Bay of Plenty

Regional Air Emission Inventory

FINAL REPORT

- Version 2
- 20/08/2003

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Executive Summary

Scope

This 2001 air emission inventory was prepared for the Bay of Plenty Regional Council (Environment Bay of Plenty) to update the 1996 inventory (OPUS 1996).

This inventory estimates emissions for sources included in the first inventory and has updated the 1996 estimates using new methodologies and factors where needed. The scope of the inventory has been significantly increased, including a larger number of sources and more contaminants.

The 1996 inventory focused on particulate matter, nitrogen oxides, carbon monoxide and sulphur dioxide. Additional contaminants in this inventory are fine particulate matter, specific volatile organic compounds and greenhouse gases. The additional emission sources are quarries, abrasive blasting, backyard burning, lawn mowing, landfills, wastewater treatment and biogenic emissions from vegetation.

Emissions estimation methods were based on the latest available techniques, including the use of New Zealand developed emission models for road and rail transport, which are expected to have improved the estimates from the first inventory.

Results

The total annual emissions for common contaminants and hazardous air pollutants are presented in the two tables below.

■ Total Annual Emissions for Primary Contaminants (2001)

Source Category	Tonnes / Year				
	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2
Transport	441	313	13412	6282	891
Domestic	693	646	5573	96	29
Industrial	1369	914	4050	543	932
Biogenic	NA	NA	NA	1301	NA
Agricultural field burning	NA	NA	395	21	NA
Total	**2503**	**1873**	**23430**	**8243**	**1852**

Transport sources dominate the emissions of carbon monoxide (57%) and nitrogen oxides (76%). Industrial sources dominate the annual emissions of fine particles at 54%. During the wintertime industry contributes 39% while domestic source increase to 49% as a result of domestic home heating. Sulphur dioxide is dominated by transport emissions from shipping and two large industrial sources.

Total Annual Emissions for Hazardous Air Pollutants (2001)

Source Category	Tonnes / Year				
	VOC	Acetaldehyde	Benzene	Formaldehyde	1-3 Butadiene
Transport	2089	60	117	63	13
Domestic and commercial	3761	103#	567	206#	310#
Industrial (combustion)	95	0.001	12	2	NA
Biogenic/waste	41557	NA	0.06	NA	NA
Total	**47502**	**163**	**696**	**271**	**323**

*includes industrial use of solvents

lawn mowing only

Domestic emissions dominate hazardous air pollutants emissions despite there being data gaps for home heating and backyard burning.

Estimates of emissions of greenhouse gases and dioxins were made, but a lack of fuel data on which to base estimates for some sources, and variances in methodology means that any comparison with the respective national inventories would need to be made with caution.

The table below gives a comparison of 2001 and 1996 emission for the common air contaminants. This is based on backcasting i.e. using the same assessment methods used to estimate 2001 emissions.

Backcast Comparison 1996 and 2001

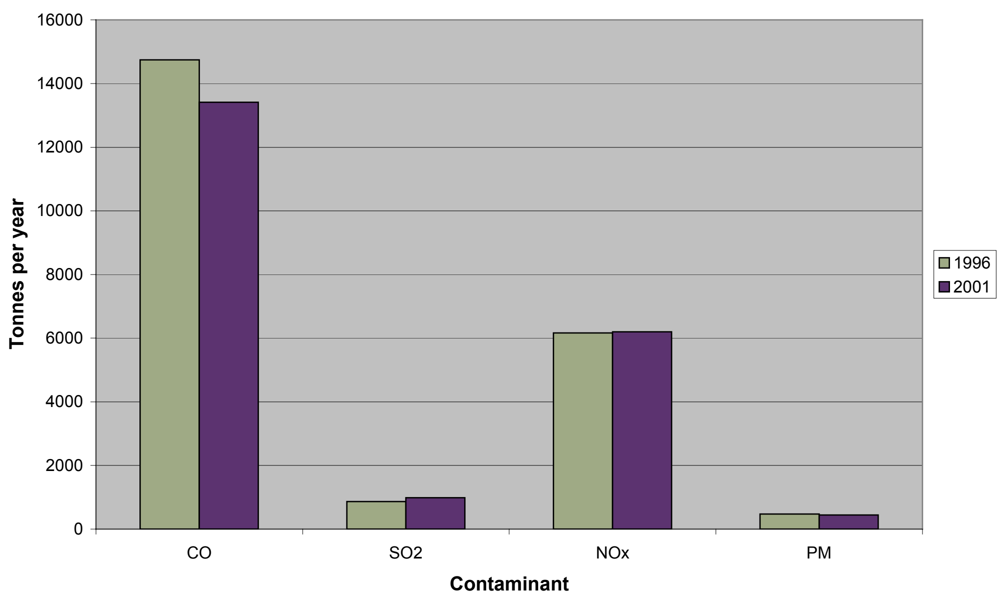
Sector	Source	Tonnes pollutant per year							
		CO		SO_2		NOx		PM	
		1996	2001	1996	2001	1996	2001	1996	2001
Transport	Shipping	61	68	419	477	343	390	52	58
	Rail	30	52	14.6	28.4	310	526	8	13
	Aircraft	89	103	0.2	0.2	301	363	55	66
	Motor vehicles	14561	13190	429	477	5209	4916	360	305
Industry	Gas	103	107	0	0.3	61	63	9	10
	Coal	27	15	43	24	34	19	28	16
	Wood	1374	3922	152	433	152	433	657	1874
Total		**16245**	**17457**	**1058**	**1440**	**6410**	**6710**	**1169**	**2342**

The domestic and agriculture sectors, which were included in the 1996 inventory, could not be backcast. This was because 2001 domestic heating emissions were extrapolated on a population basis from a home heating survey for Auckland. It was also not possible to compare the original 1996 estimates for this sector because unlike 1996, fuel sales data was not available for 2001. Domestic emissions are however, likely to have increased due to population growth. Available data indicates that coal use is decreasing and gas use is increasing.

Agricultural and forestry burn off could not be assessed for 2001 because activity data could not be sourced. Anecdotally, the reason given for the lack of data is that burnoff activity has much reduced and/or is no longer carried out. The data used for pesticides in 2001 gave estimates an order of magnitude higher than 1996. This was because the 2001 estimates were from a more comprehensive survey of pesticide use. It is likely, however, that pesticide use in the region has actually decreased due to an increase in organic production.

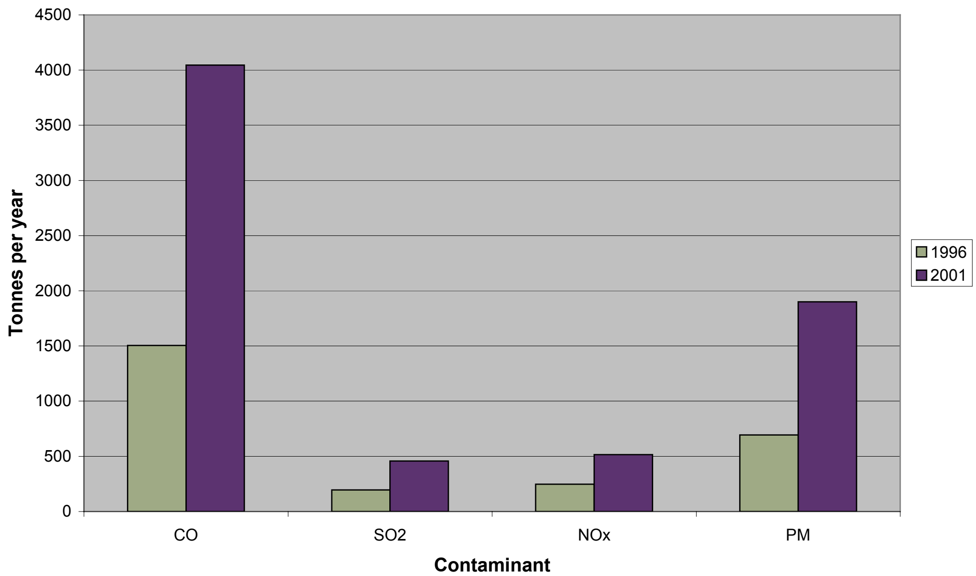
The total annual emissions from the transport and industry sectors as backcast for 1996 are presented in the figures below and compared to 2001.

- **Total Annual Emissions for Transport 1996 and 2001 (Tonnes/Year)**



All transport activities in the region have increased. Motor vehicle emissions are the major source in the transport sector and activity increased by 11%. Emission estimates however, show little change, due to lower emission factors obtained from the Ministry of Transport's vehicle emissions model for 2001 as compared to 1996. The model adjusts the emission factors each year to allow for a predicted improvement in motor vehicle emission technology, but this may or may not be happening in reality.

■ **Total Annual Emissions for Industrial Combustion 1996 and 2001 (Tonnes/Year)**



Increased industrial woodwaste combustion is the principle cause of the increase in emission estimates for the industrial sector.

Key Findings

- Agricultural and forestry burnoffs, which were previously identified as contributing 12% of particulate matter are no longer considered to be a significant source because of a reduction in this practice.
- The area of forestry in the Region has increased and large-scale industrial activity in relation to timber processing remains significant.
- Natural gas remains the primary source of energy for industrial activities in the Region and consumption has increased. Industrial woodwaste combustion has also increased and this has increased the emission estimates for fine particles.
- Transport activity in the Region has increased due to population and economic growth, however, this has not been sufficient to cause any significant increase in emissions from the transport sector.

Recommendations

This inventory was more complex than the first inventory due to changes in scope, changes in methods and the need to backcast emissions. Data gaps affect the reliability of the inventory in the key area of domestic and small commercial sources; and in the ability to estimate dioxin and greenhouse gas emissions. It is recommended that, prior to undertaking the next inventory, inventory data needs and collection methodologies be independently reviewed, considering whether the inventory meets councils needs. Particular areas to consider are:

- Methods for estimating domestic sources and whether regional activity data should be gathered such as from fuel surveys, and/or domestic and small commercial surveys
- Collection and management of industrial activity and emission measurement data
- The value of including a range of hazardous air pollutants
- The costs and benefits of methods available to estimate geothermal emissions

Environment Bay of Plenty should consider developing an ongoing inventory data collection programme to assist updating the inventory i.e. it should not be seen as a once in every five year exercise.

In addition, any further changes to methods and increases in scope should be reviewed in order to facilitate updating the inventory and backcasting consistent with policy needs.

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1. Introduction

1.1 Purpose

This is an updated air emission inventory for the Bay of Plenty Region. It builds on the 1996 inventory undertaken by OPUS International Consultants (OPUS 1997).

Emission inventories are useful to:

- quantify sources;
- review and identify policy options;
- design or review ambient monitoring programs; and
- project future emissions.

The *Proposed Bay of Plenty Regional Air Plan* (July 2000) has been amended in accordance with its Council's decisions on submissions. The Plan identifies that the emission inventory is to be updated about every 5 years or as appropriate. It is to be used with other information as a tool to monitor the effectiveness of the Plan. Updating an emission inventory every 3-5 years is also recommended in the Ministry for the Environment's *Good Practice Guide for Preparing Emission Inventories* (2001).

This inventory is to be used for evaluating trends relating to key issues in the Region such as particulate matter emissions and pesticide use, and to evaluate ambient monitoring programmes.

1.2 Scope

The reference year for this inventory is 2001. Data as close as possible to the study period has been used when available.

This inventory has been compiled by source type and the spatial distribution presented on a district-wide and urban area basis to allow comparison with the 1996 inventory. Developments since 1996 have meant that this inventory has used different estimation methodologies and included some different sources so care is needed in making comparisons.

Abrasive blasting, quarries, small combustion engines (lawnmowers), wastewater processes, landfills, domestic rubbish fires, agricultural activities and biogenic emissions are sources that are additional to the previous study.

The updated inventory also includes additional contaminants. Contaminants included in the updated inventory are summarised in Table 1-1.

Table 1-1 Contaminants for the 2001 Air Emission Inventory

Particulate matter (PM_{10} & $PM_{2.5}$)	Hydrogen sulphide
Carbon monoxide	Dioxins
Carbon dioxide	Agrichemicals
Sulphur dioxide	Pollen
Oxides of nitrogen	Methane
Selected volatile organic compounds (VOCs)	

1.3 Characteristics of the Bay of Plenty Region

1.3.1 Population and Dwellings

The Bay of Plenty Region has about 6.3% of New Zealand's usually resident population with 239,352 people on census night 2001.

Between 1996 and 2001 the Region's population increased overall by 6.7%.

Trends in population for the districts within the Bay of Plenty are summarised in Table 1-2. Just over half of the districts experienced a decrease in population, while Tauranga had 17% population growth and Western Bay of Plenty had 9.3%.

Table 1-2 Bay of Plenty Population 1996 – 2001

Territorial Authority	1996 Census Usually Resident Population Count	2001 Census Usually Resident Population Count	Increase or Decrease (-) 1996-2001	
			Number	Percent
Taupo District (part)	210	183	-27	-12.9
Western Bay of Plenty District	34,968	38,232	3,264	9.3
Tauranga District	77,778	90,906	13,128	16.9
Rotorua District (part)	61,035	61,041	6	0.0
Whakatane District	33,126	32,814	-312	-0.9
Kawerau District	7,830	6,975	-855	-10.9
Opotiki District	9,375	9,201	-174	-1.9
Region	**224,322**	**239,352**	**15,030**	**6.7**

Population growth in Tauranga and the Western Bay of Plenty is reflected in an increase in the number of dwellings as shown in Table 1-3.

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■ **Table 1-3 Dwellings Per District 1996 - 2001**

Territorial Authority	1996 Occupied Dwellings	2001 Occupied Dwellings	Increase or Decrease (-) 1996-2001	
			Number	Percent
Taupo District (part)	69	69	-	-
Western Bay of Plenty District	12,615	14,082	1,467	11.6
Tauranga District	29,745	35,487	5,742	19.3
Rotorua District (part)	20,934	21,654	720	3.4
Whakatane District	11,190	11,538	348	3.1
Kawerau District	2,433	2,343	-90	-3.7
Opotiki District	3,183	3,237	54	1.7
Region	**80,169**	**88,410**	**8,241**	**10.3**

1.3.2 Dominant Land Uses

The Bay of Plenty has a total land area of over 1.2 million hectares. The only comprehensive data available on land cover class at the time of writing was for 1996 from Statistics New Zealand reproduced in Table 3-14. More recent land use statistics have been used in calculations where available.

