with gas heating, pellet fires and coal fires also contributing minor amounts of particulate matter.

Based on the Stats NZ breakdown of home heating sources in Kaitāia and Whangārei the following heating varieties were input into the emissions inventories:

- Wood burners;
- Gas heaters;
- Pellet burners; and.
- Coal burners.

Any heating sources which fell into the 'other types of heating' category have been assumed negligible for the purposes of these inventories.

5.1.2 Fuel Burning Rate

A review of the available domestic fuel use data for New Zealand was undertaken and the most recent most relevant fuel use rates were selected for the Northland airshed inventories. The domestic fuel use data used to develop the inventories are shown in Table 5-1 along with a reference for the data source.

Table 5-1: Fuel consumption per household

Fuel Type	Fuel use Annual (kg/yr)	Fuel use Winter Day (kg/day)	Data Source
Wood	1947	16.0	Table 3-3 and 3-4 MfE Home heating emission inventory and other sources evaluation (Environet Limited - Air Quality Specialists, 2015)
Coal	3285	27.0[1]	Average fuel use statistics from the following emission inventories. Northland 2006, Hamilton 2012, Nelson 2014, Napier 2015 and National Inventory 2015. Adjusted by a Northland climate correction factor[2] of 0.87.
LPG	47	0.39	
Wood pellet	953	7.83	

1. PDP note that the weight of coal burned each winter day is unexpectantly high compared to wood considering the higher calorific value of coal.
2. Climate correction factor adjusts fuel use rates to account for warmer or colder temperatures that occur in different regions.

5.1.3 Emission Factors

Emission factors define the rate of discharge of contaminants to the air per unit weight of fuel burned. A review of the available emission factor data for New Zealand was undertaken and the most recent most relevant emission factors were selected for the Northland airshed inventories. The domestic burner emission factors used in New Zealand inventories are generally based on laboratory emission test data which is scaled up to account for the real-world operation of burners which results in higher emission rates than measure in laboratory testing. The emission factors used for the Northland airshed inventories are shown in Table 5-2 along with a reference for the data source.

Emission factors vary with the age/technology of the solid fuel burning device, with newer burners having lower emission factors. An average emission factor for domestic solid fuel burning devices has been calculated for use in the Northland airshed inventories. The age distribution of the wood burners installed in Northland is based on a survey completed for the Whangārei 2006 inventory, adjusted to fit the findings of an updated but limited survey completed in 2021[1]. The age distribution of Northland burners found from this process was sanity checked against burner age distributions from other regions and was found to align quite well. The age specific emission factors are listed in Table 5-2 along with an average emission factor which is determined by the relative numbers of each burner age within the total burner population.

Table 5-2: Emission factors used for the domestic burners in the Northland airshed inventories

Appliance & Fuel	% of burner population	PM_{10} emission factor (g/kg)	$PM_{2.5}$ emission factor (g/kg)	Data Source
Wood burning - pre-2004 appliances	56%	10.00	10.00	Napier, Hastings 2015, National 2013 Inventories
Wood burning - 2004-2010 appliances	22%	4.50	4.50	Napier, Hastings 2015, National 2013, Nelson 2014 Inventories (Environet Limited - Air Quality Specialists , 2014)
Wood burning - post 2010 appliances	22%	3.00	3.00	Napier, Hastings 2015 Inventory
Average wood burning appliance emission factor	100%	7.24	7.24	
Coal emission factor	100%	21.00	18.00	Napier, Hastings 2015 Inventory

[1] NRC staff survey by Obi Khanal, July 2021

Table 5-2: Emission factors used for the domestic burners in the Northland airshed inventories

Appliance & Fuel	% of burner population	PM_{10} emission factor (g/kg)	$PM_{2.5}$ emission factor (g/kg)	Data Source
Gas burning (LPG) emission factor	100%	0.03	0.03	Napier, Hastings 2015 Inventory
Pellet burning emission factor	100%	1.40	1.40	National 2013 Inventory

5.1.4 Seasonal Variation of Emissions

One of the key sources of particulate emissions in Northland's urban areas is solid fuel burning for domestic heating. This source of particulate has a very strong seasonal dependence, with almost all of the emissions occurring in the cooler months of the year. To exacerbate the impact of higher emissions, during winter, the dispersion of the contaminants at that time of year is less than generally occurs during the warmer months. This is reflected in the air quality monitoring data which demonstrates that the highest concentrations of particulates recorded in the airsheds occur during winter months. Therefore, to assist NRC with managing the PM_{10} and $PM_{2.5}$ in the airsheds, the inventories developed for this project focus on winter day emissions. Annual emissions are also presented which account for the seasonal variability in domestic emissions. Other emission sources are assumed to be consistent throughout the year.

5.2 Whangārei Domestic Heating Emissions

Domestic heating emissions reflect the residential housing densities in each suburb or relevant SA2 area in Whangārei. Due to the number of households which use wood burners compared to other heating types, the highest domestic contribution of particulate matter in each suburb comes from wood burners. This is shown from $PM_{2.5}$ estimates in Figure 4 below.

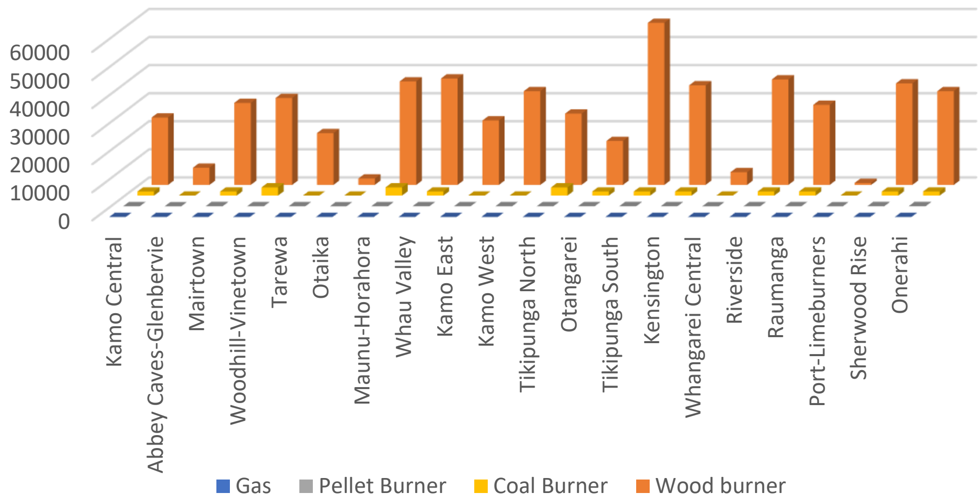

Figure 4: Whangārei $PM_{2.5}$ Domestic Winter Day Emissions (g)

Commercial, and industrial areas such as Whangārei Central and Port-Limeburners have significantly fewer domestic heating emissions than residential areas. The domestic heating $PM_{2.5}$ trends are very similar to that for the PM_{10} emissions. The domestic heating emissions for a winter day for $PM_{2.5}$ are presented for each air shed in Appendix A.

The calculated PM_{10} and $PM_{2.5}$ for winter day and annual emissions are presented in Table 5-3.

Table 5-3: Whangārei Airshed Domestic Emissions Summary

Time period	PM_{10}	$PM_{2.5}$
Annual (kg)	76,570	76,038
Winter day (kg)	629	625

The individual contributions of domestic heating in each SA2 area are presented in Figure 10 in Appendix A.

5.3 Kaitāia Domestic Heating Emissions

In Kaitāia, due to the number of households which use wood burners compared to other heating types, the highest contribution of particulate matter in each suburb comes from wood burners. This is shown from $PM_{2.5}$ estimates in Figure 5 below.

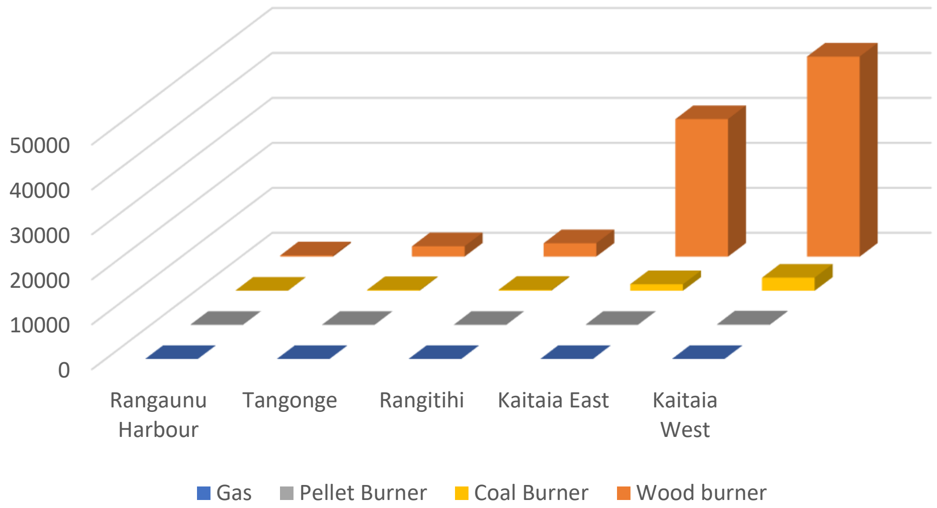

Figure 5: Kaitāia $PM_{2.5}$ Domestic Annual Emissions (kg)

Most emissions are from Kaitāia East and Kaitāia West where the most residential households are located.

The calculated PM_{10} and $PM_{2.5}$ for winter day and annual emissions are presented in Table 5-4.

Table 5-4: Kaitāia Airshed Domestic Emissions Summary

Time period	PM_{10}	$PM_{2.5}$
Annual (kg)	10,500	10,403
Winter day (kg)	86	86

The individual contributions of domestic heating in each SA2 area are presented in Figure 9 in Appendix A.

6.0 Road Transport

This section covers estimation of emissions from transport, being the vehicle fleet emission contributions in each airshed.

6.1 Method and Data Used to Calculate Emissions

The method used to calculate emissions from road transport sources is:

Emissions (g/day) = Activity data (vehicle kilometres travelled) x fleet weighted emission factor (g particulate/ vehicle kilometres travelled).

The discharge of particulate from vehicles travelling on unsealed road surfaces has not been included in the inventory.

6.1.1 Vehicle kilometres travelled (VKT)

The Ministry of Transport (MoT) Vehicle Fleet Emission Model (VFEM3) provides estimates of VKT for each SA2 in New Zealand. This vehicle activity data for 2018 was used for the Northland emission inventories.

6.1.2 Vehicle Fleet Composition

Vehicle emission factors vary with the type and age/technology of vehicles. For example, newer vehicles tend to have lower emission factors than older vehicles and light duty vehicles tend to have lower emission factors than heavy duty vehicles. Therefore, the composition of vehicle ages and types within the vehicle fleet has a significant influence on the emissions from that fleet.

For the Northland emission inventories the fleet composition, and vehicle age was assumed to be the same as the default New Zealand fleet assumptions as provided in NZTA's Vehicle Emission Prediction Model (VEPM 6.1)[2] for the year 2018.