The Region supplied more than 75% of New Zealand's total kiwifruit production and produces tangelos, nashi, avocado, feijoas, tamarillos and passionfruit. In total, 9,700 hectares were dedicated to fruit production in 1996. Exotic forestry covered an estimated 267,000 hectares or 21 percent of the land area. Farming and forestry occupied about half the total land area. A substantial portion of farming land in the Region is pastoral including beef, dairy, sheep, goats and deer farms.

The Bay of Plenty includes the most active geothermal fields in New Zealand, and New Zealand's most active volcano, which is White Island.

Distinctive factors affecting air quality in the Bay of Plenty Region, as identified from the 1996 emission inventory, include large forestry plantations and high diesel fuel use due to heavy vehicle movements. The impact of forestry on air quality has decreased with a decrease in forestry burnoffs, however, ancillary forestry activities are still significant.

1.3.3 Infrastructure

The Region has about 4,400 kilometres of road. Around two thirds of these are rural roads, including those linking the forestry areas with the Port of Tauranga. There are three domestic airports at Rotorua, Tauranga and Whakatane and a rail network that connects Tauranga and Whakatane to the Waikato Region and the main trunk railway line. There is one main port at Tauranga. The Region has 15 municipal wastewater treatment systems and 5 landfills in operation.

2. Air Contaminants Sources and Effects

The contaminants included in the emission inventory in 1996 were particulate matter, sulphur dioxide, carbon monoxide, the oxides of nitrogen, and hydrogen sulphide. These are commonly referred to as the primary or indicator air pollutants, and are produced by a wide variety of sources throughout the Region. Dioxins, agrichemicals, and pollens were also included, because these have been identified as possible issues for the Region.

Carbon dioxide, methane, selected volatile organic compounds (VOC), and fine particles (PM_{10}, $PM_{2.5}$) have been added to this inventory. Comments on each of the contaminants for inclusion in the inventory are provided in Table 2-1.

Table 2-1 Comments on Contaminants Included

Contaminant	Comment
Particulate matter (PM)	PM includes dust, smoke, aerosols, haze and fallout. Airborne PM arises from many sources including combustion processes (especially coal and wood burning), motor vehicle emissions, vehicle movements on sealed or unsealed roads, agricultural activities, quarries, road and building construction, as well as numerous industrial operations. Natural sources of PM include volcanoes, sea spray, plant and animal matter (e.g. pollens and fungal spores) and wind blown dust and dirt. PM can cause nuisance effects when it settles on surfaces such as cars, window ledges, washing, etc.
PM_{10}	Particles below 10 microns or PM_{10} can affect visual air quality and can have respiratory effects because they are small enough to be inhaled. PM_{10} has been of increasing concern with no threshold level for effects known because it has been shown to endanger human health. New Zealand ambient air quality guidelines address PM_{10} and it is now included as part of many regional ambient air monitoring programmes. PM_{10} can be estimated relatively easily with emission factors and particle size distribution data.
$PM_{2.5}$	$PM_{2.5}$ is an emerging issue because it may be responsible for specific health effects. There is a lack of data on $PM_{2.5}$. Monitoring and source assessments are being encouraged (MfE 2002). Estimates of $PM_{2.5}$ are possible but major assumptions are required due to limited emission factor data.
Sulphur dioxide (SO_2)	SO_2 is mainly produced by the burning of fossil fuels. The primary sources are coal (<0.5 – 3.0 % sulphur), fuel oil (0.5 - 3.5 % sulphur) and diesel (0.3 % sulphur). There is no significant sulphur in natural gas, petrol, or in wood. A number of industrial processes also emit sulphur dioxide, while volcanoes are a major natural source. The primary effect of SO_2 is as a respiratory irritant, although on a global scale it is also of concern in the production of acid rain and acidification of soils.
Carbon Monoxide (CO)	CO is formed as a product of incomplete combustion in burning fossil fuels. The main source in New Zealand is motor vehicle emissions, and elevated levels are mainly found in areas of significant traffic congestion. Other sources can include domestic fires, and industrial combustion. CO is a poisonous gas, which acts by displacing oxygen from the blood. Prolonged exposure at moderate levels can lead to symptoms such as headaches and dizziness. Chronic exposure at lower levels has been linked to an increased incidence of heart disease.

Contaminant	Comment
VOCs (acetaldehyde, benzene, 1,3-butadiaene and formaldehyde)	Priority hazardous air contaminants have been selected for air-shed management in the updated Air Quality Guidelines 2002. Emission factors are currently being developed for these contaminants, in particular, for vehicles by the Ministry of Transport. Some emission factors for these pollutants are available from Australia and the USA.
Carbon dioxide, nitrous oxide and methane	Methane, N_2O and CO_2 are included in the updated inventory because they are greenhouse gases and have assumed more political importance. Results may be used to determine the effect of national policies at a regional level over time. Estimation methods are available from central government and international agencies. N_2O mainly occurs from biogenic sources and nitrogen in soils.
Oxides of Nitrogen (NO_x)	NO_x describes nitric oxide (NO) and nitrogen dioxide (NO_2) which are formed in combustion processes by oxidation of the nitrogen present in combustion air. Nitric oxide is the primary product, which is then oxidised to NO_2 in ambient air. Motor vehicles are the major source of NO_x in most parts of NZ. Power stations and other large combustion sources may be significant localised sources. The main health effects are due to NO_2, which is a respiratory irritant. In major urban areas (e.g. Los Angeles) both gases are a concern as precursors for photochemical smog, produced from NO_x reacting with hydrocarbons under the influence of sunlight. Globally, NO_2 is also a contributor to acid rain.
Hydrogen Sulphide (H_2S)	H_2S is a highly toxic gas with the characteristic odour of rotten eggs. It is a major component of geothermal emissions. H_2S is also produced from anaerobic decomposition of many organic wastes, and is a by-product of pulp and paper manufacture, the tanning industry and meat rendering plants. The primary health effects of H_2S are on the nervous system. At high concentrations the gas causes paralysis of the vital functions such as breathing. Victims die from asphyxiation. At low concentrations H_2S can anaesthetise the sensory organs and cannot be smelt when present in dangerous concentrations.
Dioxins	Dioxins are a class of complex organic compounds known as polychlorinated dibenzo-p-dioxins and the related polychlorinated dibenzofurans. These are formed at trace levels in most combustion processes. They are persistent in the environment, and some members of the group are extremely toxic. The chemical 2,3,7,8-tetrachlorodibenzo-p-dioxin is a human carcinogen and has been labelled "the most toxic chemical known to mankind". MfE published an inventory of dioxin emissions[1] including industrial, domestic and natural sources such as forest fires. The biggest contributors were landfill fires, domestic burning and other combustion sources.
Agrichemicals	Agrichemical spray drift is a large source of air pollution complaints in the Bay of Plenty, particularly near intensive horticultural areas. Herbicide drift can damage horticultural crops. The use of insecticides and fungicides is also of concern when they are used incorrectly usually due to the possible human health effects from exposure. Issues also arise from contamination of organically-grown produce.
Pollen	Airborne pollen can cause significant impacts in the Region at certain times of the year. Plantation forests are a major source of airborne pollen, which affects visual air quality, and causes nuisance impacts due to deposition. There are also health concerns about effects on people who suffer from asthma and other respiratory illnesses.

[1] Ministry for the Environment, *New Zealand inventory of dioxin emissions to air, land and water, and reservoir sources*, March 2000

3. Methodology and Data Sources

3.1 Data Collection Criteria

The data were collated on a district council area basis wherever possible.

The various sources selected for the inventory represent the most significant sources in the Region encompassing: transport, industrial, residential and commercial, agricultural, forestry, and geothermal sources as for the 1996 inventory. Biogenic and greenhouse emissions are new to the inventory.

The urban and rural distribution of emissions was also of interest, because many of the sources tend to be concentrated into urban areas. Contributions from the three largest urban areas in the Region i.e. Rotorua, Tauranga and Whakatane were estimated.

Data were collected to represent as closely as possible the 2001 reference year and the most reliable source for activity data that was available.

3.2 Data Sources

Most emission estimates were calculated using emission factors and activity statistics. For example:

Motor vehicle emissions	=	*Emission factor g/km*	*	*vehicle kilometres travelled*
Industrial boiler emissions	=	*Emission factor g/l*	*	*litres of fuel used*

The emission factors used were from a number of sources depending on availability. Factors used were mainly from the Australian National Pollutant Inventory Emission Estimation Techniques (NPI EET). This database has factors for speciating VOCs that were not available from other sources. The majority of EET factors are derived from the US Environmental Protection Agency (US EPA 1996) and other US EPA references and are therefore consistent with other New Zealand studies that rely on US EPA factors.

Information from recent emissions inventories in New Zealand was also used, particularly where New Zealand specific emission factors and activity data have been derived, such as used in Christchurch (Wilton 1999), Nelson (Wilton 2001) and Auckland (Environet Ltd 2003). Data and methodologies from the New Zealand Greenhouse Gas Inventory (NZGHGI 2002) and the New Zealand Dioxin Inventory (2000) were used to be consistent with national reporting.

The Ministry for the Environment advised that factors from the United Nations Environmental Programme Dioxin Toolkit (UNEP 2001) should be used in preference to those in the New Zealand Inventory because these would be used in the next national dioxin inventory[2].

The emission factors used in this inventory were generally more specific and more comprehensive than those from the previous study. Some of the new factors required activity data of a different form to the old factors.

The methodology and activity data for each source type are summarised in sections 3.2.1 to 3.2.7 below.

3.2.1 Industrial

Industrial emissions sources included wood, diesel, coal, and gas combustion, asphalt plants, quarries and timber processes. Emission monitoring data was available for Carter Holt Harvey Tasman, Fletcher Challenge Forests Ltd Rotorua, ICI NZ Orica, Dominion Salt, and NZMP Ltd Edgecumbe. Monitoring data, rather than emission factors, were used for estimating the emissions for particular contaminants where available.

Industrial sites were identified from Environment Bay of Plenty records of air discharge consent holders. Quarry sites were identified from an Environment Bay of Plenty monitoring report (Environment B·O·P, 1999) and spray painting operations were identified by council staff[3].

Most activity data was sourced by directly contacting the industrial sites through a mail survey and follow up phone calls to obtain information such as production or fuel use rates and hours of operation for 2001. A summary of the sources and activity data for the estimation is provided in Appendix A. Data for quarries, spray painting and abrasive blasting operations is in the SKM spreadsheet *"industrial source calcs.xls"*.

US EPA[4] and UNEP emission factors were used for estimating industrial emissions. Emission factors applicable to quarrying and aggregate extraction were not available from US EPA without significant information for industrial sites such as: overburden removal rates, soil moisture, blasting activity and vehicle types and movements. A factor from Parrett (1992) was used to estimate emissions from extraction because it could be more simply applied. US EPA emission factors for uncontrolled crushing and screening were used to estimate processing emissions.

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[2] *pers com*. Simon Buckland, Ministry for the Environment, February 2003
[3] Facsimile, Shane Iremonger, 11 December 2002
[4] EPA, Air Chief Version 9.0, December 2001

The industrial figures, reported for VOCs in sections 5, are low because they are for combustion and bitumen processes only. No activity data directly related to large scale industrial solvent use was collected as part of this study, but it was estimated as part of domestic and commercial emissions as discussed below.

For spray painting and abrasive blasting, activity estimates were based on the Nelson Emission Inventory (2001) rather than directly surveying these industries within the Region due to limited resources. The Nelson activity data is useful as a screening level assumption on the basis that these types of operations around New Zealand are likely to have similar “average” levels of activity. This could be investigated in the future via a regionally specific survey, although the overall contribution of these sources is relatively minor.

The Nelson Inventory (2001) gave a rate of emission of 2.7 kg of VOC per site per day for spray painting operations. Emissions were calculated assuming operating hours of 5.5 days per week and 50 weeks per year. VOC emissions from spray painting are estimated at around 85 tonnes per year. The NZGHGI methodologies used for NMVOCs from domestic and commercial emissions, as discussed in section 3.2.4 of this Report, include industrial paint application, therefore the estimates based on Nelson were not included in the inventory total to avoid double counting. The total from all sources using the NZGHGI method was about 600 tonnes per year.

3.2.2 Transport

3.2.2.1 Rail

An emission model from the Ministry of Transport (MoT 1999) was used to estimate emissions for rail transport. The rail model contains a database of the entire New Zealand rail network. Emission factors are built into the rail model for each section of track depending on factors such as typical speeds and the incline. The model calculates emissions of VOC, NO_x, CO and total particulate matter. Emissions were calculated by the model based on train schedule data for 2001, which was provided by Tranz Rail. Data for particular rail lines was extracted from the model using a spatial overlay of the regional and district council boundaries.

VOCs of interest were estimated based on EET emission factors using fuel consumption data that was output from the MoT model. The EET factors are presented in Table 3-1. Fine particles were estimated on the basis of figures used in the Auckland inventory (ARC 1998) that were originally from US EPA sources.

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Table 3-1 EET Factors for Rail Transport

Pollutant	Line Haul Emission (g/l of Fuel)
Acetaldehyde	0.755
Benzene	0.044
1,3-butadiaene	0.0401
Formaldehyde	0.223

Dioxin emission factors are available from UNEP (2001) for steady state operation of diesel engines. The factor is 0.5 µg TEQ tonne^{-1} of fuel burned. CO_2 was estimated using a factor from the NZGHG inventory of 68.7 tonnes per TJ for diesel fuel and diesel consumption data generated by the model. SO_2 was estimated on the basis of 0.2 % weight sulphur in the fuel (Ministry for Economic Development 2000).

The rail model was used to backcast 1996 emissions rail emissions but the data provided for the previous study could not easily be applied to the model. New data was obtained from Tranz Rail. Tranz Rail provided data from 1998 as being representative of 1996, because 1996 data was not available.