6.1.3 Emission factors

Emission factors define the rate of discharge of contaminants to the air per kilometre of vehicle travel. A review of the available emission factor data for New Zealand was undertaken and the most recent most relevant emission factors were selected for the Northland airshed inventories. Fleet weighted emission factors were determined using VEPM 6.1 assuming default New Zealand fleet for fleet composition, and vehicle age, applying a speed of 50 km/h for all vehicles, assuming flat terrain and the year 2018. The influence of cold start and non-tailpipe emissions was included in the emission factors. Table 6-1 displays the fleet average emission factors used for the Northland inventories. $PM_{2.5}$ emissions are solely driven by exhaust emissions, PM_{10} emissions are the sum of exhaust and brake and tyre wear emissions.

Table 6-1: Fleet average vehicle emission factors used for the Northland inventories

Emission factor	Exhaust Emissions – $PM_{2.5}$ (g/km)	Brake & Tyre Emissions – PM_{10} (g/km)
Fleet average (2018)	0.0297	0.0250

[2] NZTA VEPM Version 6.1 (2020). PDP note that VEPM 6.2 was released by Waka Kotahi in August 2021. The updates provided in VEPM 6.2 are highly unlikely to significantly impact the results of the vehicle emission calculations undertaken for this study.

6.2 Whangārei Road Transport Emissions

The busiest area for vehicle emissions is in Whangarei Central which is estimated to contribute 9,599 kg PM_{10} annually. Residential and rural areas are estimated to contribute significantly less traffic-based emissions than high density, commercial and industrial areas. A summary of road transport emissions in Whangārei is presented in Table 6-2.

Table 6-2: Whangārei Airshed Road Transport Emissions Summary

Summary	PM_{10}	$PM_{2.5}$
Annual (kg)	54,833	42,296
Winter day (kg)	150	116

6.3 Kaitāia Road Transport Emissions

The busiest area for traffic flow Kaitāia is in Kaitāia East, which is the main thoroughfare for the town, and is estimated to contribute 2,477 kg PM_{10} annually. Residential and rural areas are estimated to contribute significantly less traffic-based emissions than high density, commercial and industrial areas. A summary of transport emissions in Kaitāia is presented in Table 6-3 below.

Table 6-3: Kaitāia Airshed Road Transport Emissions Summary

Summary	PM_{10}	$PM_{2.5}$
Annual (kg)	4,055	3,128
Winter day (kg)	11	9

7.0 Industrial and Commercial

This section covers estimation of emissions from known industrial activities with potential to discharge particulate matter in each airshed.

7.1 Method and Data Used to Calculate Emissions

The method used to calculate emissions from industrial and commercial sources is:

Emissions (g/day) = Activity data (kg fuel per hour burned or number of hours of discharge) x emission factor (g particulate/kg of fuel burned or g particulate/hour).

7.1.1 Discharge Activities

The industrial air discharges were identified through obtaining all resource consents for air discharge activities in each airshed. Each resource consent was reviewed and the discharge types included in the inventory were categorised as follows:

- Abrasive Blasting (sometimes including spray painting)
- Large Industry Stack discharge;
- Crematorium Stack discharge;
- Generator Stack discharge;
- Asphalt Stack discharge;
- Boiler Stack discharge; and
- Concrete Mixing

The following industrial/commercial discharge types are not included in the inventory:

- Particulate emissions from permitted activities such as small diesel fired boilers or space heaters;
- Dust (fugitive dust from a waste transfer station was difficult to estimate and considered mostly negligible or mainly from roads); and
- Odour (odorous activities such as wastewater ponds are considered negligible to particulate matter discharges).

The list of sources and activity rates identified from the consent information was reviewed and confirmed by NRC staff.

7.1.2 Emission Factors and Activity Data

The following information sources were used to assign emission factors to each source type and location:

- Stack emission testing results supplied by NRC (K2 Environmental Limited, 2020);
- US EPA AP42 emission factors (U. S. Environmental Protection Agency, 1997);
- NPI emission factors (National Pollutant Inventory , 2011);
- KTA50-G3 generator engine datasheets (Cummins Engine Company , 2001); and,
- PDPs experience with emission rates and activity data from similar sized sites for each activity type (Christopher Bender, 2021).

The activity data for each source was taken from the information contained in the relevant resource consent and was sanity checked by NRC staff[3].

The summary of industrial emission factors (EF) and activity data used for the Whangārei and Kaitāia inventories is provided in Table 7-1.

Table 7-1: Industrial emission factors and activity data

Discharge activity	PM_{10}	PM_{10} unit	$PM_{2.5}$	$PM_{2.5}$ unit	Activity hr/day	Data source
Blasting	7	g/kg sand	1	g/kg sand	6	AP-42 Background Document: section 13.2.6 Abrasive blasting
Large Industry Stack discharge (Triboard Mill and Cement Plant)	4810	g/hr	3848	g/hr	24	Stack testing - Air Resource Management December 2020

[3] Email correspondence, Obi Khanal, 'Draft Deliverables: NRC Airshed Investigation: Phase 1: Whangārei and Kaitāia Air Emission Inventories for Particulate Matter' July 2021

Table 7-1: Industrial emission factors and activity data

Crematorium Stack discharge	39	g/cremation	35	g/cremation	5 cremati ons/day	NPI emission factors, PDPs experience
Generator Stack discharge	121	g/hr MW	0	g/hr MW	7	Assumed KTA50-G3 generators
Asphalt Stack discharge	670	g/hr	536	g/hr	24	K2 Environmental Downer stack testing
Concrete Mixing (Allied Concrete & Firth Industries)	156	g/hr	78	g/hr	8	AP42 Section 11.12 Concrete Batching and resource consent 12697
Boiler Stack discharge (Northland Mill)	680	g/hr	544	g/hr	24	Stack testing - Air Resource Management December 2020

7.2 Whangārei Industrial and Commercial Emissions

The majority of industrial emissions in the Whangārei airshed are from the Port-Limeburners SA2 with some minor industrial emissions in Springs Flat. A summary of industrial PM_{10} and $PM_{2.5}$ emissions in the Whangārei airshed is presented in Table 7-3.

Table 7-2: Whangārei Airshed Industrial Emissions Summary

Summary	PM_{10}	$PM_{2.5}$
Annual breakdown (kg)	25,249	7,843
Winter day (kg)	69	21

Point sources of industrial emission are shown in Figure 6.

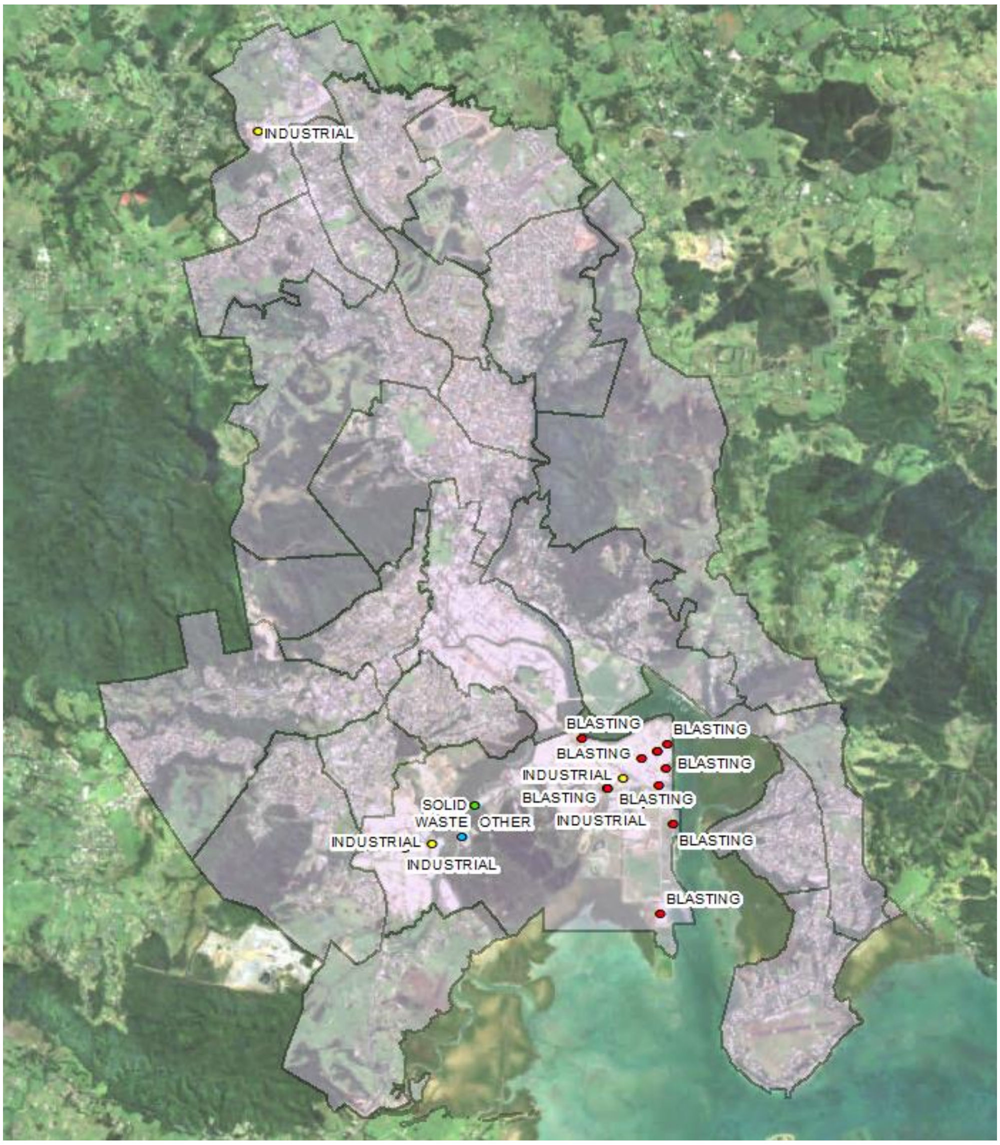

Figure 6: Industrial point source locations in Whangārei

7.3 Kaitāia Industrial and Commercial Emissions

Industrial emissions in the Kaitāia airshed are spread out between Tangonge, Oturu and Kaitāia East SA2s, with majority of the emissions coming from Kaitāia East. A summary of industrial PM_{10} and $PM_{2.5}$ emissions in the Kaitāia airshed is presented in Table 7-3.

Table 7-3: Kaitāia Airshed Industrial Emissions Summary

Summary	PM_{10}	$PM_{2.5}$
Annual breakdown (kg)	51,038	39,964
Winter day (kg)	145	114

Point sources of industrial emission are shown in Figure 7.

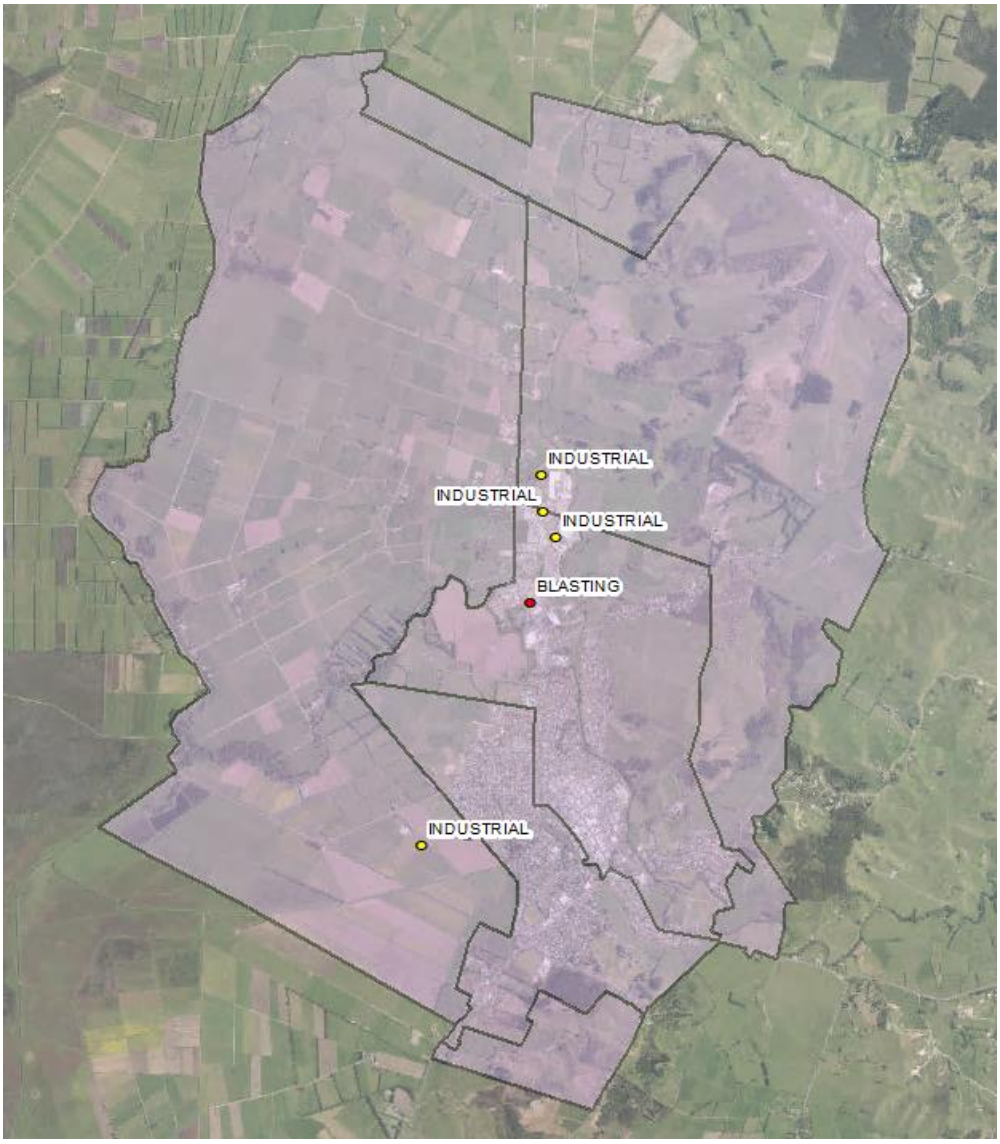

Figure 7: Industrial point source locations in Kaitāia

8.0 Backyard Burning

8.1 Method and Data Used to Calculate Emissions

The method used to calculate emissions from backyard burning sources is:

Emissions (g/day) = Activity data (number of houses) x outdoor burning emission factor (g particulate/household/day).

The information available to estimate the emissions from backyard burning was very limited, but the most relevant and robust data selected for the Northland inventories. However, it should be noted that the total emissions reported from this source are likely to contain a relatively high uncertainty.

8.1.1 Backyard burning estimation

The emissions from backyard burning was estimated using the MfE home heating emission inventory and other sources evaluation and validated through cross checking with local knowledge[4]. The MfE inventory breaks down outdoor burning trends based on geographical area for urban and rural properties in the North Island.

8.1.2 Urban and rural backyard burning

The survey undertaken to inform the 2006 inventory suggested that rural backyard burning emission are higher than urban emission factors as rural burning is more frequent and burn larger quantities of waste. Rural areas in this inventory have been classed as SA2 areas with significantly more green space (rural land) than residential housing, industrial or commercial areas. For the purposes of these inventories the following SA2 areas which intersect the airshed are classed as rural:

- Part of the Rangaunu Harbour SA2 area (Kaitāia)
- Part of the Tangonge SA2 area (Kaitāia)
- Oturu (Kaitāia)
- Part of the Abbey Caves-Glenbervie SA2 area (Whangārei)
- Otaika (Whangārei)

All other SA2 areas in the Whangārei and Kaitāia airsheds have been classed as urban.

8.1.3 Emission Factors

The summary of industrial emission factors (EF) and activity data used for the Northland inventories is provided in Table 8-1.

[4] Email correspondence, Obi Khanal. July 2021

Table 8-1: Backyard Burning Emissions factors

Emission factors	PM_{10} (g/house-hold/day)	$PM_{2.5}$ (g/house-hold/day)	Source
Urban North Island	2	2	Table 4-2 MfE Home heating emission inventory and other sources evaluation, 2015
Rural North Island	15	15	Table 4-2 MfE Home heating emission inventory and other sources evaluation, 2015

8.2 Whangārei Backyard Burning Emissions

The Whangārei airshed consists of mostly urban space so there is less backyard burning assumed than for rural zones. Outdoor burning in the Whangārei airshed is only permitted on a property greater than one hectare in area under the rules in the Regional Plan. However, to make the best use of the available backyard burning activity and emission rate data, for this inventory a backyard burning emission rate was applied to all residential properties in the Whangārei airshed. This means that the potential positive impact of the Regional Plan rule was not included in the inventory. Therefore, the estimates of the total emissions from the Whangārei airshed are likely to be conservative. A recommendation to investigate the potential impact of the Regional Plan rule on backyard burning emissions is made in Section 12.0. The estimated emissions for burning of backyard rubbish is given in Table 8-2.

Table 8-2: Whangārei Airshed Backyard Burning Emissions Summary

Summary	PM_{10}	$PM_{2.5}$
Annual (kg)	14,037	14,037
Winter day (kg)	38	38

8.3 Kaitāia Backyard Burning Emissions

The Kaitāia airshed consists of more rural areas so more backyard burning is assumed in these rural zones. The estimated emissions for burning of backyard rubbish is given in Table 8-3.

Table 8-3: Kaitāia Airshed Backyard Burning Emissions Summary

Summary	PM_{10}	$PM_{2.5}$
Annual (kg)	1,871	1,871
Winter day (kg)	5	5

9.0 Airshed Total Emissions

From the four identified main contributors' total emissions have been estimated for the Whangārei and Kaitāia airsheds.

9.1 Whangārei

9.1.1 PM_{10} Emissions

The annual and winter day PM_{10} emission source contributions to the Whangārei airshed are broken down in Figure 8 and Figure 9 respectively.

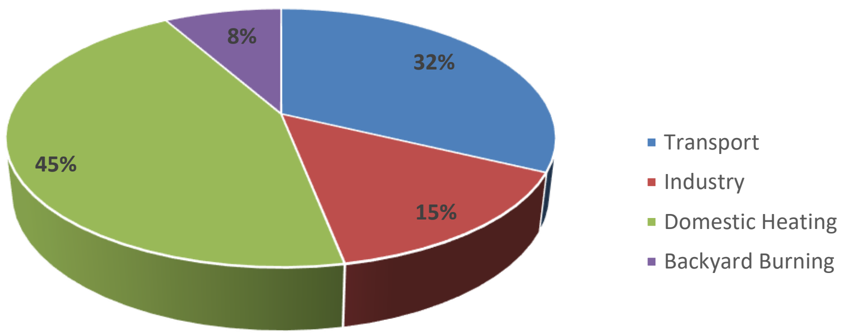

Figure 8: Source contribution to Whangārei Airshed Annual PM_{10} emissions

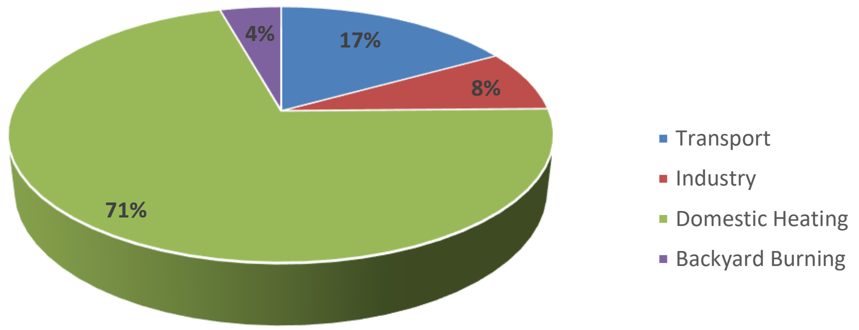

Figure 9: Source contribution to Whangārei Airshed Winter Day PM_{10} emissions

The largest contributors to annual PM_{10} emissions in Whangārei are estimated to be domestic heating and transport. While the domestic heating contributions to annual PM_{10} are 45%, the daily contributions in winter are significantly higher (71%) as majority of homes with fuel burning heating devices are using them in winter. The estimated PM_{10} emissions for each source are shown in Table 9-1.

Table 9-1: Whangārei Airshed PM_{10} Emissions by Source type

Emissions (kg)	Transport	Industry	Domestic Heating	Backyard Burning	Total PM_{10}
Annual	54,833	25,249	76,570	14,037	170,688
Winter day	150	69	629	38	887

While the biggest overall contribution to PM_{10} is domestic heating, there are some localised SA2 areas which are estimated to have higher emissions of PM_{10}, which are:

- Industrial emissions at Port Limeburners; and
- Transport in Whangārei central and Kensington.

These PM_{10} emission estimates by source type are shown in Figure 5 in Appendix A.

9.1.2 $PM_{2.5}$ Emissions

The annual and winter day $PM_{2.5}$ emission source contributions to the Whangārei airshed are broken down in Figure 10 and Figure 11 respectively.

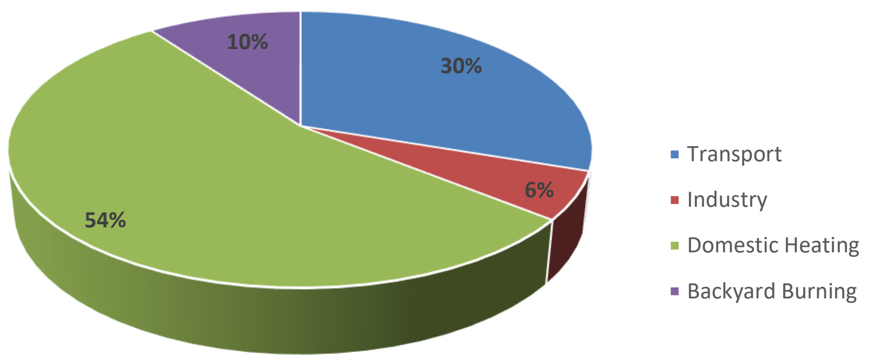

Figure 10: Source Contribution to Whangārei Airshed Annual $PM_{2.5}$ Emissions

The largest contributor to annual $PM_{2.5}$ emissions in Whangārei is estimated to be domestic heating with transport the second largest contributor. While the domestic contributions to annual $PM_{2.5}$ are 54%, the daily contributions in winter are expected to be significantly higher as majority of homes with fuel burning heating devices are using them in winter. Breakdown of daily winter $PM_{2.5}$ emissions are shown in Figure 11, where it can be seen 78% is estimated to be from domestic heating.