2001 rail data for the Rotorua line was based on 405 movements along the track (a total for both directions) to approximate a daily return service for 2001, which ceased in approximately October. The line is now mothballed[5]. The Taneatua and Whakatane branch lines were not incorporated into the rail model because the lines had infrequent services or were not used. Hence, activity on these lines could not be accounted for[6]. The assistance of "The Fuels and Energy Group" is acknowledged in running the rail model.

3.2.2.2 Road

Motor vehicle emission factors were derived from the MoT vehicle model for 2001 (NZTER version 1). A default vehicle fleet profile was used as recommended by the MoT because it was considered that data from regional vehicle registrations would not necessarily be reflective of the local fleet[7].This differs from the approach used in 1996[8], and may under estimate the contribution from diesel vehicles, which are expected to be higher than average due to the Region's forestry and port activities.

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[5] *Pers com*, Tony White, Tranz Rail, December 2002
[6] *Pers com*, Karen O'Reilly, Fuels and Energy, December 2002
[7] *Pers com*, Paul Irving, MoT, November 2002
[8] Information on vehicle types was obtained from the Land Transport Safety Authority's Motor Registration Centre.

CO_2 and SO_2 were estimated from factors used in the Nelson inventory (2001) because factors were not available from the NZTER. These were based on an extrapolation from the Christchurch inventory (1999) using national fleet data for 2001. The emission factors in grams of pollutant per kilometre travelled (VKT) are presented in Table 3-2.

Table 3-2 Motor Vehicle Emission Factors From VFECs and Nelson (2001)

Road Condition	Grams pollutant per VKT					
	PM	CO	NO_x	VOC	SO_2	CO_2
Rural Highway – free flow	0.140	4.634	2.206	0.629	0.217	367.85
Suburban – free flow	0.137	7.906	2.282	1.287	0.217	367.85

All PM was assumed to be PM_{10} and $PM_{2.5}$ was assumed to be 60% of PM_{10} as per the Nelson Inventory.

Territorial local authorities and Transit New Zealand supplied VKT data based on traffic flow measurements, or projections, if measurements were not available. There is a reasonable amount of uncertainty in the data because counts are not available for all sections of all roads, and road counts are not done every year. Either the 2001 count or the latest count available was used, but sometimes these data were as old as the early 1990s.

Speciation of VOCs was based on EET factors as a weighted average for diesel and petrol vehicles in the fleet. The speciation factors used are presented in Table 3-3.

Table 3-3 Speciation factors for Motor Vehicles (weight % of VOC)

Benzene	Acetaldehyde	1,3-Butadiaene	Formaldehyde
0.06	0.03	0.01	0.03

The dioxin emission factor for a 4–stroke engine running on unleaded fuel without a catalyst is 0.1 μg TEQ $tonne^{-1}$ of fuel burned UNEP (2001). Fuel consumption was estimated by assuming an average fuel consumption rate of 13 litres per 100 kilometres (about 10.4 kg per 100 km)[9] and multiplying by the vehicle kilometres travelled. Emission factors used in the New Zealand Dioxin Inventory (2000) are based directly on VKTs and are 16 to 25 pg per kilometre. Dioxin estimates using UNEP factors were within the range of the New Zealand inventory factors.

[9] US Greenhouse Gas protocol weighted average of diesel and petrol

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3.2.2.3 Shipping

Commercial shipping movement and time-in-port information was obtained from the Port of Tauranga. Pleasure craft ownership data for the Region is available from the Maritime Safety Authority[10], but it was not obtained due to an absence of relevant activity data. Pleasure craft contributed 0.1% or less to the athropogenic emissions in Auckland (ARC 1998) and would not be expected to alter the findings of the inventory if estimates were included for the Bay of Plenty.

Emission factors for shipping were from the NIP EET for a gross registered tonnage of 10,000 - 50,000. The relevant emission factors are summarised in Table 3-4. It was assumed that the auxiliary engines were run while in port, and the main engines were run while entering and leaving the harbour. The average berthing time was 25 minutes. The contribution of shipping to the Tauranga urban area was assumed to be that of running the auxiliary engines while in port.

Table 3-4 EET Emission Factors for Commercial Shipping

Source	Emission Factor (kg/hour)					
	CO	NO_x	SO_2	TSP	VOC	CO_2
Main engine	13.5	167	127	16.8	3.41	8040
Aux engine	1.19	6.66	5.66	0.9	0.436	430

Acetaldehyde, benzene, 1,3-butadiaene and formaldehyde were estimated using the speciation factors in Table 2-6. PM_{10} and $PM_{2.5}$ were estimated from TSP.

Table 3-5 EET VOC and PM Speciation for Commercial Shipping Exhaust

Pollutant	Weight Fraction Diesel Exhaust
Acetaldehyde	0.0327
Benzene	0.0191
1,3-butadiaene	0.0158
Formaldehyde	0.0968
PM_{10}	1
$PM_{2.5}$	0.92[1]

[1] ARC 1997

Emission factors for dioxin on the basis of time in port were not available. The UNEP factor for diesel engines is 0.5 µg TEQ per tonne of fuel burned. Fuel consumption data for shipping, in particular pertaining to the Tauranga District was not available, therefore dioxin emissions for shipping have not been included.

[10] *Pers com*, Shane Iremonger, January 2003

3.2.2.4 Aircraft

Airport activity data for the number of takeoffs and landings was obtained from a report on Regional Airport Requirements (RAR, 2002). Movement data for the three airports was reported for both 1996 and 2001. Landing and take offs (LTOs) were assumed to be half the number of movements, and are summarised in Table 3-6. Data was also obtained from airport managers for 2001 as per the previous inventory, but there were some large differences in the figures between the two sources.

The RAR report was considered a reasonable source of LTO data for the airports and allowed domestic passenger and general aviation movements to be differentiated, which was useful for the application of emission factors.

Table 3-6 Regional Aircraft LTOs for 1996 and 2001

Airport	Movement Type	LTOs 1996	LTOs 2001
Tauranga	Domestic	3,766	5,648
	General aviation	20,181	31,254
Rotorua	Domestic	6,349	5,990
	General aviation	12,342	8,509
Whakatane	Domestic	1,456	1,664
	General aviation	931	931
Total Region		**45,025**	**53,996**

Emission factors applicable to regional aircraft and general aviation were used from the Australian NPI EET. Regional airlines are defined as those that provide regular scheduled public transport services linking smaller rural centres with principle cities. The general aviation sector includes private, business, training and agricultural aerial movements. Default time-in-mode data is used in the emission factors from the EET.

Selected VOCs and PM_{10} were estimated based on the EET speciation factors presented in Table 3-7.

Table 3-7 EET Speciation Factors for Aircraft

Pollutant	Weight Fraction
Acetaldehyde	0.0465
Benzene	0.0194
1,3-butadiaene	0.018
Formaldehyde	0.1501
PM_{10}	0.976

Emission factors for CO_2 and dioxin based on LTOs were not available. Fuel consumption data could be used to estimate emissions but it is not readily available and consequently dioxin from aviation has not been included in this inventory. At a national level the NZGHGI (2002) reports that CO_2 from aircraft contributes 1.1% of the total greenhouse gas emission or 843,200 tonnes. This figure was prorated on a population basis to estimate CO_2 from aviation for the Bay of Plenty. This is likely to over estimate CO_2 because aircraft movements are not expected to be directly proportional to population.

3.2.3 Waste

Emissions from the waste sector (municipal wastewater plants and landfills) are primarily greenhouse gases (GHGs), i.e. methane, nitrous oxide and CO_2.

Greenhouse gases were estimated using methods from the NZGHGI. That inventory uses a methodology for landfills, which uses total annual tonnage over time and predicts methane emissions for a particular year. The method uses generic assumptions, which are independent of the number of landfills (open or closed). Gross tonnages for the Region were used as a basis for apportioning methane estimates from the NZGHGI.

During the data collection phase of this study MfE was finalising the landfill review and audit report, which includes an update of the 1998/99 national landfill census. The report includes the number of landfills broken down by region for 2002 as well as the 1995 and 1998/99 figures. Unfortunately these data are reported as aggregated regional numbers, because the information is considered commercially sensitive for private landfill operators. Therefore, calculations for individual sites that would allow for emissions to be estimated by district are not possible. In any case, similar information is not available for closed landfills, but closed landfills are an important consideration because they continue to emit landfill gas for up to thirty years with gas peaks often occurring after closure. This aspect is accounted for in the NZGHGI methodology.

The Bay of Plenty disposed of 221,000 tonnes/annum in 1998 and 151,000 tonnes/annum in 2002. The national waste figure used for the 2002 for the NZGHGI was 3,389,000 tonnes/annum, therefore the Region is estimated to be contributing about 4.5% of national methane emissions from landfills. The predicted emissions were prorated for each district on the basis of population. This is a simplification because some districts no longer have active landfills, but there are still emissions from closed landfills with those districts.

The reduction in waste quantities for the Region over the period reported by MfE is likely to be attributed to transportation of waste from Tauranga and Western Bay of Plenty to the Waikato Region.

CO_2 was calculated on the basis of 55% methane and 45% CO_2 in the landfill gas with no capture and flaring. CO_2 released from waste is the decomposition is derived from biomass sources (e.g. crops, forests) which are re-grown on an annual basis. The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories only report CO_2 from non-biogenic wastes. CO_2 from landfills has however been accounted for in the totals reported here because the effects of land use changes have not been accounted for in this inventory, where as they are in the NZGHGI. Care is therefore needed in making comparisons to the NZGHGI.

The US EPA default concentration for benzene applicable to landfills with no or unknown co-disposal is given in Table 3-8. No information was available for the other selected VOCs, although these can be expected to occur.

Table 3-8 Speciated Landfill Gas Constituents (US EPA defaults)

Pollutant	Molecular weight	Concentration ppmv
Benzene	78.11	1.91

Data on wastewater treatment plants was obtained from the NZGHGI and the Environment Bay of Plenty consents database. The methodology for estimating emissions from each treatment plant used a population-based estimate of waste quantity and emission factors for particular types of plant as per the NZGHGI. Industrial (on-site) wastewater operations are included in the estimates per district by estimating the population equivalents relevant to the industrial contribution.

3.2.4 Domestic and Small Commercial Sources

3.2.4.1 Domestic Home Heating

Fuel sales data was not used for the 2001 because accurate fuel sales data was not able to be obtained, particularly for wood, which has many outlets and private sources. Coal Research Limited was contacted regarding coal fuel sales and advised there had been no survey since 1995. Obtaining the data for fuel sales is dependent on the level of cooperation of the suppliers. Gas sales data was obtained from a number of suppliers but was not able to be used because it was not complete due to a lack of co-operation from some suppliers.

New Zealand Statistics data for the main fuel types used in the Bay of Plenty are summarised in Table 3-9. The actual total number of dwellings is less than shown because many dwellings use more than one heat source. “Other” includes electricity, solar power and no heating. The data cannot be used directly because it does not relate to the relative mass of fuel consumed. The data suggests that gas use is increasing and coal is decreasing.

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Table 3-9 Fuel Type Used to Heat Dwellings Bay of Plenty 1996 and 2001

Heat Source	Number of Dwellings	
	1996	2001
Mains gas	4,965	7,491
Bottled gas	23,892	30,135
Wood	39,009	38,403
Coal	3,795	2,880
Other	55,173	55,455
Total	**126,834**	**134,364**

Domestic home heating estimates for wood, gas and coal combustion were based on data from domestic emission surveys conducted in other areas of New Zealand. Small commercial sources, which were previously included based on fuel sales data could not be included.

Two approaches were considered to estimate domestic home heating emissions. The first was based on extrapolating data from the Timaru and Nelson inventories and the second was based on Auckland domestic survey data (Environet Ltd 2001). The domestic home heating surveys for Nelson and Timaru (Wilton 2001) gave an average daily wintertime fuel consumption of about 10 kg per day during the wintertime. The Auckland figure was about 5 kg per day, half the South Island figure. The Bay of Plenty is probably somewhere between the two figures, but local data collection using a domestic survey would be needed to confirm this.

Aspects such as age and type of appliances and fuel use (type and quantity) in Auckland are more likely applicable to the Bay of Plenty than data for the South Island. Auckland emissions estimates were therefore used to estimate emissions by prorating on a population basis. The relevant emission factors from the Auckland study are provided in Table 3-10.

Table 3-10 Emission Factors for Domestic Heating from ARC (Environet Ltd, 2001)

Appliance type	Emission factor g/kg						
	PM_{10}	CO	NO_x	SO_2	VOC	CO_2	$PM_{2.5}$
Open fire – wood	10	100	1.6	0.2	30	1600	10
Open fire – coal	21	80	4	5.0	15	2600	12
Pre 1991 woodburner	13	130	0.5	0.2	39	1600	13
91-96 woodburner	7	70	0.5	0.2	21	1800	7
Post 1997 woodburner	6	60	0.5	0.2	15	1800	6
Multifuel – wood	13	130	0.5	0.2	39	1600	13
Multifuel – coal	28	120	1.2	3.0	15	2600	12
Oil	0.9	0.6	2.2	3.8	0.25	3200	0.43
Gas	0.6	0.18	1.3	$7.6 * 10^{-9}$	0.2	2500	0.04

To estimate dioxin emissions it was necessary to calculate the fuel use based on population and apply emission factors. The emission factors used were average emission factors for wood and coal from the Timaru Inventory, which were based on data from Christchurch. The factors were 8.5 and 7.5 μg I-TEQ per tonne respectively.

Emission factors for acetaldehyde, 1,3-butadiaene, and formaldehyde were not available and they were not included in the inventories on which the extrapolations were made, therefore estimates of selected VOCs for home heating are were not possible.

3.2.4.2 Backyard Burning

Emissions from backyard burning were not included in the Timaru and Christchurch inventories because the practice is banned. Auckland has some restrictions that apply and it was considered that the built up nature of much of the Auckland Region means that the data for backyard burning would not necessarily be applicable to the Bay of Plenty.

Outdoor burning was included in the Nelson (2001) inventory and data from that study has been used here. Emissions were estimated by applying an emission factor to activity data collected as part of the domestic survey. The average weight of material per burn was assumed to be 150 kg and 12% of households burn with an average of 10.6 burns per year. Emission factors were from AP-42 based on a 60:40 split of garden versus household waste as per the Nelson Inventory (2001). The emission factors are provided in Table 3-11. Wintertime estimates were based on 3.2 burns per year.