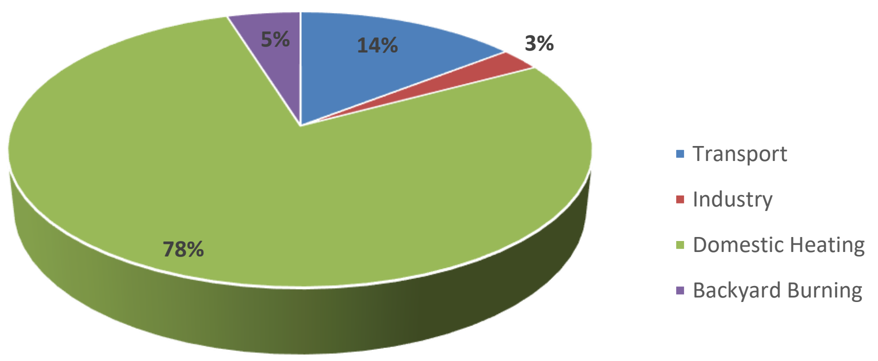

Figure 11: Source Contribution to Whangārei Airshed Winter Day $PM_{2.5}$ emissions

The estimated $PM_{2.5}$ emissions for each source is shown Table 9-2.

Table 9-2: Whangārei Airshed $PM_{2.5}$ Emissions by Source type

Emissions (kg)	Transport	Industry	Domestic Heating	Backyard Burning	Total PM_{10}
Annual	42,296	7,843	76,038	14,037	140,213
Winter day	116	21	625	38	801

While the largest contribution to $PM_{2.5}$ is domestic heating from wood burners (see Appendix A), the SA2 with the largest estimated emissions is Port-Limeburner's due to the relatively large number of industrial sources in that area.

9.2 Kaitāia

9.2.1 PM_{10} Emissions

The annual and winter day PM_{10} emission source contributions to the Kaitāia airshed are broken down in Figure 12 and Figure 13 respectively.

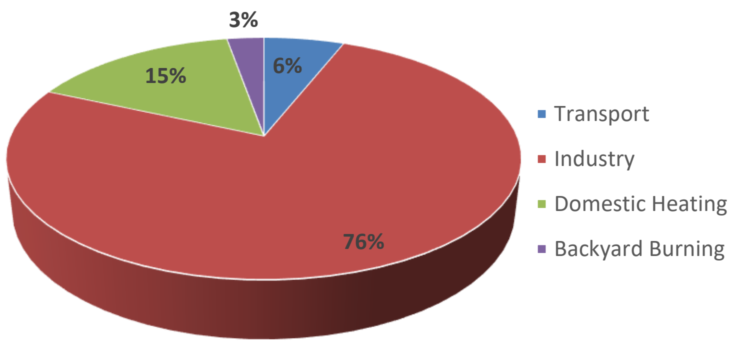

Figure 12: Source contribution to Kaitāia Airshed Annual PM_{10} Emissions

The largest contributor to annual PM_{10} emissions in Kaitāia airshed is estimated to be industry at 76%. While the domestic heating contributions to annual PM_{10} emissions are just 15%, the daily contributions in winter are higher (35%) as majority of homes with fuel burning heating devices are using them in winter. A breakdown of daily winter emissions is shown in Figure 13.

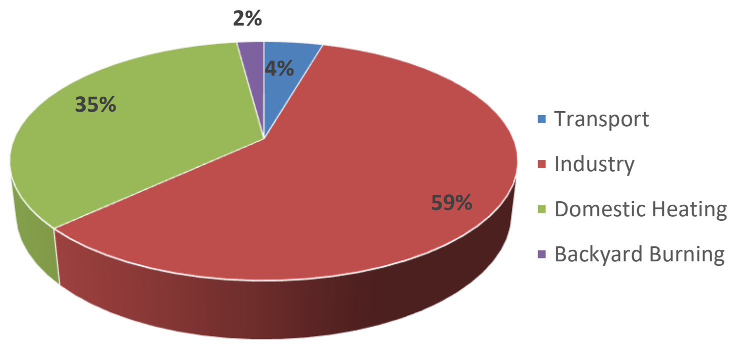

Figure 13: Source contribution to Kaitāia Airshed Winter Day PM_{10} Emissions

The estimated PM_{10} emissions for each source type are shown in Table 9-3 below.

Table 9-3: Source Contribution to Kaitāia Airshed PM_{10} Emissions

Emissions (kg)	Transport	Industry	Domestic Heating	Backyard Burning	Total PM_{10}
Annual	4,055	51,038	10,500	1,871	67,463
Winter day	11	145	86	5	248

The biggest contribution to PM_{10} emissions in the Kaitāia airshed is industry spread across three SA2 areas, Oturu, Kaitāia East and Kaitāia West (see Appendix A).

9.2.2 $PM_{2.5}$ Emissions

The annual and winter day $PM_{2.5}$ emission source contributions to the Kaitāia airshed are broken down in Figure 14 and Figure 15 respectively.

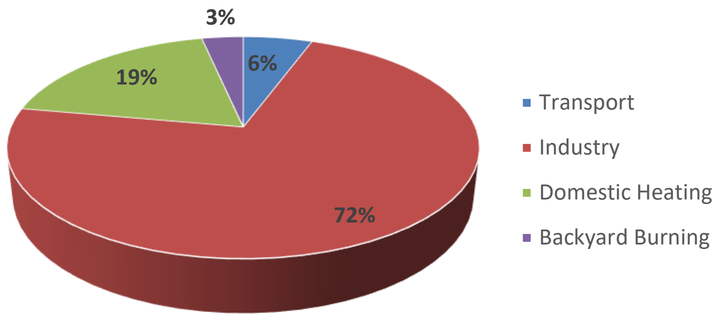

Figure 14: Source contribution to Kaitāia Airshed Annual $PM_{2.5}$ Emissions

The largest contributor to annual $PM_{2.5}$ emissions in the Kaitāia airshed is estimated to be industry at 72%. While the domestic contributions to annual $PM_{2.5}$ are just 19%, the daily contributions in winter are higher (40%) as majority of homes with fuel burning heating devices are using them in winter. A breakdown of daily winter $PM_{2.5}$ emissions is shown in Figure 15 where it can be seen that even in winter industrial emissions are still estimated to be higher than from the domestic source in the Kaitāia airshed.

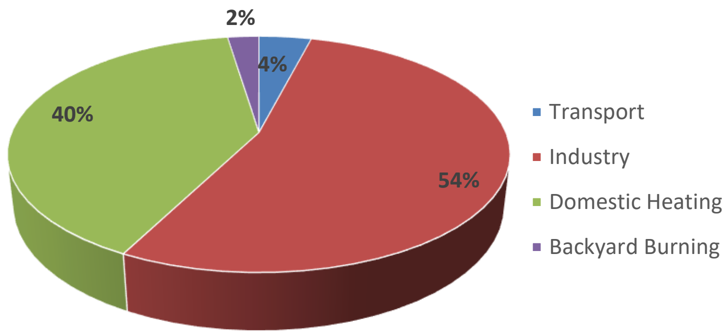

Figure 15: Source contribution to Kaitāia Airshed Winter Day $PM_{2.5}$ (kg)

The estimated PM_{10} emissions for each source type are shown in Table 9-4.

Table 9-4: Source Contribution to Kaitāia Airshed $PM_{2.5}$ Emissions

Emissions (kg)	Transport	Industry	Domestic Heating	Backyard Burning	Total PM_{10}
Annual	3,128	39,964	10,403	1,871	55,366
Winter day	9	114	86	5	214

The biggest contribution to $PM_{2.5}$ in the Kaitāia airshed is industry spread across three SA2 areas, Oturu, Kaitāia East and Kaitāia West. There is also a localised large contribution of $PM_{2.5}$ from domestic heating on winter days (see Appendix A)

10.0 Trends in Whangārei Airshed PM_{10} Emissions - 2006 to 2018

A comparison of 2006 and current 2018 Whangārei airshed inventories for PM_{10} has been undertaken to track changes in emissions over time. The comparison of the two inventories must be made with due caution because of the amount of time that has elapsed since the 2006 inventory and the changes in the sources of activity and emission data used in 2006 and 2018. However, the comparison of the two inventories does provide a useful, albeit indicative, trend in PM_{10} emissions over time for the Whangārei airshed. Table 10-1 compares the Whangārei airshed PM_{10} winter day emission estimates for 2006 and 2018 by emission source.

Table 10-1: Whangārei winter day airshed PM_{10} emission estimates for 2006 and 2018

Year	Transport (kg)	Industry (kg)	Domestic Heating (kg)	Backyard Burning (kg)	Total emissions (kg)
2006	104	203	734	172	1,213
2018	150	69	629	38	887
% change in emissions 2006 to 2018	+44%	-66%	-14%	-78%	-27%

Notes:
1. *The percentage change is calculated by $(V_2 - V_1)/V_1$ where V_1 is the baseline value and V_2 is the new value*

Table 10-1 suggests a reduction in domestic PM_{10} emissions in the Whangārei airshed of approximately 14% over the period 2006 to 2018. There has been an upward pressure on this source of PM_{10} as the number of households using solid fuel devices has increased in line with the population growth of the city in the last 12 years. In the 2006 inventory there was a relatively high proportion of high emitting older burners. In 2021 local burner data suggest is a higher proportion of lower emitting newer burners. The increase in the number of devices has been more than balanced by the improved emission performance of the newer burners.

Table 10-1 suggests a large reduction in industrial PM_{10} emissions in the Whangārei airshed of approximately 66% over the period 2006 to 2018. No new major PM_{10} emission sources have been consented in that period in the Whangārei airshed and a number of previously consented industrial sources have ceased operating since 2006.

Table 10-1 suggests a significant increase in transport emissions and a very large decrease in backyard burning emissions over the years 2006 to 2018. However, the changes in PM_{10} emissions from these two sources, as indicated in Table 10-1, are most likely largely driven by the changes in input data used for the 2006 and 2018 inventories.

Emission inventories for other regions suggest a slow decline in transport emissions over time as the improvements in vehicle efficiency and improved emission reduction technology more than compensates for the increase in vehicle numbers. The very large decrease in backyard burning emissions is most likely to be an artifact of the change in input data specifically a much lower number of backyard burns in 2018 compared to 2006. In summary, at best, these changes provide a high-level uncertainty indicator on the trends in emissions from these sources over time. As such, it is recommended that very little weight should be given to the estimated trends in emissions from transport and backyard burning.

A comparison of the relative contributions of domestic heating sources to winter day total PM_{10} emissions in the Whangarei airshed in 2006 and 2018 shows that the proportion of domestic heating sources to total emissions remains more or less constant at approximately 61 - 71% respectively. A comparison of the relative contributions of industrial sources to winter day total PM_{10} emissions in the Whangarei airshed in 2006 and 2018 shows that the proportion of industrial sources to total emissions has approximately halved from 17% to 8%. This reflects the significant reduction in the total industrial PM_{10} emissions from 2006 to 2018.

The remaining percentage of total emissions comes transport and backyard burning in both the 2006 and 2018 inventories. But as noted above very little weight should be given to the estimated trends in emissions from transport and backyard burning over the years 2006 to 2018.

11.0 Summary of Findings and Conclusions

The key objective of Phase 1 of this project was to provide robust information which would enable NRC to pinpoint and quantify the key PM_{10} and $PM_{2.5}$ sources in the Whangārei and Kaitāia airsheds. To meet the key project objective particulate matter emission inventories have been developed for the Whangārei and Kaitāia airsheds.

The emission inventories included four key source types: domestic fuel burning devices, road transport, industry and backyard burning. Emissions were calculated using best practice methods and the most robust/representative input data available was used to inform the calculations. Some limitations in the available data were identified and are discussed in Section 12. The emissions for both airsheds were based on the geospatial unit SA2 and calculated for an annual total and a winter day.

In the Whangārei airshed, the domestic heating, transport and industry sources contribute 45%, 32%and 15% respectively to the annual PM_{10} total emissions of 171 tonnes. Hotspot SA2s have been identified for both these sources. The domestic heating source dominates (71%) the Whangarei airshed total PM_{10} emissions on a winter day (887 kg). Similar source type, temporal and spatial patterns are seen in the Whangarei airshed $PM_{2.5}$ emissions except for domestic emissions being more prominent.

In the Kaitāia airshed, the domestic and industry sources contribute 15% and 76% respectively to the annual PM_{10} total emissions of 67 tonnes. Hotspot SA2s have been identified for both these sources. The industrial source dominates (59%) the Kaitāia airshed total PM_{10} emissions on a winter day (248 kg), with the e domestic sources contributing 35%. Similar source type, temporal and spatial patterns are seen in the Kaitāia airshed $PM_{2.5}$ emissions except for domestic emissions being more prominent.

A comparison of the 2006 and 2018 Whangarei airshed inventories has been undertaken to track changes in emissions of PM_{10} over the period 2006 to 2018. This comparison suggests a reduction in total winter day PM_{10} emissions in the Whangārei airshed of approximately 27% from 1.2 tonnes/day to 0.9 tonnes/day. This reduction reflects the trends observed in the key domestic and industrial emission sources. The comparison of the 2006 and 2018 Whangārei airshed inventories for transport and backyard burning PM_{10} emissions shows large changes over the 12-year period. These trends are not considered likely to reflect reality are most likely artifacts due to the changes in the data sources used to calculate the emissions from these sources.

This information will be used in Phase 2 of the project which is to Identify potential hotspots suitable for NESAQ PM_{10} and $PM_{2.5}$ monitoring in the Whangārei and Kaitāia airsheds.

12.0 Emission and Activity Data Limitations and Potential Improvements

The quality of information presented in an emission inventory is highly dependent on the quality of the data used to inform the calculations. While the most robust/representative input data available has been used to inform the calculations undertaken for the Whangārei and Kaitāia airsheds, the data available was limited, sometimes dependant on surveys undertaken over 12 years previously or from data collected for other regions. During the development and reporting of the Whangārei and Kaitāia emission inventories the following key activity and emission data gaps were identified:

- The annual total and winter amounts of fuel burned in domestic solid fuel devices;
- The age profile of domestic solid fuel burners installed in both airsheds;
- Activity data for industrial sources which was based on consent limits rather than actual operating hours;
- The number of backyard burning events that occur;
- Amount of waste burned in each backyard burning event; and
- The potential impact of the Regional Plan rule which limits backyard burning to properties greater than 1 ha in area.

The following sources have been excluded from the inventories:

- Permitted industrial activities or smaller commercial discharges;
- Aviation, rail and marine transport;
- Dust from unsealed roads; and,
- Natural sources such as sea salt or soil particles.

These four sources will contribute particulate emissions in the airsheds, but it is likely they are relatively small contributors compared to the four key sources detailed in the Whangārei and Kaitāia emission inventories. At a future date, when the relevant activity and emission factor data is readily available, the inventories could be refined to include these sources.

13.0 References

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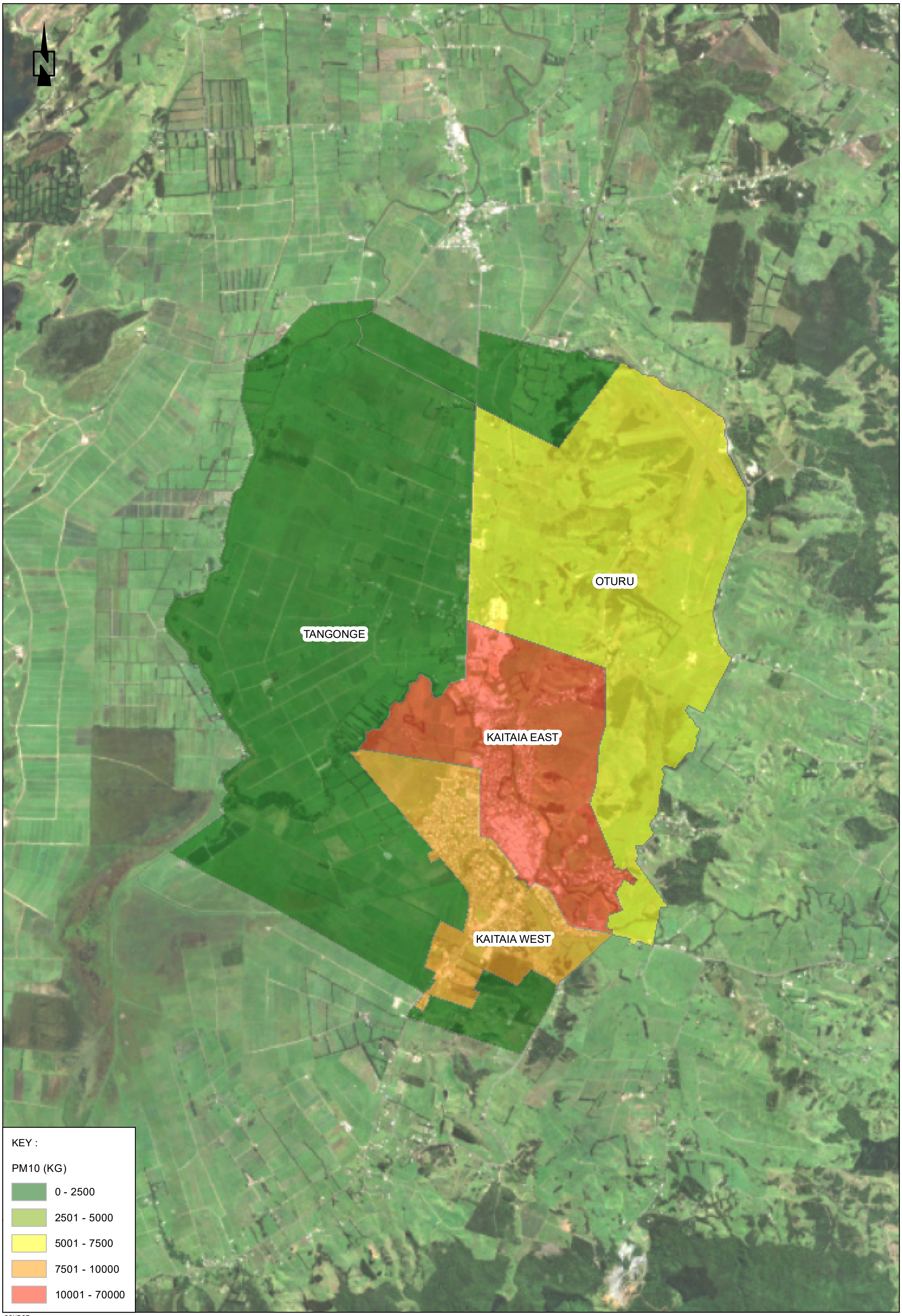
Appendix A

Emission Inventory SA2 Breakdown Maps



SOURCE:
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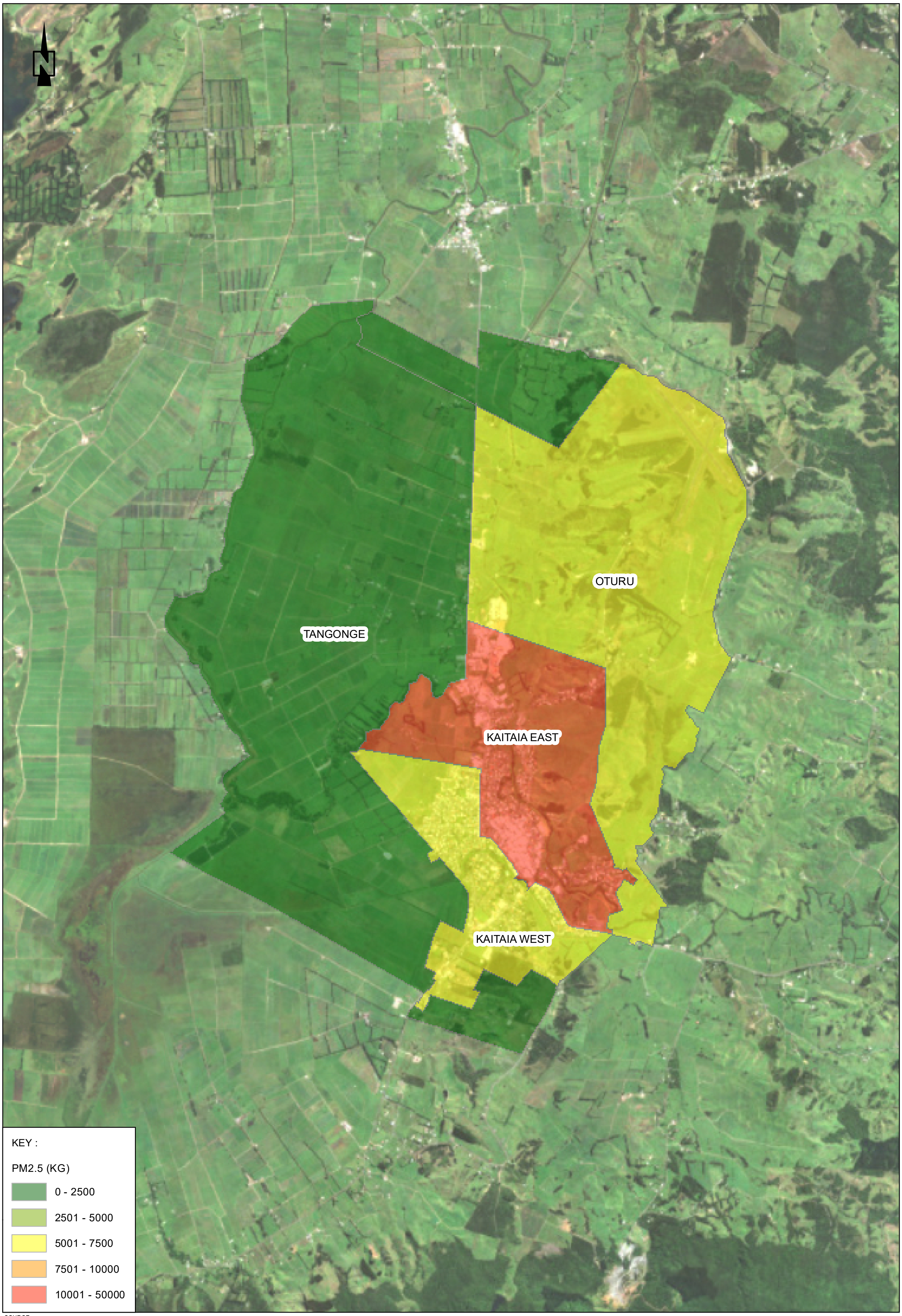
2. SA2 PROVIDED BY STATS NZ AND USED WITH PERMISSION.