Table 3-11 Emission Factors for Backyard Burning

Emission factor g/kg of waste burnt							
$PM_{2.5}$	PM_{10}	CO	NO_x	SO_x	VOC	CO_2	Benzene
11.7	12.5	42	3	0.5	4.3	1470	0.5

New Zealand Dioxin Inventory (2000) emission factors for dioxin from backyard burning are provided in Table 3-12. The UNEP factor was used in this inventory. The UNEP factor is at the high end of the range of the MfE factors.

Table 3-12 Dioxin Emission Factors for Backyard Burning

	Range μg I-TEQ per tonne		
	MfE Lower	MfE Upper	UNEP
Organic waste	1	29	-
House waste	29	300	-
Weighted factor	9.4	110.3	300

In the New Zealand Dioxin Inventory backyard burning estimates were based on the ARC inventory (1998). This gave a national per capita figure of 15 kg of waste burnt per person per year. This compares with 70 kg for the Bay of Plenty using the Nelson data. It is possible that burning rates in other parts of New Zealand are higher than Auckland because restrictions apply to burning in Auckland. Therefore the higher figure from Nelson has been used for the Bay of Plenty.

As for home heating, estimates of selected VOCs are not possible because speciation factors are not available.

3.2.4.3 Lawn Mowing

Lawn mowing emissions were estimated by prorating data from the Auckland Inventory (1998) on the basis of the number of dwellings. In Auckland ninety-three percent of the population had lawns to mow, and 89% of them used motor mowers.

Summer use was estimated at 0.35 hours/mower/week and wintertime use was estimated at 0.16 hours/mower/week. Hand and electric mowing accounted for 11% of lawnmower use. Emission factors used in this inventory were a weighted average of 2-stroke and 4-stroke mowers based on the Auckland inventory and were applied on a per household basis. Dioxin emissions could not be calculated because emission factors are based on fuel consumption and fuel consumption is not known.

Emission of acetaldehyde, 1,3-butadiaene, and formaldehyde were estimated on a percent weight basis of VOC based on data from the EET.

3.2.4.4 Solvent Use

The method for estimating non-methane VOCs (NMVOCs) was based on the NZGHGI method, which provides New Zealand per capita emission factors for paint application, drycleaning and chemical manufacturing and uses an aggregate estimate for domestic and commercial emissions as in Table 3-13.

Population numbers used were from Statistics New Zealand as reported elsewhere in Table 1-2.

Estimates of VOC from spray painting were made as discussed under Section 3.2.1, but were not included in the totals because emissions are already accounted for.

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Table 3-13 Solvent and Other Product Use (NZGHGI 2002)

Category	kg VOC/person per year
Surface coatings and thinners	4.03
Degreasing and drycleaning	0.62
Chemical products	1.00
Printing	0.41
Small Commercial	0.23
Industrial	0.90
Other domestic and commercial	-
Household products	0.86
Toiletries	0.64
Rubbing compounds	0.29
Windshield rubbing fluids	0.29
Adhesives	0.13
Polishes and waxes	0.22
Space deodorisers	0.09
Laundry products	0.02
Sub Total	2.54
Total	**9.73**

It was assumed that all industrial uses of solvents are covered in the NZGHGI per capita estimates. Regional variation could occur if there were a proportionately large number of industrial facilities with large scale solvent use. Data would need to be collected from resource consent information, monitoring and or direct survey to investigate this.

3.2.5 Agriculture and Forestry

3.2.5.1 Livestock and Crops

Emission estimates of CH_4 and N_2O from livestock, manure, fertiliser use and from burning crop residues were based on the NZGHGI methodologies using data for livestock numbers, fertiliser application rate data and land use data. Details of the calculations can be found in the SKM spreadsheet *"Agriculture/GHG.xls"*.

Methane and N_2O emissions from enteric fermentation and manure management were estimated using livestock numbers for the Region obtained from Statistics New Zealand as at June 1999. Data by district council was not available.

Land cover data was used for estimating pollen and biogenic emissions of NO_2 and VOC. The data summarised in Table 3-14 was obtained from MAF[11]. Forestry data by district was obtained from MAF (2001). Radiata pine is the dominant species, making up 89 percent of the planted forest area, with Douglas-fir the next most common species, making up 6 percent.

Territorial local authorities were contacted to obtain information on burn off areas, but only Opotiki District Council was able to provide information. Opotiki District reported 10 hectares of planned burning and 100 hectares of unplanned burning. Forestry companies were contacted directly for data on burn off rates from their operations. Anecdotally, it appears that the practice of burning has been very much reduced in the Region over the last five to ten years, and the practice is no longer generally acceptable.

While estimates for burning forestry could not be made, the NZGHGI methods provide an estimate of CO, NOx and methane on the basis of the area used for cropping so this was included. Particulate matter, which is a principal contaminant from burning was not able to estimated.

■ **Table 3-14 Land Cover Class for Bay of Plenty (1996 / 97)**

Type	Hectares
Planted Forest	267 000
Indigenous Forest	569 800
Shrubland	46 000
Tussock	3 800
Pastoral	279 800
Horticultural	13 400
Inland Water	24 100
Inland Wetland	700
Coastal Wetland	2 500
Bare Ground	4 900
Coastal Sands	2 200
Urban Areas	10 400
Urban Open space	1 500
Total	**1 226 100**

11 www.maf.govt.nz/statistics/primaryindustries/regions/tables/landcover/bop.htm. SPOT satellite imagery dated 1996/97. Version 2 based on imagery dated 2001/02 should be available January 2004

3.2.5.2 Pesticides

Pesticide use in kg of active ingredient per annum was estimated from application rate data for particular land uses, which were given in a MAF review of pesticide use (MAF 1999).

The MAF review was the most recent source of information on pesticide use patterns.[12] It includes information from producer boards, grower groups, companies and agricultural consultants. Regional data on application rates was used for the estimates where available otherwise, national average data was used. The data on application rates was gathered using spray diaries.

The application rate data was used with land use data from MAF 1999 survey work and Statistics New Zealand for 1996. The inventory should be updated as more recent land use data becomes available. The calculation will slightly overestimate total use, because the land area that is in organic production is unknown and has not been accounted for. The MAF report gives a figure for organic kiwifruit production of 7% of the total acreage, but figures for other crops were not available.

The total pesticide use for New Zealand (excluding mineral oil) grew between 1984 and 1994 reaching a peak of about 3,700 tonnes of active ingredient per annum and has declined to the 1998 total of 3,300 tonnes. Herbicides dominate pesticide use (68%) followed by fungicides (24%) and insecticides (8%). About two thirds of total use is concentrated in four classes of pesticides (phenoxy hormones, phosphonyls, inorganic fungicides, dithiocarbanates).

MAF reported that pesticide use in production of vegetables such as asparagus, green peas and sweetcorn is relatively low and is mainly concentrated on early season weed control. Fresh vegetables such as lettuce, brassicas and potatoes tend to have intensive spray programmes throughout the growing season. Onions receive very frequent pesticide applications. Pesticide use in plantation forestry is concentrated on weed control during the first 1-2 years establishment phase of the crop rotation. Consequently, the overall impacts of pesticide use in the timber production cycle are minimal.

Pesticide use in kiwifruit production has undergone major reductions over the past decade with the adoption of the Kiwigreen integrated fruit production programme. Over 90% of kiwifruit is now grown under the Kiwigreen integrated pest control system which includes a limited range of pesticide options.

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[12] *pers com.* Ellen Blake, Ministry for the Environment, September 2002

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3.2.5.3 Fertiliser

Fertiliser application rate data as a weighted average of various agricultural land uses was used to estimate the nitrogen input into soils and to subsequently calculate the N_2O emission from soils. Application rate data was supplied by Ballance Agri-Nutrients Ltd and is summarised in Table 3-13.

■ **Table 3-15 Nutrient Sales Waikato / Bay Of Plenty / King Country 2001-2002**

Type	% Land Use	N (kg Nutrient / Hectare / year)
Dairy	49%	113
Beef	33%	22
Sheep	9%	11
Other Livestock	5%	22
Maize	1%	280
Vegetables	0%	436
Other Horticulture	1%	70
Other	2%	517
Weighted average based on landuse		**79**

The total area of the Region in production land was estimated at 298,600 hectares based on land use data from Statistics New Zealand (1999).

Fertiliser supply companies were contacted and advised that they could not release information on total fertiliser sales use because it is proprietary information. Therefore a comparison with the data from 1996 was not possible.

Statistics New Zealand has commenced an agricultural survey that includes collecting data on fertiliser use. In future this data will be useful for monitoring trends in fertiliser use.

3.2.5.4 Pollen

Pollen was estimated using the emission factor for exotic forestry plantations of 200 kg/ha from the previous inventory (OPUS 1997) and forestry data from MAF (2001)

3.2.6 Geothermal Use and H_2S

Information on industrial uses of geothermal steam and H_2S emissions was obtained from resource consent monitoring data. An attempt was made to obtain information on the emissions from small users of geothermal steam by contacting the territorial authorities, but in all cases they said that they were unable to provide the required data. Environment Bay of Plenty holds data on the main geothermal fields but estimates of H_2S are not possible at this time. This is discussed later in Section 5.7 of the report.

3.2.7 Biogenic Emissions

Emissions of nitrogen oxides and volatile organic compounds occur naturally from biogenic sources (living organisms). Biogenic emissions from vegetation and soils were estimated using land cover information presented in Table 3-14 and emission factors developed for the Auckland Regional Inventory (1998). Auckland is currently updating its inventory and has used the same emission factors. The Auckland emission rates are a combination of Australian and other overseas data. Factors for biogenic emissions of CH_4, N_2O and CO were not available from work done for the ARC.

An average annual temperature of 15^{o}C was assumed for the Bay of Plenty Region and the emission factors corrected for sunlight and temperature are presented in Table 3-16. Seasonal and spatial variability could be investigated but fine scale land use data was not readily available and it is not considered that this would add significantly to the overall inventory.

Table 3-16 NO_x Emission Factors for Different Land Uses

Land use category	kg NO_x/9 km^2/hr as NO_2 at 15^{o}C
Commercial / Industrial	0
Residential	0.029
Mixed rangeland pasture / agricultural	0.289
Forest	0.039
Ocean / Water / Estuary	0.013
Barren land	0.201

The adjusted emission factors for VOCs are presented in Table 3-17. The Auckland study uses a model developed by the Victorian EPA that incorporates leaf biomass factors and environmental factors. The complexity of this model is beyond the scope of the current Bay of Plenty Inventory, therefore the factors have been simply applied to the Bay of Plenty Region adjusting only for differences in average annual sunlight and temperature. The emission factors did not include information on specific VOC species.

Biogenic sources including commercial forestry and indigenous forests are recognised as carbon sinks and reservoirs in national accounting for greenhouse gas emissions. The role of forestry as a sink has not been taken into account in this study, although it should be noted that the Region's forests represents a significant reservoir of carbon.

Table 3-17 VOC Emissions for Different Land Uses

Land Use Category	Total VOC Emission Factor
	$\mu g/m^2$/hour standardised to 15°C and adjusted for sunlight
Pine forests	707.4
Indigenous forests	444.2
Grasslands	66.2
Croplands	141.0
Scrublands	249.0
Residential/industrial	19.5
Urban parkland	48.4

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4. Uncertainty

Uncertainties are inherent in any emission inventory. Uncertainty arises from:

- The use of average emission figures.
- Applying emission factors from other regions, or countries.
- Activity levels that cannot readily be captured.

The uncertainty in emission factors as a result of averaging is usually reported in the emission factor reference. Wherever possible emission factors have been used that are relevant to New Zealand. The MoT's rail and vehicle models containing New Zealand specific factors have been used for transport sources and New Zealand developed factors have been used for domestic heating.

US EPA derived factors have been used for industrial sources, this is typical practice because it is generally the only comprehensive data set, but they may not be relevant to New Zealand operating conditions. Real emission test data was used where available.

Factors for total particulate are not always available because the focus has been on PM_{10} for some time. Gaps in factors for total particulate have meant that meaningful estimates cannot be provided. There is also a lack of $PM_{2.5}$ factors for non-combustion industrial sources making $PM_{2.5}$ estimates uncertain due to the assumptions needed.

PM_{10} emission factors for wood combustion appear to be very conservative. Estimates using the emission factors compared to measurement data for Carter Holt Harvey Tasman give about four times the emission. The factors for PM_{10} have a significant effect on the inventory because industry is identified as a major source of PM_{10} and much of this is due to wood combustion.

Factors for specific VOCs are not readily available meaning covering of sources has been limited.

The pesticide application rate data, used to estimate pesticide use, is expected to be fairly representative because the survey involved growers keeping spray diaries of application rates and data specific to the Bay of Plenty was available. The calculations may however, overestimate the total use for the region because the data does not account for areas of land that may be in organic production.

The emission factors is used in the inventory were the best available at the time. Uncertainty in the activity statistics for each source is summarised in Table 4-1.

Table 4-1 Uncertainty in Activity Statistics for Inventory Sources

Source		Comment
Transport	Motor vehicles	Reasonable certainty in VKT data given the road length data from regional council data base. Limitations are in whether measurements have been taken at enough points on a road to be truly representative. Vehicle counts are likely to vary seasonally particularly, due to tourism over summer, but the VKT data is expected to be reasonably representative of an annual average.
	Rail	High certainty in activity data, based on train schedules provided by Tranz Rail.
	Shipping	High certainty in number of ships, and types of ships visiting the port and in the average berthing times, with data provided by the Port of Tauranga. Uncertainty in the assumption that the auxiliary engines run for the entire time the ships are in port.
	Aircraft	Reasonable certainty in the data for landing and take offs obtained from the McGregor report prepared for the Regional Council, but low certainty for the time in mode data that is assumed in the factors used for Australian regional airports and general aviation.
Domestic		All domestic source activity data is reasonably uncertain because it has been extrapolated from other regions where domestic surveys have been conducted. For example, there was a factor of at least two difference in the activity factors for fuel use for domestic heating in Auckland and South Island towns and large differences in backyard burning rates for various regions.
Industrial		There is reasonable certainty in the activity data for industrial sources, the majority of which was obtained by direct contact with industry. Activity data for abrasive blasting and spray painting was extrapolated from Nelson, therefore there is less certainty with this, but the effect on the inventory is negligible.
Agriculture	Pesticide use	The land cover data needed to apply the pesticide application rate data is now relatively old, being relevant to 1996/97, however, major land use changes are not expected to have occurred in this time and therefore the data is expected to be moderately certain although it does not allow for areas that are in organic production.
	Pollen	Forestry data is from 1999 and is expected to be of high certainty. However, no pollen from other vegetation types has been included in the estimates. Forestry is the dominant landuse overall in the Region, so the data is considered to be moderately certain. (But note that the pollen emission factor is very crude).
	Livestock	Livestock numbers were from Statistics New Zealand and data was available regionally, this data is expected to have a high level of certainty.
	Agricultural burning	Information on quantities of forestry burnoff were not generally available, and anecdotally the practice is much reduced, therefore forestry burning could not be directly included. The land use data on which crop burnoff emissions were estimated has moderate certainty.
Waste	Landfills	Regional quantities of waste per annum were used to extrapolate from national emission estimates. This is expected to be reasonably certain as it was obtained from the recent landfill census. This method of extrapolation does not account directly for the history of waste deposition and closed landfills specific to the Region, therefore it has moderate certainty.
	Wastewater	The activity data is based on national aggregate figures per head of population and does not account for regional variation, therefore it is expected to have moderate certainty.

Source		Comment
Geothermal	Natural	Estimates of H_2S were not possible because flux rates from geothermal fields are not known, although data on the field sizes and locations is available.

Data availability for future inventories needs consideration. Data may not be available from the same sources as used here, for example, the RAR report. The ability to gather reliable information depends on cooperation from the people supplying the data and increasingly organisations are likely to seek payment for providing data, which needs to be accounted for in setting budgets.

Inventories are useful tools for assessing the sources contributing to pollution but the results need to be interpreted and used bearing in mind that the inventory is not the result of an exact science. Certain policy decisions may require a more refined and/or localised information base and further investigations may be needed in such cases.

5. Estimated Emissions 2001

This section presents the emission for the various sources estimates for the various sources based on the best information available for activity data and emission factors to represent the 2001 year. The data presented has been imported from the relevant calculation sheets, any apparent addition errors are due to rounding.

5.1 Transportation

5.1.1 Shipping

Tauranga is a major shipping port for New Zealand. A total of 1259 ships entered the port in 2001. The duration of the stay was on average 1.5 days and ships had an average gross registered tonnage of 17,800. The estimated emissions from commercial shipping are presented in Table 5-1.

Table 5-1 Emissions for Commercial Shipping (Tauranga)

Contaminant	Tonnes / Year 2001
CO	68
NO_x	477
SO_2	390
PM_{10}	58
$PM_{2.5}$	54
VOC	23
Acetaldehyde	0.8
Benzene	0.4
1,3-butadiaene	0.4
Formaldehyde	2
CO_2	27925

5.1.2 Motor Vehicles

The total vehicle kilometres travelled for the Region was estimated at about 2,200 million kilometres for 2001. This compares to the figure for 1996 reported by OPUS of nearly 2000 million kilometres. This is an increase in VKTs of about 11% compared to a population increase of 6.7%. The emissions estimates are presented in Table 5-2.

Dioxin emission using UNEP emission factors were 22.8 mg I-TEQ per year , which is within the range of 3.3 to 50.4 mg I-TEQ using emission factors from MfE.

Table 5-2 Annual Emissions from Motor Vehicles

District	2001 VKTs (000,000)	Emissions (Tonnes / Year) 2001										
		PM_{10}	$PM_{2.5}$	CO	NOx	SO_2	VOC	CO_2	Benzene	Acetaldehyde	1,3-Butadiaene	Formaldehyde
Taupo (part)	53.7	8	5	249	119	12	34	19769	2	0.9	0.2	0.8
Western BOP	530.6	74	44	2670	1175	115	376	195178	22	9.7	2.2	9.4
Tauranga	535.7	74	44	3909	1215	116	624	197052	36	16	3.6	15.6
Rotorua (part)	538.3	75	45	3352	1207	117	511	198015	30	13.1	2.9	12.8
Whakatane	383.1	53	32	2188	855	83	324	140921	19	8.3	1.9	8.1
Kawerau	30.5	4	3	219	69	7	35	11220	2	0.9	0.2	0.9
Opotiki	124.9	17	10	603	276	27	83	45932	5	2.1	0.5	2.1
Region Total	**2,196.7**	**305**	**183**	**13190**	**4916**	**477**	**1987**	**808088**	**115**	**51**	**11.4**	**49.8**

Table 5-3 : Annual Emissions from Rail Transport

District	Emissions (Tonnes / Year) 2001										
	PM_{10}	$PM_{2.5}$	CO	NOx	SO_2	VOC	CO_2	Benzene	Acetaldehyde	1,3-Butadiaene	Formaldehyde
Western BOP	4.6	4.2	18	184	8.7	6.8	6707	0.11	1.95	0.10	0.58
Tauranga	2.2	2.0	8.8	89	4.2	3.3	3251	0.06	0.95	0.05	0.28
Rotorua (part)	0.0	0.0	0.1	1.3	0.1	0.1	46	0.00	0.01	0.00	0.00
Kawerau	0.1	0.1	0.5	4.7	0.2	0.2	170	0.00	0.05	0.00	0.01
Whakatane	6.1	5.6	24.3	247	11.6	9.1	8999	0.15	2.62	0.14	0.77
Region Total	**13.1**	**12.0**	**52**	**526**	**24.8**	**19**	**19173**	**0.32**	**5.57**	**0.30**	**1.65**

5.1.3 Rail

The Region has an active rail network linking the main trunk line to the major Port in Tauranga and servicing the forestry industry in Whakatane District. The Rotorua Line is now mothballed but did operate for part of 2001. The emission estimates for rail movements are presented in Table 5-3. Fuel consumption data was estimated by the rail model at 7,384,000 litres. Fuel consumption estimates were used to calculate dioxin emissions giving an emission of 3.1 mg I-TEQ per annum.

5.1.4 Aircraft

The Region has three airports located at Tauranga, Rotorua and Whakatane. Tauranga airport has the most aircraft movements, but many of them are for general aviation. Rotorua and Tauranga have similar levels of domestic movement. The predicted emissions for both general aviation and domestic activity are presented in Table 5-4. All PM_{10} was assumed to be $PM_{2.5}$.

The contribution of CO_2 was estimated from the NZGHGI based on the Region having 6.7% of New Zealand's population. CO_2 was estimated at 56,494 tonnes although this is likely to be an over estimate because aircraft movements are unlikely to be directly proportional to population. The Region does not have international flights, which are expected to contribute significantly to New Zealand's total CO_2 emission. If the data is available in future, it may be preferable to prorate the emission based on the quantity of aviation gas from refuelling, compared with national consumption. Such an approach would be consistent with the IPCC approach, which allocates a country's emissions on the basis of point of fuel supply.

5.2 Industrial Sources

Industries included in the inventory included major combustion sources, pulp and paper, dairy and asphalt plants. Estimated emissions from industry are presented in Table 5-5.

Spray painting emissions estimated by extrapolating data from the Nelson Inventory (2001) gave an estimate for VOC emissions of around 85 tonnes per year, however, VOCs from spray painting are already accounted for in the methodologies for domestic and commercial emissions so were not included in order to avoid double counting. Industrial VOC emissions were not specifically investigated as part of the study of Environment Bay of Plenty's resource consent information or the industrial survey. Therefore, the VOC estimates are from combustion sources only. Industrial VOC use such as solvents is also accounted for in the per capita estimates under domestic and commercial use.

Table 5-4 Activity Data and Emissions from Aircraft

District	Activity data LTOs		Tonnes / Year 2001									
	1996	2001	PM_{10}	$PM_{2.5}$	CO	NOx	SO_2	VOC	Acetaldehyde	Benzene	1,3-Butadiaene	Formaldehyde
Tauranga	23947	36902	48	48	44	258	0.1	27	1.3	0.5	0.5	4
Rotorua	18691	14499	15	15	46	91	0.1	25	1.2	0.5	0.5	4
Whakatane	2387	2595	2	2	13	15	0.0	7	0.3	0.1	0	1
Region Total	**45025**	**53996**	**65**	**65**	**103**	**363**	**0.2**	**59**	**2.8**	**1.1**	**1**	**9**

Table 5-5 Annual Emissions from Industry

District	Tonnes / Year 2001									
	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2	VOC	CO_2	Acetaldehyde	Benzene	Formaldehyde
Taupo (part)	8	2	0	0	0	0	0	0.0	0	0
Western Bay of Plenty	354	183	304	36	35	7	51462	0.0	0	0
Tauranga	46	31.5	18	15	745	2	23367	0.0	10	0.1
Rotorua (part)	567	456	1124	141	127	26	215158	0.0	2	0.02
Kawerau	249	161	2450	308	6	55	34653	0.0	0	0.4
Whakatane	145	81	154	43	19	5	86932	0.0	0	0.04
Opotiki	0	0	0	0	0	0	0	0.0	0	0
Region Total	**1369**	**914**	**4050**	**543**	**932**	**95**	**411571**	**0.0**	**12**	**0.6**

Table 5-6 Annual Emissions from Backyard Burning

District	Tonnes / Year 2001							
	PM_{10}	$PM_{2.5}$	CO	NOx	SO_2	VOC	CO_2	Benzene
Taupo (part)	0	0	1	0	0.0	0	19	0.0
Western Bay of Plenty	34	31	113	8	1.3	12	3950	1.3
Tauranga	85	79	284	20	3.4	29	9953	3.4
Rotorua (part)	52	48	174	12	2.1	18	6073	2.1
Kawerau	28	26	92	7	1.1	9	3236	1.1
Whakatane	6	5	19	1	0.2	2	657	0.2
Opotiki	8	7	26	2	0.3	3	908	0.3
Region Total	**211**	**197**	**708**	**51**	**8.4**	**73**	**24797**	**8.4**

Table 5-7 Annual Emissions from Domestic Heating

District	Tonnes / Year 2001							
	PM_{10}	$PM_{2.5}$	CO	NOx	SO_2	VOC	CO_2	Benzene
Taupo (part)	0.4	0.3	3	0.0	0.0	1	74	0.0
Western Bay of Plenty	76	71	702	6.6	3.2	200	15117	6.7
Tauranga	193	179	1770	16.7	8.0	504	38096	16.9
Rotorua (part)	117	109	1080	10.2	4.9	308	23246	10.3
Kawerau	63	58	576	5.4	2.6	164	12386	5.5
Whakatane	13	12	117	1.1	0.5	33	2515	1.1
Opotiki	18	16	161	1.5	0.7	46	3475	1.5
Region Total	**480**	**447**	**4410**	**41.7**	**20.1**	**1256**	**94910**	**42.1**

Table 5-8 Annual Emissions from Lawn Mowing

District	Tonnes / Year 2001										
	PM_{10}	$PM_{2.5}$	CO	NOx	SO_2	VOC	CO_2	Acetaldehyde	Benzene	1,3-Butadiaene	Formaldehyde
Taupo (part)	0.0	0.0	0.4	0.0	0.0	0.1	2	0.1	0.4	0.2	0.2
Western Bay of Plenty	0.4	0.3	72	0.6	0.02	16	377	16	82	49	33
Tauranga	1.1	0.8	182	1.4	0.04	41	949	41	207	124	83
Rotorua (part)	0.7	0.5	111	0.9	0.02	25	579	25	126	76	51
Kawerau	0.4	0.3	59	0.5	0.01	14	309	13	67	40	27
Whakatane	0.1	0.1	12	0.1	0.003	3	63	3	14	8	6
Opotiki	0.1	0.1	17	0.1	0.004	4	87	4	19	11	8
Region Total	**2.8**	**2.0**	**454**	**3.6**	**0.1**	**103**	**2365**	**103**	**516**	**310**	**207**

Dioxins from industrial combustion sources are estimated at 376 mg I-TEQ per year. The metallurgical industry was not able to be included because in the dioxin estimates because information from the Ministry for the Environment's study of the secondary metal[13] industry was not available at the time of writing.

5.3 Domestic and Commercial Sources

Results for annual emissions from backyard burning, domestic home heating (wood, coal and gas) and lawn mowing are presented in Table 5-7, and Table 5-8 respectively.

Regional emissions of dioxin from backyard burning ranged from 159 to 1861 mg I-TEQ per year. These figures were obtained using the same factors as used in the national inventory, but a higher activity rate, as discussed in section 3.2.4.2. By comparison, the total national emissions given in the national inventory were 540 to 6400 mg I-TEQ per year. Calculations using the UNEP (2001) factor for uncontrolled domestic waste burning of 300 μg TEQ per tonne gives a higher emission rate of 5000 mg I-TEQ per year.

Lawn-mower emissions have been estimated. They are a minor contributor to classical air pollutant emissions, although they appear to contribute significantly to emissions of hazardous air pollutants.

Non-methane VOCs from domestic and commercial sources are estimated on a population basis using factors from the NZGHGI. The results are presented in Table 5-9.

Table 5-9 Domestic and Commercial Solvent Emissions

District	NMVOC (Tonnes / Year)
Taupo District (part)	2
Western Bay of Plenty District	372
Tauranga District	885
Rotorua District (part)	594
Whakatane	319
Kawerau District	68
Opotiki District	90
Region Total	**2,329**

[13] The Ministry for the Environment commissioned a study in 2002 to develop activity data and emission factors from the secondary metals industry in New Zealand. This report is expected to be published in September 2003.

The estimate for spray painting operations based on a per site emission rate developed from Nelson data was 85 tonnes per year. This is included in the aggregated emissions calculated above and has not been accounted for separately as discussed elsewhere.