FIGURE 1 : KAITAIA AIRSHED PM10 ANNUAL INVENTORY

SCALE : 1:60,000 (A4)

0 0.5 1 2 3
Kilometres



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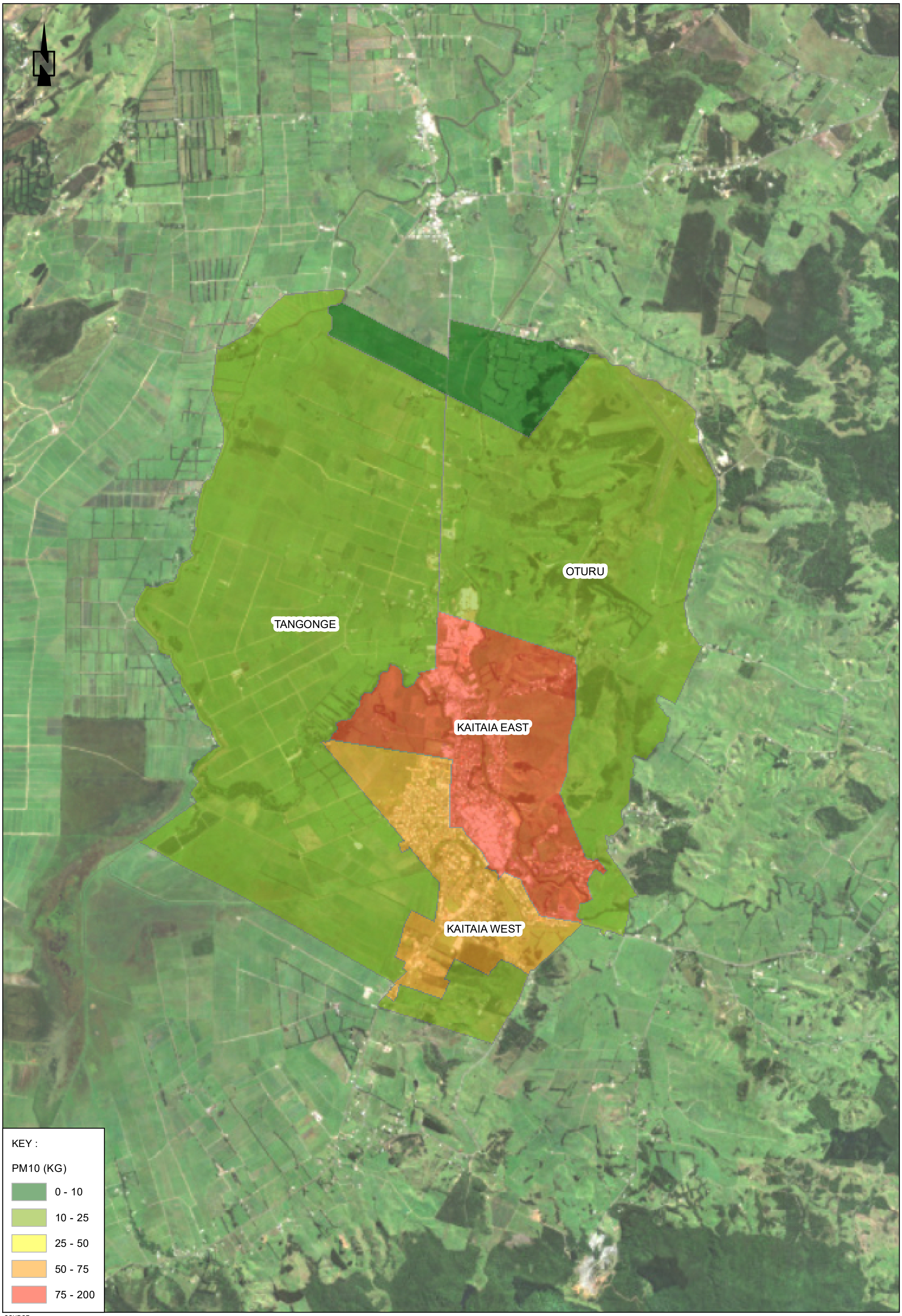
2. SA2 PROVIDED BY STATS NZ AND USED WITH PERMISSION.

FIGURE 2 : KAITAIA AIRSHED PM2.5 ANNUAL INVENTORY

SCALE : 1:60,000 (A4)

0 0.5 1 2 3

Kilometres



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AND LICENCED BY LINZ FOR RE-USE UNDER THE CREATIVE
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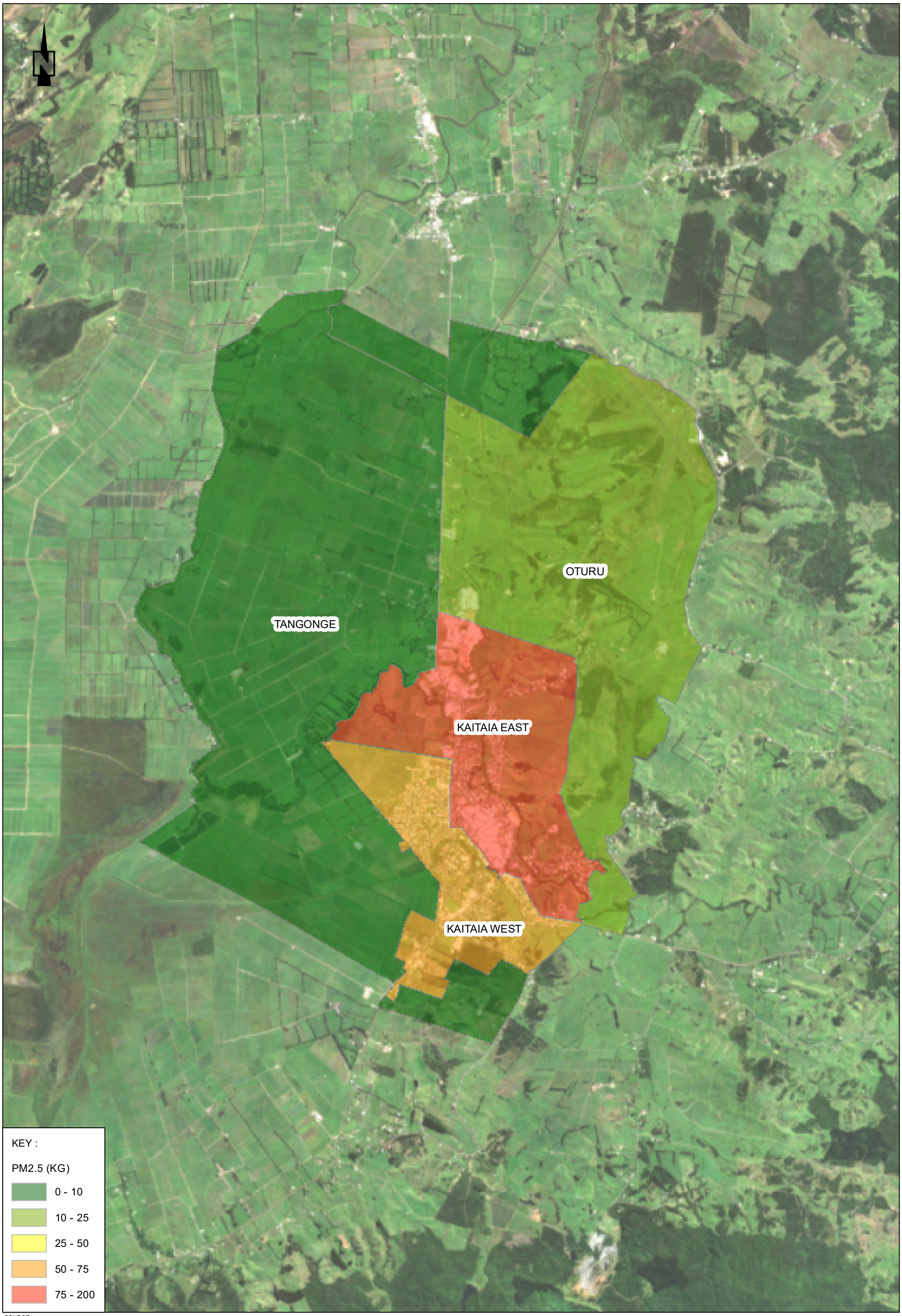
FIGURE 3 : KAITAIA AIRSHED
PM10 WINTER DAY

SCALE : 1:60,000 (A4)

0 0.5 1 2 3
Kilometres



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AND LICENCED BY LINZ FOR RE-USE UNDER THE CREATIVE
COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENCE.
2. SA2 PROVIDED BY STATS NZ AND USED WITH PERMISSION.

FIGURE 4 : KAITAIA AIRSHED
PM2.5 WINTER DAY

SCALE : 1:60,000 (A4)

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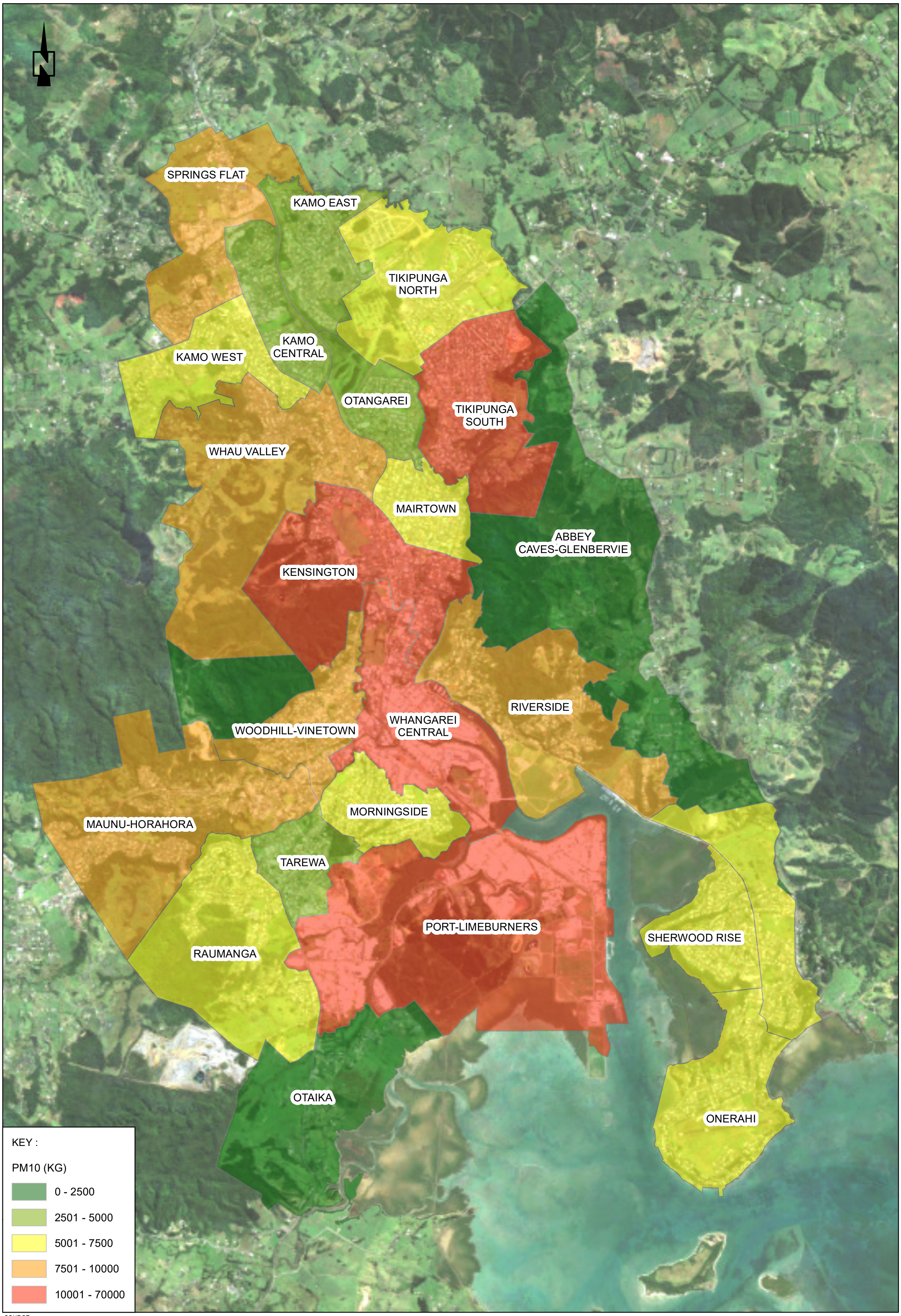
Kilometres



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2. SA2 PROVIDED BY STATS NZ AND USED WITH PERMISSION.