5.4 Waste

The estimated emissions from landfills and wastewater are presented in Table 5-10. Landfills in the Bay of Plenty are located at Athenree, Murupara, Whakatane and Rotorua. Currently, no landfills in the Region have gas collection but Whakatane and Rotorua are considering options for gas management systems[14]. The total waste going to landfill in the Region is 151,000 tonnes per annum, which results in a methane emission of 7000 tonnes per year, or about 4.5% of the national gross total methane emission for 2001 without collection and flaring.

Table 5-10 GHG Emissions from Municipal Landfills and Waste Water Treatment Plants (WWTPs)

District	Tonnes / Year				
	WWTPs		Landfills		
	CH_4	N_2O	CH_4	CO_2	Benzene
Kawerau	0	0.006	0	0	0
Opotiki	0.08	0.003	270	213	0.00
Rotorua	0	0.037	1791	1410	0.02
Tauranga	7.9	0.056	2667	2101	0.02
Western BOP	0.5	0.010	1122	883	0.01
WDC	4.4	0.016	1167	919	0.01
Taupo	0	0	0	0	0.00
Region	**13.0**	**0.129**	**7018**	**5526**	**0.06**

5.5 Biogenic Emissions

Total NO_x emission from biogenic sources is estimated at over 1,300 tonnes per annum. This could be prorated for each district on the basis of land area as a first approximation but may be of limited value, for example for Kawerau District, which is largely urban.

The total VOC emission from biogenic sources is estimated at 41,557 tonnes per annum. Biogenic methane, CO and N_2O were not estimated.

[14] *pers com*. Glenn Wigley, Ministry for the Environment, January 2003

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5.6 Agriculture and Forestry

5.6.1 Livestock and Agriculture

The estimated emissions from agriculture based on NZGHGI methodologies are presented in Table 5-11.

Table 5-11 Agricultural Source GHG Emissions for Bay of Plenty

Source	Tonnes / Year (2001)			
	Methane	N_2O	CO	NO_x
Livestock enteric fermentation and manure management	45100	6	-	-
Agricultural soils (nitrogen from synthetic fertiliser and manure)	-	17330	-	-
Field burning of agricultural residues	19	0.6	395	21.3
Total	**45119**	**17337**	**395**	**21.3**

5.6.2 Pollen

Pollen estimates for exotic forestry plantations are provided in Table 5-12. The pollen production season is July to August. Taupo and Whakatane Districts have the most significant areas of forestry.

Table 5-12 Pollen from Exotic Forestry

District	Exotic timber per district year 3 – 30 plantings ha (2001)	Pollen (Tonnes / Year)
Taupo (part)	96,839	19,368
Rotorua (part)	28,185	5,637
Whakatane	115,399	23,080
Western Bay of Plenty	26,365	5,273
Opotiki	18,870	3,774
Kawerau	28	5.6
Region total	**285,686**	**57,137**

5.6.3 Pesticides and Fertiliser

The estimated level of pesticide use is reported in Table 5-13. Estimates of pesticide use were not made for the 1996 inventory, although reference was made to an earlier report which provided rough estimates for 1985-1988. Comparison with these figures shows that the latest MAF application rate data are an order of magnitude higher than the earlier study. The more recent estimates are expected to be more reliable than the earlier data, which was based on a partial survey of only some sectors. MAF indicates that pesticide use has been on the decline in recent years, as discussed in section 3.2.5 of this Report. Herbicide use is predominant at about 75% of all pesticide use.

Table 5-13 Annual Pesticide Use Bay of Plenty

Land use	Pesticide Use by Active Ingredient (Tonnes / Year)			
	Insecticides	Herbicides	Synthetic fungicides	Total
Arable farming	1.1	10.6	0.02	11.7
Horticulture	71.6	66.3	4.7	172.6
Vegetables	0.8	3.2	8.1	12.1
Pastoral	756.9	4202.7	0	4959.6
Forestry	698.2	1607.2	328.6	2634.0
Total	**1528.5**	**5890**	**371.4**	**7790**

Fertiliser suppliers were unwilling to provide data on fertiliser sales as discussed in section 3.2.5.2 of this Report. Although fertiliser nutrient application rate data was used to estimate the emissions of N_2O as reported above.

5.6.4 Agricultural Burning

Information received from the territorial authorities and rural fire officers regarding agricultural burning in the Region for 2001 are summarised in Table 5-14.

There is insufficient data to provide reasonable estimates of emissions from agricultural burning.

The methods used to estimate GHG emissions from agriculture in the NZGHGI include methods for estimating CO and NO_x as reported above in section 5.6.1. The estimate for CO placed field burning of agricultural residues at 2% of total CO and NO_x at less than 0.3%.

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■ **Table 5-14 Agricultural Burning Responses**

District	Comment
Taupo (part)	One consent for Fletcher Challenge for burning windrows (expired 2002)
Rotorua (part)	Forestry companies are using burning very infrequently, only if there is a lot of slash left behind, nothing major occurred in 2001. The last major burns were reportedly about 10 years ago.
Whakatane	The number of fire permits can be provided but staff have no idea of quantity. Generally a declining method, mainly for general rubbish, tree prunings, stumps and straw.
Tauranga	The District Council does not burn for reserve clearing and has no other applicable information.
Western Bay of Plenty	No indication of conditional burning.
Opotiki	10 hectares planned. 100 hectares unplanned.
Kawerau	No data

5.7 Geothermal

The Bay of Plenty has an extensive variety of geothermal resources that cover the Taupo volcanic zone to White Island. Emissions of naturally occurring H_2S are emitted with steam as a result of volcanic and geothermal activity. The geothermal resources of the Region are summarised in the Environment Bay of Plenty state of the environment report (2001) and in a recent report on regional groundwater resources (2002).

Some research on emissions from geothermal sources has been conducted but the results vary by several orders of magnitude, and are therefore difficult to extrapolate to all sources.

Data for the land area of the fields and temperatures exist, and so reasonable estimates of the heat flux can be made. It is possible that this could be related to H_2S emissions by making informed estimates as to the relationship. A methodology for determining surface heat per m^2 could be used to crudely estimate the surface flux, which then could be used to estimate a flux of emissions. However, the costs involved in doing this work precluded it from inclusion in the inventory.

At this stage there is insufficient data to estimate naturally occurring H_2S in the Region.

6. Data Summaries and Analysis

Summary tables for all data reported by contaminant and district for each source category are provided in Appendix B. Key summaries are provided below. There may be apparent addition errors from rounding used to present the numbers.

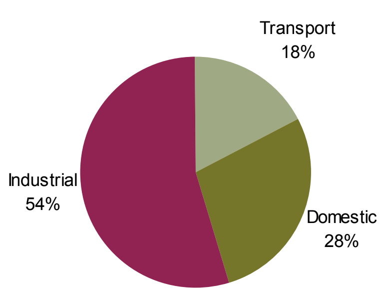
6.1 Primary Contaminants

Table 6-1 Total Annual Emissions for Primary Contaminants 2001

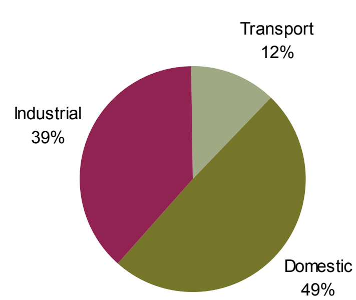
Source Category	Tonnes / Year				
	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2
Transport	441	313	13412	6282	891
Domestic	693	646	5573	96	29
Industrial	1369	914	4050	543	932
Biogenic	NA	NA	NA	1301	NA
Agricultural field burning	NA	NA	395	21	NA
Total	**2503**	**1873**	**23430**	**8243**	**1852**

Pie charts for the percentage contribution of various sources for each contaminant are presented in Figure 6-1 to Figure 6-3.

Figure 6-1 Annual and Wintertime PM_{10}



Annual



Wintertime

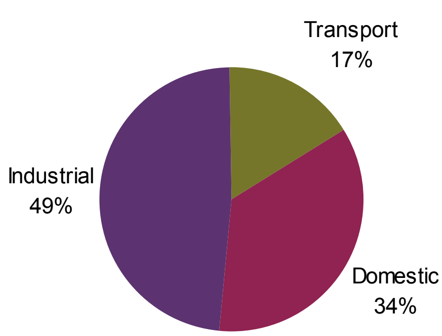
For PM_{10} the major source on an annual basis appears to be industry. Within industry the major contributors are the wood fired combustion sources and the wood processing industry at 80% of emissions. Quarries are also significant, and estimated to contribute 16% of PM_{10}. It is likely that emission factors may be unduly conservative for both of these sources in particular the factor used for storage and handling of materials at quarries is 0.15 kg per tonne. For wood fired boiler plant for Carter Holt Harvey Tasman, emission calculated using emission factors were 4 times those from the measurement data, therefore the factors are also may be over estimating other industrial sources.

In wintertime the domestic sector predominates PM_{10} emissions due to domestic heating, although backyard burning and lawn mowing emissions reduce over this time.

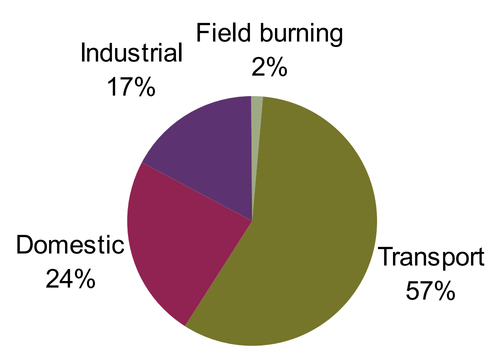
Pollen is generally not in the respirable (PM_{10}) fraction so has not been included in the totals for particulate matter. Pollen is estimated to contribute about 57,000 tonnes of particulate matter per annum, but this occurs over a period of a few weeks in late winter. The contribution of pollen is considerably larger than the total PM_{10} fraction from all other sources. The districts with the major contribution to pollen from exotic forestry are Whakatane and Taupo.

There was little data available for $PM_{2.5}$ contributions from industry for non-combustion sources. An assumption was made that much of the PM from wood processing and quarries would not contain $PM_{2.5}$. Overall however, $PM_{2.5}$ shows a similar distribution to PM_{10} with domestic sources contributing a proportionately higher level of $PM_{2.5}$.

■ **Figure 6-2 Annual $PM_{2.5}$ and CO Sources**



$PM_{2.5}$

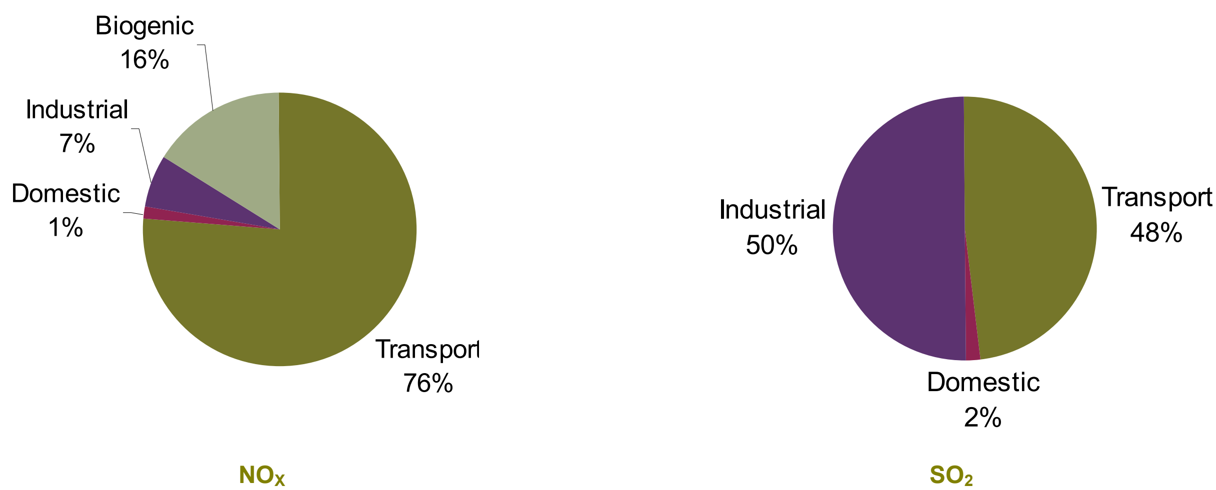


CO

Carbon monoxide and nitrogen oxide emissions are both dominated by transport. Data for seasonal variation of these sources is not available, but there is likely to be some increase in the motor vehicle traffic and emissions over summer because the Region is a summer holiday destination. Domestic sources are a reasonably large contributor to carbon monoxide and this contribution would increase over the winter months as for particulate matter from domestic combustion.

The domestic sector contributes very little SO_2. The majority of the SO_2 from the transport sector is from shipping activities in the port of Tauranga. Likewise, the majority of the industrial SO_2 emission comes from two industrial sites located in the Mt Maunganui industrial area.

■ **Figure 6-3 Annual NO_x and SO_2 Sources**



6.2 Hazardous Air Pollutants

A summary for the annual emissions of hazardous air pollutants is presented in Table 6-2. Biogenic emissions from vegetation predominate total VOC emissions. This is due to very large forestry plantations and significant areas of indigenous planting in the Region. The domestic sector (lawnmowing only) appears to dominate the emissions of hazardous air pollutants. This contribution would increase further if estimates were available for domestic home heating and backyard burning.

■ **Table 6-2 Total Annual Emissions for Hazardous Air Pollutants 2001**

Source Category	Tonnes / Year				
	VOC	Acetaldehyde	Benzene	Formaldehyde	1-3 Butadiene
Transport	2089	60	117	63	13
Domestic and commercial	3761	103#	567	206#	310#
Industrial (combustion)	95	0.001	12	2	NA
Biogenic/waste	41557	NA	0.06	NA	NA
Total	**47502**	**163**	**696**	**271**	**323**

*includes industrial use of solvents

lawn mowing only

6.3 Dioxin Emissions

Regional dioxin emissions are summarised in Table 6-3. Domestic combustion and particularly backyard burning dominate the emissions at 5061 mg I-TEQ. Backyard burning estimates were made using the UNEP dioxin emission factor for of 300 μg I-TEQ per tonne. This compares with the weighted average range from the New Zealand Dioxin Inventory of 9 to 110 μg I-TEQ per tonne for domestic and organic waste. The uncertainty associated with this emission factor has a large effect on predicted total emissions. Using the upper factor from MfE, dioxin emissions would be about one third of that estimated below. The estimates are based on UNEP emission factors, based on advice from the Ministry for the Environment, discussed previously.

■ **Table 6-3 Total Annual Dioxin Emissions**

Source Category	Emission Range (mg TEQ per year)
Transport (excluding aviation and shipping)	26
Domestic (excluding lawn mowing)	5,365
Industrial	376
Total	**5,765**

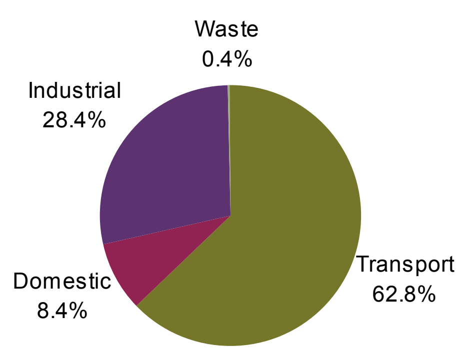
6.4 Greenhouse Gases

Total annual carbon dioxide emissions are estimated at 1.4 million tonnes. The transport sector contributes over 60% of the CO_2. Industry contributes just over 30% of the regional CO_2 emission. The contributions to total CO_2 are shown in Figure 6-4.

Table 6-4 Total Annual CO_2 Emissions (2001)

Source Category	Emission Tonnes / Year
Transport	911,680
Domestic	122,072
Industrial	411,571
Waste	5,526
Total	**1,450,849**

Figure 6-4 Annual CO_2 Source Contributions



N_2O was estimated from wastewater, livestock agricultural burnoff, and agricultural soils based on methods from the NZGHGI. Factors for other potential sources of N_2O such as biogenic emissions were not available. N_2O estimates are therefore dominated by agricultural soil emissions. The data is presented in Table 6-5. Emissions of methane are dominated by livestock.

Table 6-5 Total Annual N_2O and Methane Emissions (Tonnes/year)

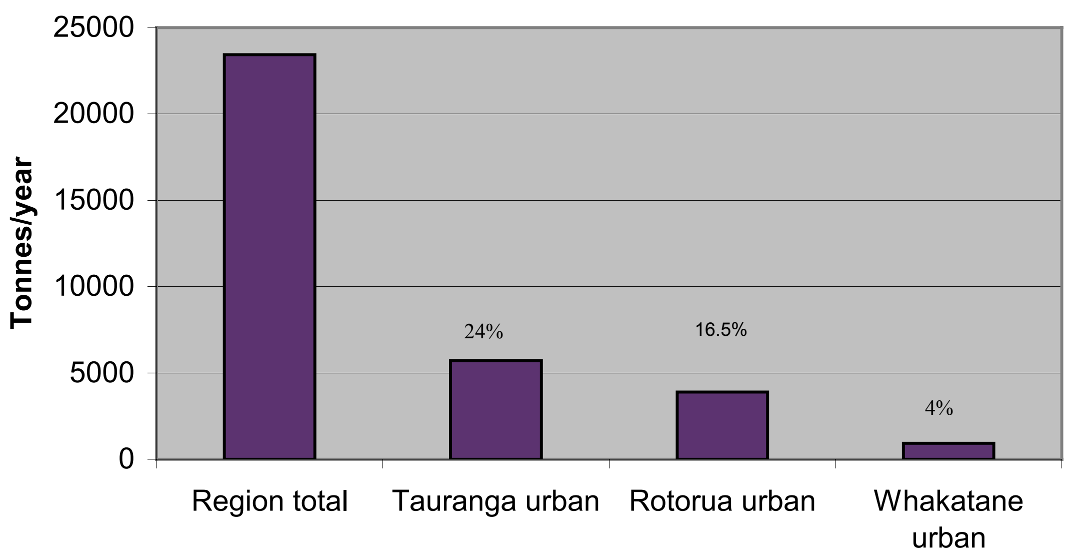
Source	N_2O	CH_4
Landfills	0	7018
Wastewater treatment	0.13	13
Livestock enteric fermentation and manure management	5.9	45077
Agricultural soils (nitrogen from synthetic fertiliser and manure)	17330	0
Field burning of agricultural residues	0.6	18.8
Total	**17337**	**52127**

Methane from waste (landfills and wastewater) is equivalent to 147,000 tonnes per annum of CO_2 based on a global warming potential for methane of 20 compared to 1 for CO_2.

6.5 Urban Area Contributions

All data for urban area contributions for each pollutant is provided in Appendix A. The contributions of the common air pollutants are illustrated in the following figures. The percentage urban area contributions for the common air pollutants are very similar to that for the 1997 inventory. The urban contribution for NO_x has decreased slightly in percentage terms because of the inclusion of biogenic NO_x.

- **Figure 6-5 Urban Carbon Monoxide Contribution**



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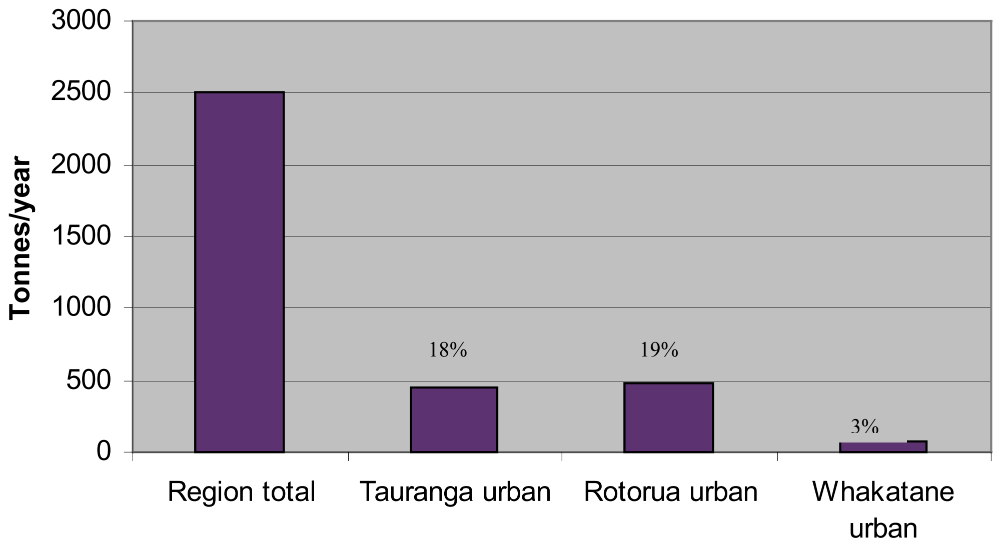
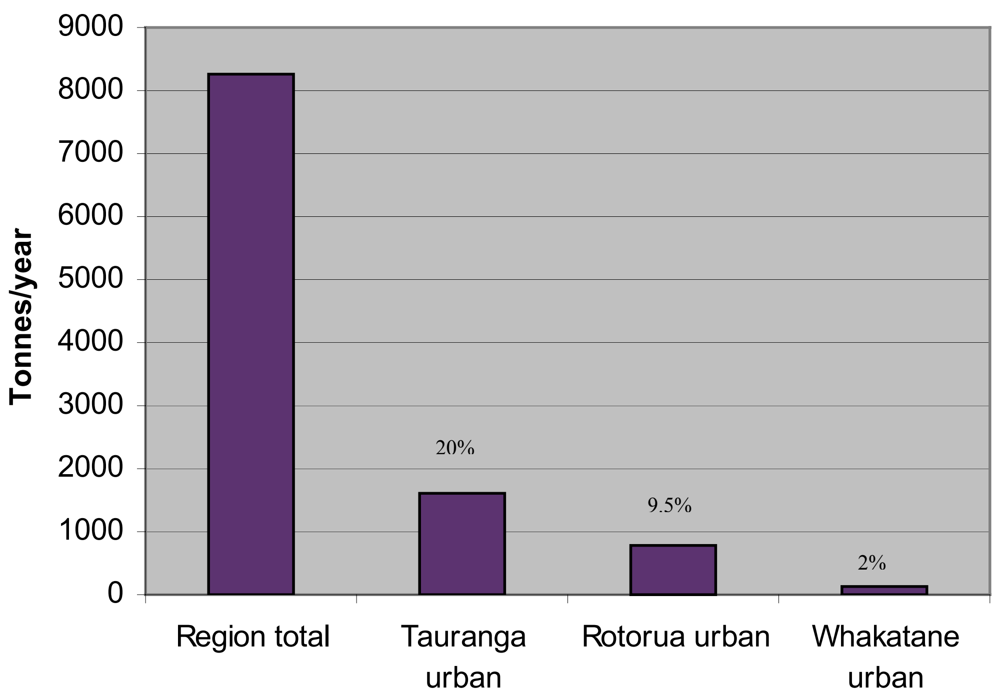
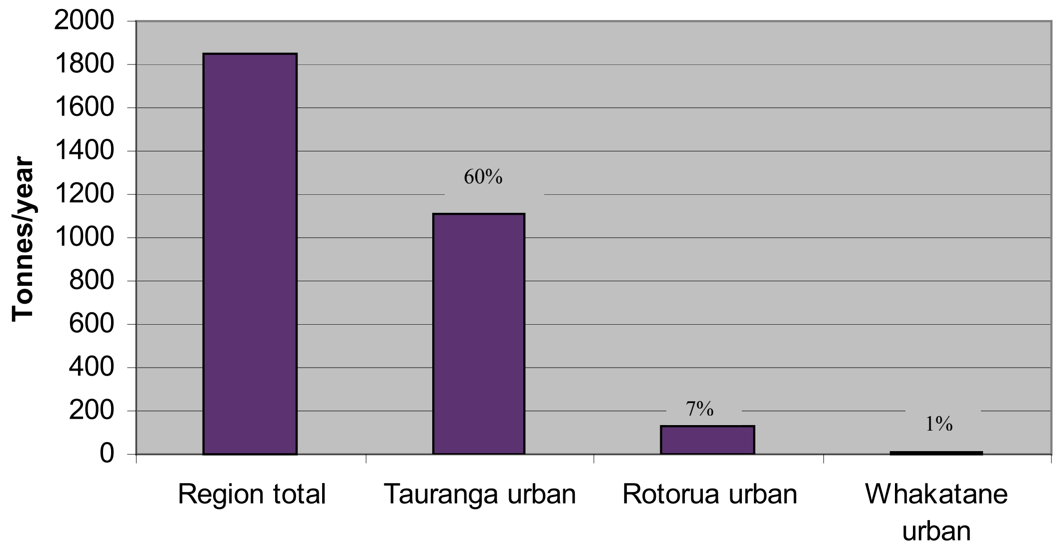
■ **Figure 6-6 Annual Urban PM_{10} Contribution**



■ **Figure 6-7 Urban Nitrogen Oxide Contribution**



- **Figure 6-8 Urban Sulphur Dioxide Contribution**



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7. Comparison with 1996

7.1 Transport

7.1.1 Shipping

For the 2001 calendar year 1259 ships entered the Port of Tauranga with an average berthing time of 1.5 days and an annual average gross registered tonnage[15] of 17,800. This compares to 1052 ships with an average length of stay of 1.62 days reported for 1996.

Commercial shipping data for 1996 were used with the EET emission factors used for 2001 to backcast emissions for shipping. The change to the EET factors from the WHO factors used in 1996 was useful because they are more comprehensive in terms of pollutants covered. The results for 1996 and 2001 using the EET emission factors are presented in Table 7-1 and compared to the predictions using WHO.

Table 7-1 Commercial Shipping Backcast Results

Contaminant	Tonnes / Year		
	1996 WHO (Table 8 OPUS 1997)	1996 EET	2001 EET
CO	0.06	61	68
NO_x	154.6	419	477
SO_2	695.3	343	390
PM (total)	11.6	52	58

In 1996, 50% of the ship emissions were included in the contribution to the Tauranga urban area. In 2001, the emissions from the auxiliary engines were included in the urban area contribution because the main engines do not run while in port. The distinction had not been possible with the earlier factors.

As shown in Table 7-1 the estimated emissions for 2001 are significantly different from the 1996 figures. This comes about because of significant differences in the emission factors used in the two calculations. The more recent estimates are believed to be the more reliable, because the WHO factors are very generic and relatively dated, whereas the EET factors are more specific for the types of ships found in Australian ports.

Overall shipping activity has increased by nearly 20%, and there has been a corresponding increase in air emissions, which is slightly offset by the shorter stays in port.

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[15] For the 12 months to the end of June 2002

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7.1.2 Rail

Data of the appropriate format for the MOT model was not available either from the 1996 inventory or from Tranz Rail. Therefore, backcasting the emissions was done using 1998 train movement data as an approximation of the train movements for 1996. A comparison of train movement data is presented in Table 7-2. There appears to have been an increase in rail movements by about 30% overall.

Table 7-2 Train Movements 1996, 1998 and 2001

District	Movements / Year	Line	Movements / Year	
	1996[a]		1998	2001
Tauranga	5475	East Coast Main Trunk to Tauranga	5512	8788
Western BOP	5475	East Coast Main Trunk Tauranga to Whakatane and Kawerau	4056	4004
Kawerau	365	Mount Maunganui Line	8840	11128
Rotorua	730	Rotorua	1248	405
Whakatane	1460	Murupara Line	2184	3744

[a] Based on daily data estimates provided for the 1996 inventory

Table 7-3 Emissions Estimates from the MoT Rail Model for 1998 and 2001

District	Pollutant, Tonnes / Year							
	CO		NOx		SO_2		PM	
	2001	1998	2001	1998	2001	1998	2001	1998
Western BOP	18	11	184	114	8.7	5.4	4.6	2.8
Tauranga	8.8	6.1	89	62	4.2	2.9	2.2	1.5
Rotorua	0.1	1.2	1.3	12.6	0.1	0.6	0.0	0.3
Kawerau	0.5	0.2	4.7	2.4	0.2	0.1	0.1	0.1
Whakatane	24.3	11.7	247	119	11.6	5.6	6.1	3.0
Region Total	**52**	**30**	**526**	**310**	**24.8**	**14.6**	**13**	**8**

Predictions are generally much higher from the rail model than those estimated for 1996 as reported by OPUS and reproduced in Table 7-4 below. The estimates based on MoT factors are expected to be more realistic than those used in 1996.