FIGURE 5 : WHANGĀREI AIRSHED PM10 ANNUAL INVENTORY

SCALE : 1:60,000 (A4)

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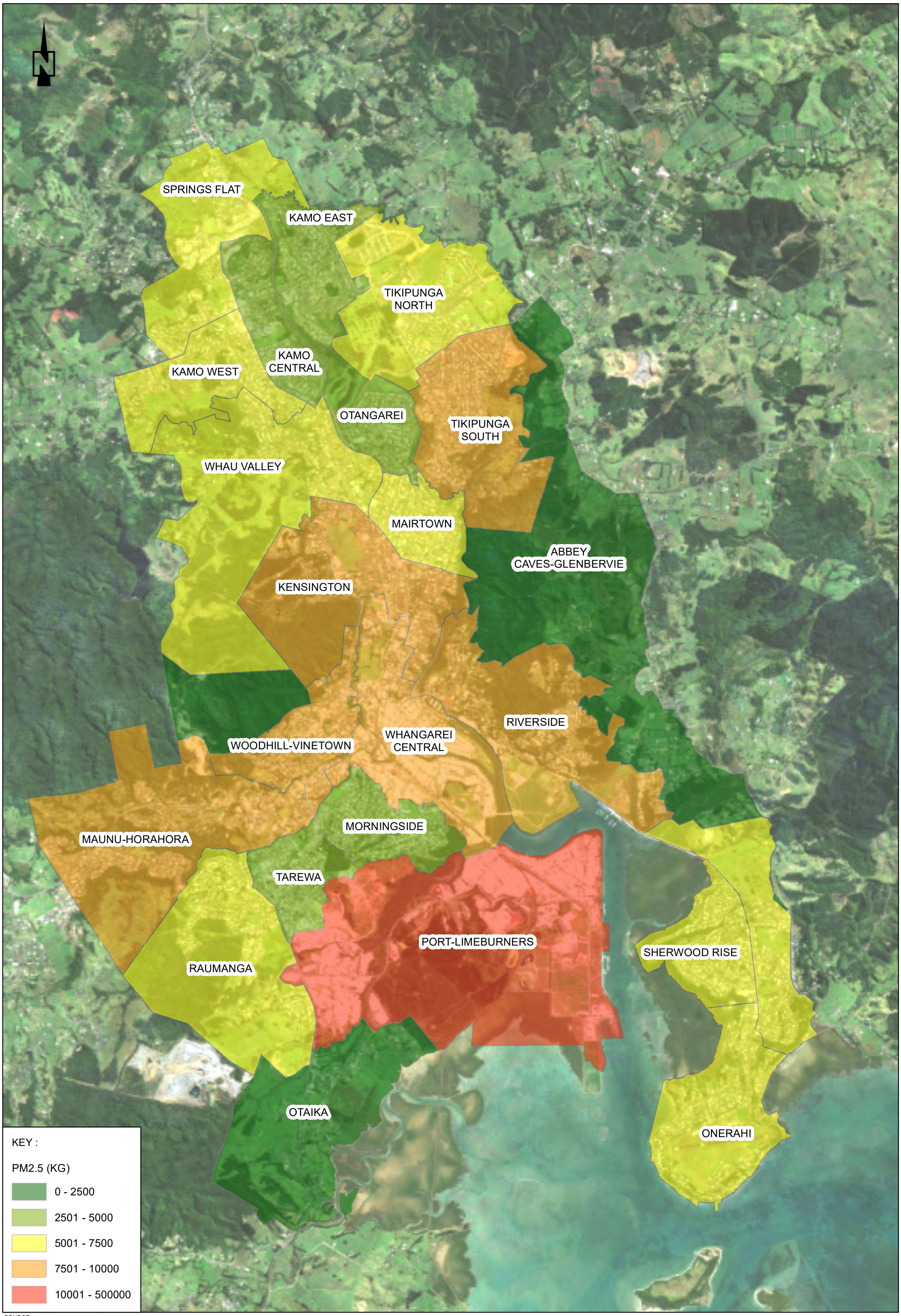
Kilometres



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2. SA2 PROVIDED BY STATS NZ AND USED WITH PERMISSION.

FIGURE 6 : WHANGĀREI AIRSHED PM2.5 ANNUAL INVENTORY

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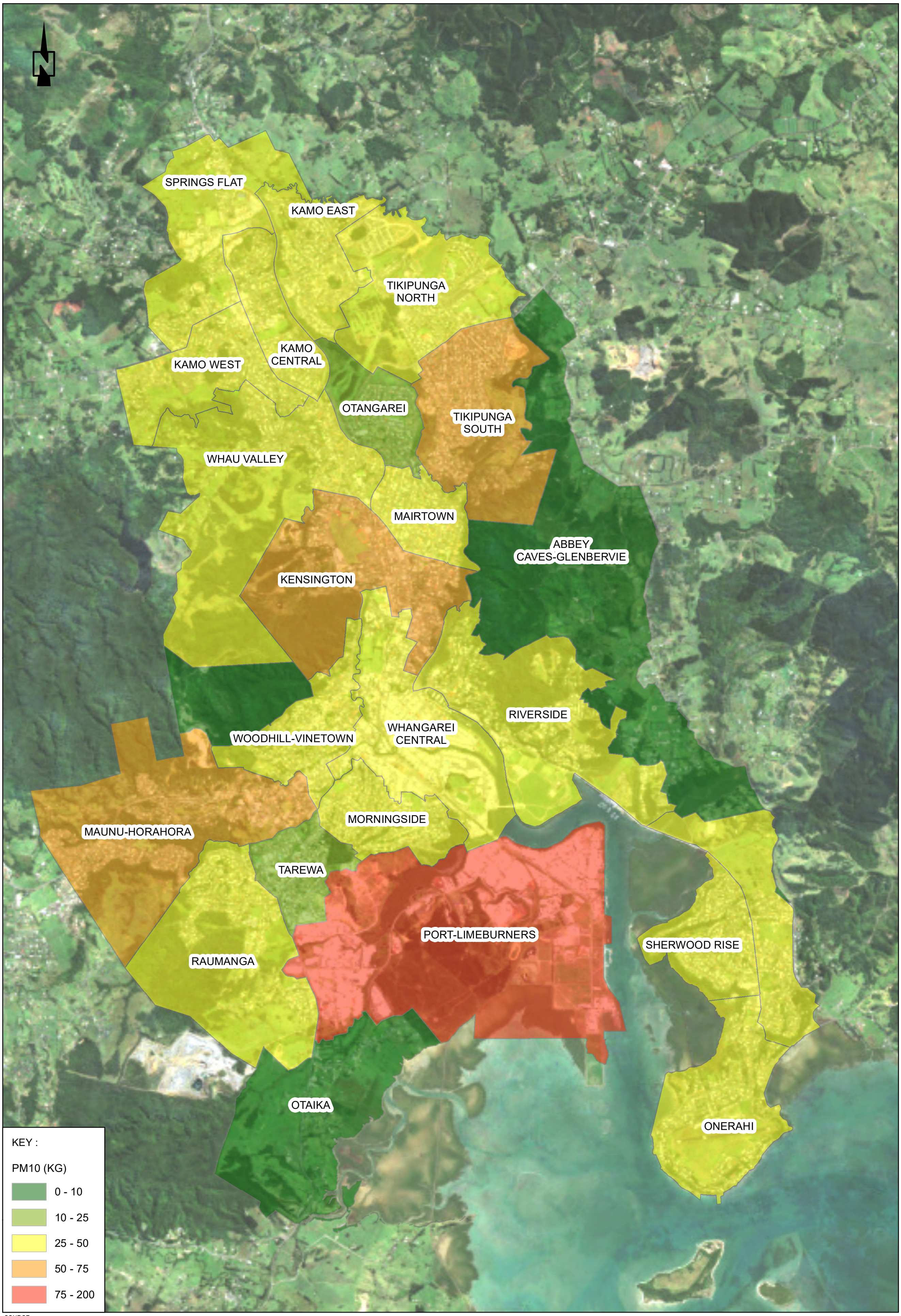
Kilometres



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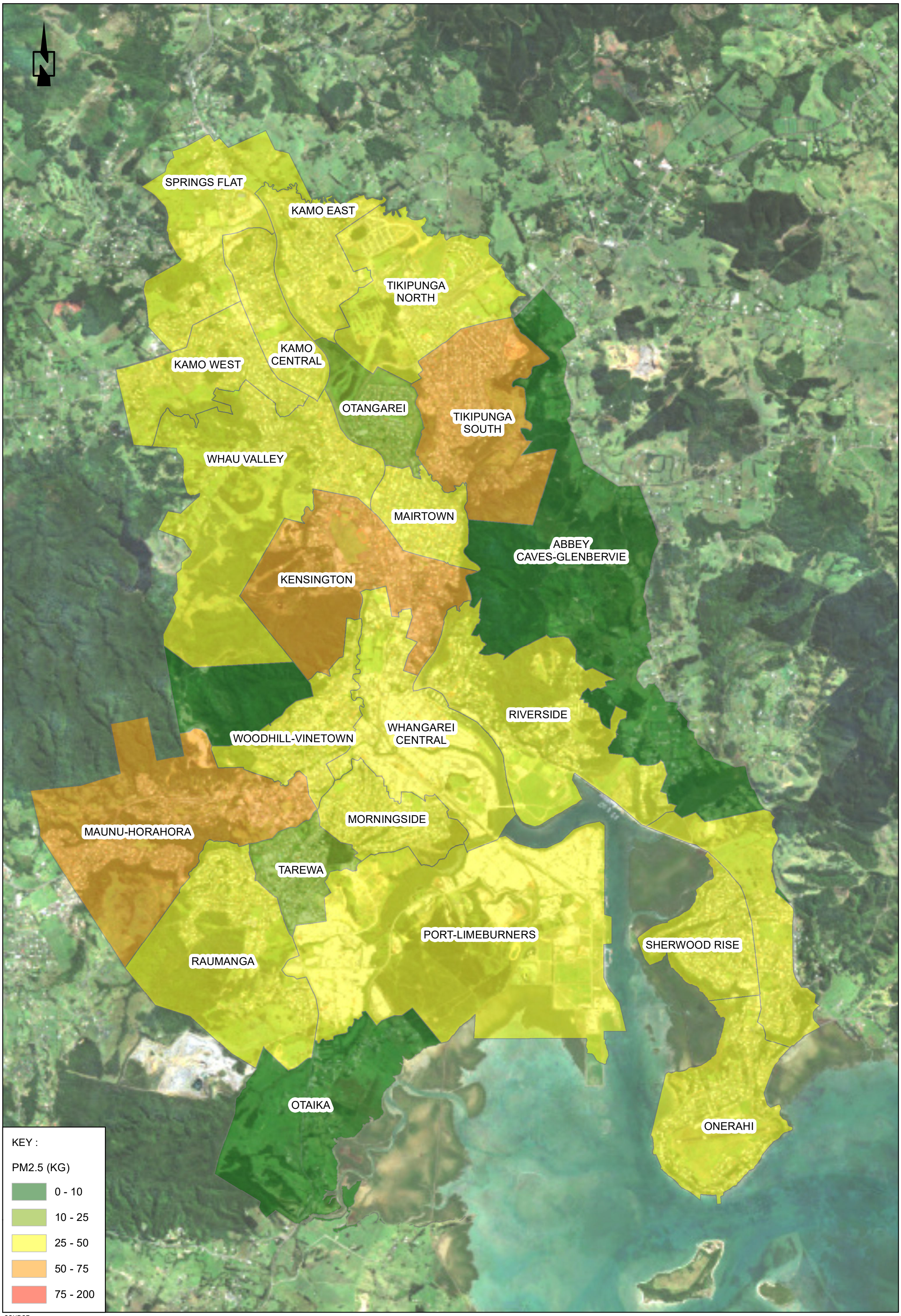
2. SA2 PROVIDED BY STATS NZ AND USED WITH PERMISSION.

FIGURE 7 : WHANGĀREI AIRSHED
PM10 WINTER DAY

SCALE : 1:60,000 (A4)

0 0.5 1 2 3
Kilometres

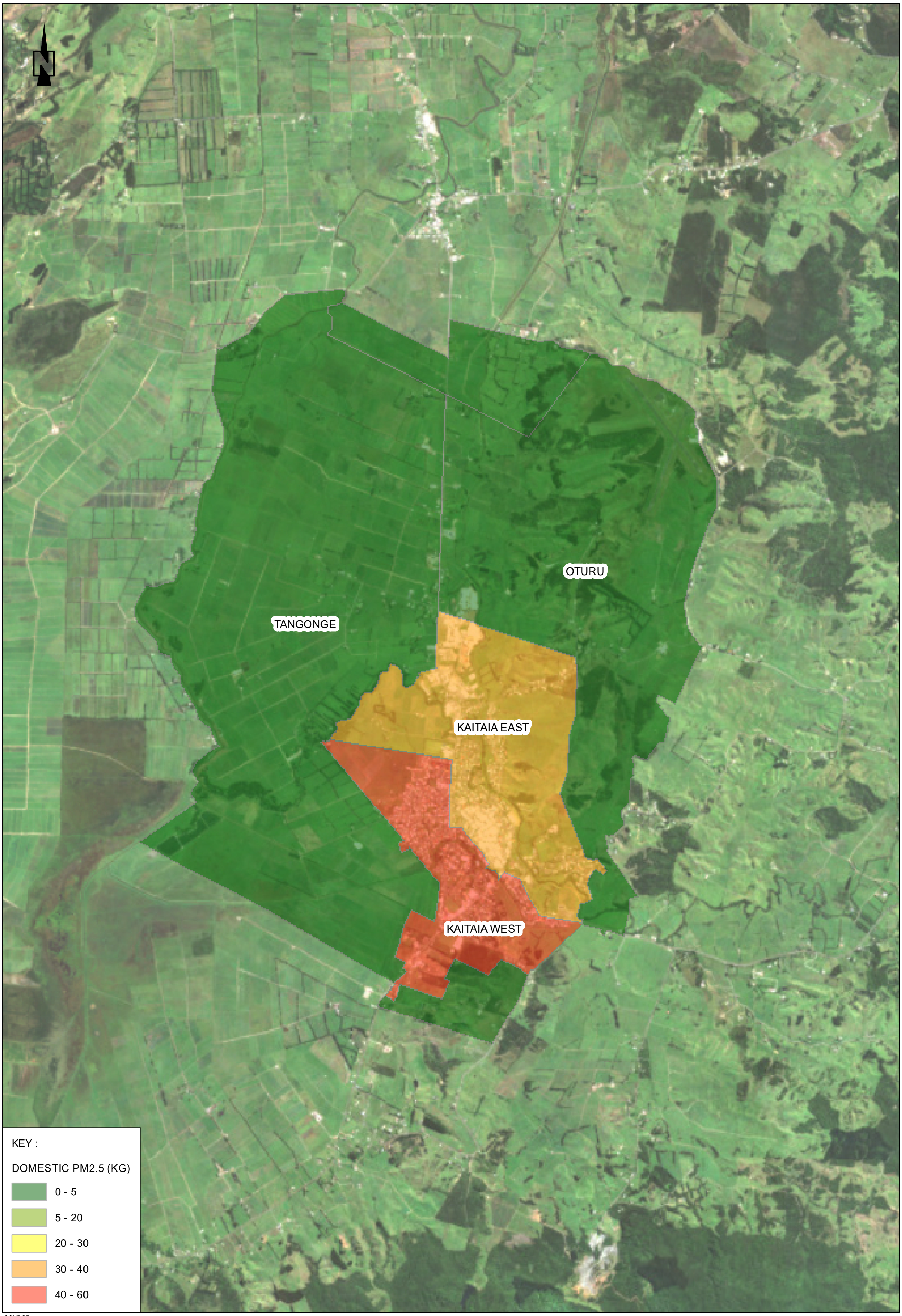


SOURCE:
1. AERIAL IMAGERY (FLOWN 2016) SOURCED FROM THE LINZ DATA SERVICE https://services.arcgisonline.co.nz/arcgis/rest/services/Imagery/newzealand/MapServer/0 AND LICENCED BY LINZ FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENCE.
2. SA2 PROVIDED BY STATS NZ AND USED WITH PERMISSION.

FIGURE 8 : WHANGĀREI AIRSHED
PM2.5 WINTER DAY

SCALE : 1:60,000 (A4)

0 0.5 1 2 3
Kilometres

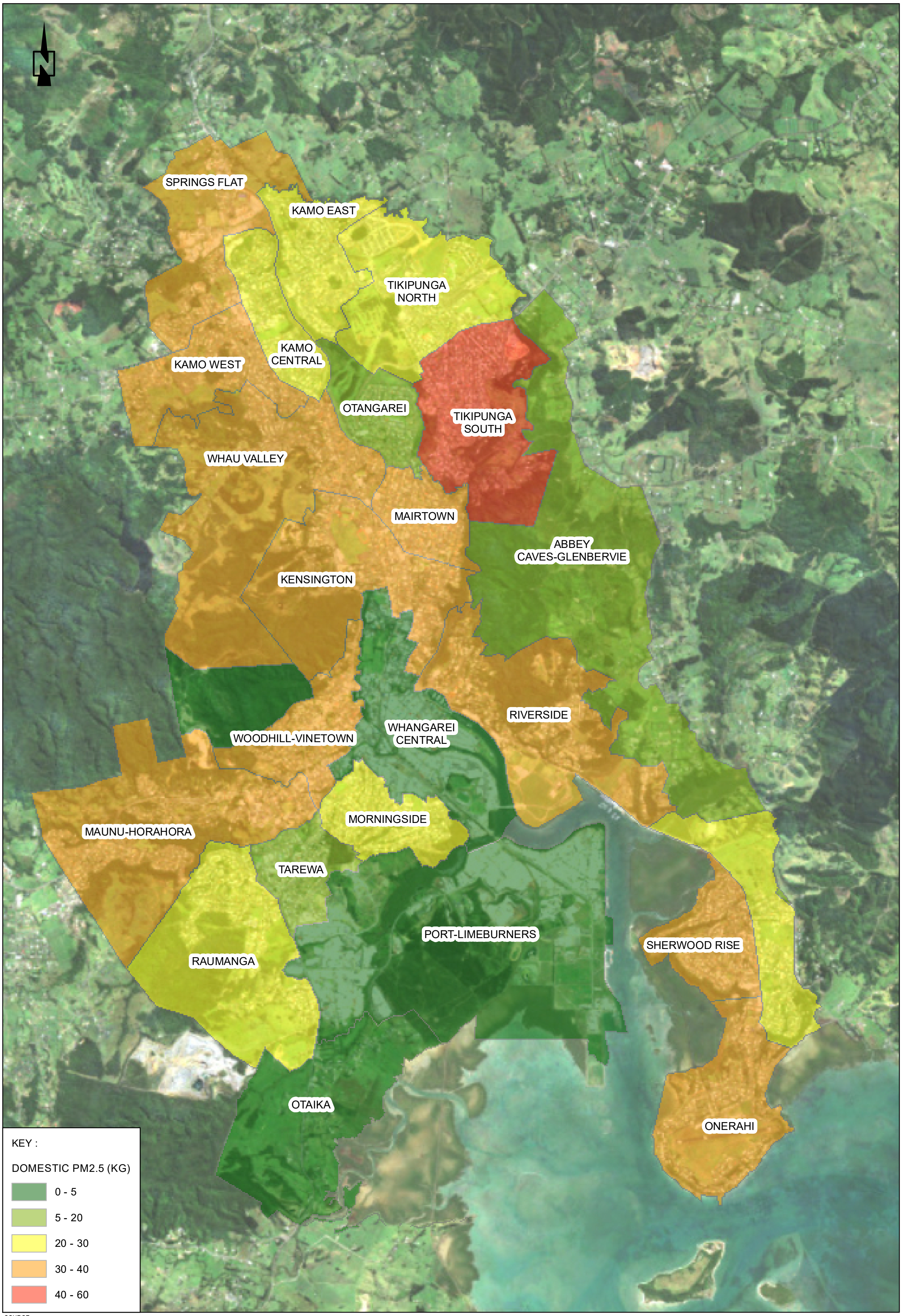


SOURCE:
1. AERIAL IMAGERY (FLOWN 2016) SOURCED FROM THE LINZ DATA SERVICE https://services.arcgisonline.co.nz/arcgis/rest/services/Imagery/newzealand/MapServer/0 AND LICENCED BY LINZ FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENCE.
2. SA2 PROVIDED BY STATS NZ AND USED WITH PERMISSION.

FIGURE 9 : KAITAIA AIRSHED
PM2.5 WINTER DAY DOMESTIC EMISSIONS

SCALE : 1:60,000 (A4)

0 0.5 1 2 3
Kilometres



SOURCE:
1. AERIAL IMAGERY (FLOWN 2016) SOURCED FROM THE LINZ DATA SERVICE https://services.arcgisonline.co.nz/arcgis/rest/services/Imagery/newzealand/MapServer/0 AND LICENCED BY LINZ FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENCE.
2. SA2 PROVIDED BY STATS NZ AND USED WITH PERMISSION.

FIGURE 10 : WHANGĀREI AIRSHED
PM2.5 WINTER DAY DOMESTIC EMISSIONS

SCALE : 1:60,000 (A4)

0 0.5 1 2 3
Kilometres