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■ Table 7-4 Emission Estimates from Rail OPUS (1997)

District	Pollutant, Tonnes / Year			
	CO	NO_X	SO_2	PM
Western BOP	0.1	1.7	3.9	0.3
Tauranga	0.2	2.9	4.6	0.4
Rotorua	0.0	0.2	0.5	0.0
Kawerau	0.0	0.0	0.1	0.0
Whakatane	0.1	1.1	2.5	0.2
Region Total	**0.4**	**4.9**	**11.6**	**0.9**

The OPUS 1996 figures were much lower than the estimates from the backcasting mainly because the estimated fuel consumption figures used by OPUS were much lower than those used in the MoT model. The estimates for fuel use given by the respective methodologies are summarised in Table 7-5.

■ Table 7-5 Fuel Use Estimates for Rail 1996, 1998 and 2001

District	Litres per day	Annual Fuel Used ('000s L)		
	1996 (OPUS)	1996 (OPUS)	1998 Rail Model	2001 Rail Model
Western BOP	208	76	1595	2583
Tauranga	246	90	875	1252
Rotorua	24	9	177	18
Kawerau	6	2	34	65
Whakatane	132	48	1673	3466
Region Total	**616**	**225**	**4353**	**7384**

7.1.3 Aircraft

Data for aircraft movements for both 2001 and 1996 was available from a report on Regional Airport Requirements (McGregor 2002) for both general aviation movements and domestic aviation movements. This data was used in preference to data that had been collected by OPUS for 1996 and Sinclair Knight Merz for 2001 directly from airport managers, although there was reasonable agreement between the OPUS data and that supplied in the McGregor report for 1996. The data shows an overall increase in air movements of about 20%.

The EET emission factors are considered a reasonable approach given the breakdown of factors for domestic and general aviation and the speciation of VOCs as compared to methods used by OPUS that require identification of emission factors for each aircraft type in the fleet. The figures for

1996 have been recalculated on the basis of the McGregor data and the EET methodologies. A comparison of the LTO data is provided in Table 7-6.

Table 7-6 Total Aircraft LTOs for 1996 and 2001

Airport	1996 (OPUS)	LTOs 1996 (McGregor)	LTOs 2001 (McGregor)
Tauranga	24874	23947	36902
Rotorua	17674	18691	14499
Whakatane	2414	2387	2595
Regional Total	**44962**	**45025**	**53996**

A comparison of the estimated emissions from 1996 and recalculated emissions using the data from McGregor with the EET methodology is provided in Table 7-7. The emission factors between the years are very different, however, a comparison cannot be made because the calculations (emission factors) from 1996 were not available.

Table 7-7 Total Aircraft Emissions 1996 and 2001

Data Source	Tonnes / Year			
	CO	NOx	SO_2	PM
2001 (EET/McGregor)	103	363	0.2	66
1996 (EET/McGregor)	89	301	0.2	55
1996 (OPUS)	569	20	0.1	0

7.1.4 Motor Vehicles

Motor vehicle estimates for 2001 saw an increase in the overall VKTs for the Region. VKTs were 2,196,786,000 for 2001 compared with 1,975,400,000 for 1996, which suggests there has been about a 11% increase in vehicle movements compared to a population increase of 6.7%. As discussed earlier in the report there are limitations in the availability of VKT data. An improvement in data availability may be responsible for some of the apparent increase in VKTs.

The VKT data for 2001 and 1996 on a per district basis is given in Table 7-9.

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■ Table 7-8 VKT data per District 1996 and 2001

District	VKT per annum (000,000s)		
	1996 (OPUS)	2001	% change
Taupo District (part)	47.1	53.7	14.1
Western Bay of Plenty District	390	530.6	36.0
Tauranga District	513.3	535.7	4.4
Rotorua District (part)	624.4	538.3	-13.8
Whakatane	302.5	383.1	26.6
Kawerau District	15.4	30.5	98.1
Opotiki District	82.7	124.9	51.0
Total	**1,975.4**	**2,196.8**	**11.2**

Table 7-9 provides a comparison of emissions for 2001 with the estimates for 1996 using both the OPUS results and 1996 emission factors from the VFECs model.

■ Table 7-9 Total Motor Vehicle Emission 1996 and 2001

Data Source	Tonnes / Year			
	CO	NOx	SO_2	PM
2001 (VFECs/Nelson)	13190	4916	477	305
1996 (VFECs/Nelson)	14561	5209	429	360
1996 (OPUS)	16280	10014	460	442

The comparison between the results backcast for 1996 using VFECs factors for 1996 with the 2001 shows that improvement in technology has offset the increase in VKTs between the two inventories. The main difference between the OPUS estimates and the VFECs methodology is the use of different factors and the weightings put on heavy diesel vehicles in 1996 as compared to 2001 which has been discussed elsewhere.

7.2 Domestic Heating Emissions

The population of the Region has increased by 6.7% from 1996 to 2001. Annual emissions from domestic heating are summarised in Table 7-10. The OPUS estimates were based on estimates of fuel consumption for domestic heating for coal and gas. The OPUS estimate for wood was based on 15 kg per day in 45% of dwellings for 170 days per year. The 2001 estimates were based on survey data from the Auckland Regional Council Domestic Heating Survey (2001). The uncertainty associated with emissions from this sector is discussed in Section 4.

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In 1996 the estimates for domestic emissions included small commercial sources which have not been able to be estimated here due to a lack of available fuel sales data as discussed elsewhere.

Table 7-10 Annual Emissions from Domestic Heating 1996 and 2001

Data Source	Tonnes / Year			
	CO	NO_x	SO_2	PM
2001 Residential	4410	42	20	480
1996 (OPUS) Residential/Commercial	7991	244	243	1110

7.3 Industry

Overall there has been little change to the level of industrial activity in the Region since 1996, with no major closures or new plants. A comparison of fuel consumption data for the main fuels used in industrial combustion processes is provided in Table 7-11. The table also presents the results for fuel consumption for 1996 backacst using 2001 emission factors.

Table 7-11 Industrial Fuel Consumption Back-calculated 1996 and 2001

Fuel	Annual consumption		Tonnes pollutant 1996				Tonnes pollutant 2001			
	1996	2001	CO	NOx	SO_2	PM	CO	NOx	SO_2	PM
Gas (m^3/y)	76,694,375	79,317,225	103	61	0	9	107	63	0.3	10
Coal (t/y)	9,108	5,049	27	34	43	28	15	19	24	16
Wood (t/y)	202,100	576,765	1374	152	152	657	3922	433	433	1874
Total	-	-	**1505**	**247**	**195**	**694**	**4044**	**515**	**457**	**1900**

Table 7-12 presents the results for all industrial sources as calculated in 1996 and 2001. The particulate matter value in Table 7-12 for 2001 is lower than in Table 7-11 because real emission data is used as opposed to the comparison above, based on emission factors only.

The main differences between the years is that coal use has decreased while wood combustion has significantly increased. Gas use has increased slightly. The large difference in NO_x emissions between the 1996 and 2001 years is mainly due to a change in emission factors for NO_x from gas combustion, which has reduced by about one third mainly due to an assumption that burners are low NO_x, based on information supplied in the industry survey. The increase in wood combustion and a slightly higher particulate matter emission factor have contributed to the increase in particulate matter emissions from the industrial sector.

■ Table 7-12 Total Annual Emissions from Industry 1996 and 2001

Data Source	Tonnes / Year			
	CO	NO_x	SO_2	PM
2001	4050	543	932	1369
1996 (OPUS)	5687	1210	646	849

7.4 Agriculture and Forestry

Burning is a permitted activity under both the regional air quality and land management plans, therefore the regional council does not keep records that can be used to estimate emissions. Likewise, information at the district level is fragmented and is insufficient for the purpose.

The previous inventory identified that burning, particularly forestry burning, was a reasonably significant contributor to particulate matter emissions at 12% annually. If anecdotal evidence is correct, then agricultural burning has significantly reduced and will no longer be a major contributor to particulate matter in the Region.

Forestry data for the Region, used to estimate pollen and pesticide use, indicate that there has been approximately a 25% increase in planting. The reported area in exotic forests for 1996 (OPUS) was 225,754 ha compared with 285,686 ha in 2001[16] or an increase of about 60,000 ha.

[16] 2001 data was supplied by MAF, note these data differ to that provided in Table 3-14 for 1996/97 from the Land Cover database of 267,000 ha.

8. Summary of Data Gaps and Limitations

The main data gaps and limitations are identified below:

- Nationally and internationally the focus has moved away from total particulate matter to fine particulate matter (PM_{10} and $PM_{2.5}$), as have monitoring methods and emission factors. As a result total particulate matter was not estimated in this inventory. Emission factors for $PM_{2.5}$ are being developed but assumptions were needed to estimate $PM_{2.5}$.
- Useful factors for particulate matter from quarries are not readily available. Emission factors from Parrett (1992) were used to estimate the contribution from quarries. It is recommended that their appropriateness be reviewed because quarry emissions were a reasonably significant industrial sources of fine particulate matter, but experience shows this is unlikely to be the case.
- The factors for fine particulate are from the US EPA and are likely to be conservative resulting in an over estimation of industrial particulate matter contributions. These factors should be refined for future studies, if possible.
- A lack of available data for fuel combustion (gas, wood and coal sales) meant that the estimate of small-scale commercial fuel combustion sources was not possible. Sources of sales data should be evaluated before commencing any future study to ensure that methods used are appropriate, such as by direct survey of small-scale industry.
- The data from regional council files for large-scale industrial sources was inadequate for the purposes of emission estimation. There was also relatively little compliance monitoring data available. As a consequence industrial activity data was gathered largely by industry survey. Large scale industrial solvent use, could be investigated in any future method developed for capturing activity data for large scale industrial sources to account for any regional variation.
- Data gaps in the estimations for dioxin and greenhouse gases occurred because activity data for other emissions was not suitable for use with emissions factors for these contaminants. In particular, fuel data was not available to estimate emissions from aviation, lawnmowing and shipping. This means that any comparisons with the relevant national inventories need to be made with caution and methods should be considered to estimate fuel consumption for these sources in future.
- Data for small-scale industrial sources (abrasive blasting and spray painting) was extrapolated from Nelson. The contribution from abrasive blasting is negligible and its inclusion in future inventories should be reviewed. Spray painting operations were accounted for as part of commercial VOC emissions. If the method used in this inventory is retained then separate estimations of spray painting emissions is not considered necessary.

- Domestic home heating and backyard burning are significant sources of fine particulate matter and benzene. Estimates in this study were extrapolated from other studies and there is a large degree of uncertainty in the assumptions as a result. It is recommended that the need for regionally specific data be reviewed by Environment Bay of Plenty should it wish to refine the estimates for these sources. Acetaldehyde, formaldehyde and 1,3 butadiene, in particular, could not be estimated for domestic backyard burning and domestic combustion, although they are likely to be relatively significant.
- Geothermal sources could not be estimated, as was the case in 1996. It is recommended that costs of estimating the emissions be weighed against the potential benefits before commissioning any further study of these emissions.
- The motor vehicle emission fleet data was not adjusted for regional variation on the basis that the registration data typically used for this has been found to not necessarily be representative of local conditions and on the advice of MoT. The need for adjustment and the data source for any adjustment should be reviewed before undertaking any future inventory.

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Units and Abbreviations

g	gram
µg	microgram (10^{-6} g)
ng	nanogram (10^{-9} g)
m	metre
m^3	cubic metre
N	Nitrogen
Nm^3	Normal cubic metre of dry gas at °C and 101.3 kPa
Tj	Terra joule (10^{12} j)
ARC	Auckland Regional Council
CO	Carbon monoxide
EET	Emission estimation technique
GHG	greenhouse gas
I-TEQ	International Toxic Equivalent
LTO	Landing and takeoff
MfE	Ministry for the Environment
MoT	Ministry of Transport
NMVOC	Non-methane volatile organic compounds
NPI	National Pollutant Inventory
NZGHGI	New Zealand Greenhouse Gas Inventory
NZTER	New Zealand Traffic Emission Rates
PM	Particulate matter
TSP	Total suspended particulate
UNEP	United Nations Environmental Programme
US EPA	United States Environmental Protection Agency
VKT	Vehicle kilometre travelled
VOC	Volatile organic compounds

Appendix A Industrial Sources

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Table A-1 Gas Fired Industrial Plant

						2001		2001	2001
District/urban centre	consent #	Site	new name	Process	Hours of operation per year	Rating	units	Fuel Use (GJ)/yr of NG fired	Fuel Use m^3/yr of NG fired
RD	30109	FLETCHER CHALLENGE FORESTS LTD Rainb		Boiler	8640	10	MW	311040	7,776,000
RD	30109	FLETCHER CHALLENGE FORESTS LTD Rainb		3 boilers to heat kilns	8640	2.75	MW	85536	2,138,400
					8640	3	MW	93312	2,332,800
RD	30073	Waiariki Polytech		Boiler (boiler & 2 Kilns)	(for training)	1.1	MW	13,207	330,172
TD	30122	TAURANGA DISTRICT COUNCIL		Sludge drying	not operating	0		0	0
TD	30086	Nikau	Kiwi Green mussels	Boiler		4000 lb/hr steam	MW	1121.6	28,040
TD	30094	Tauranga Abattoir Byproducts		Boiler	2160	4000 lb/hr steam		6000	150,000
				Boiler		2000 lb/hr steam			
WE	61251	SOUTHERN NURSERIES LTD Katikati		Heater, air (gas heaters)		11 x 100 - 200	kW	1.10804	27.701
WE	30056	Pukepine Sawmill Limited		Kilns		1	MW	60000	1,500,000
TM	30132	ICI Chemical (	Orica Chemnet	Boiler	8,400			14,810	370,250
TM	30097	Bakels Edible oils rendering		Steampac Boiler				5,000	125,000
				Boiler No.3 (Vaporax Boiler)	May not be in use now			0	0
				Vapour Incinerator (Afterburner)				7,000	175,000
				Rotary kiln Drier				11,000	275,000
TM	30084	Bakels Edible oils refining		Boilers (3)		200	kW	84,000	2,100,000
TM	30078	ICI NZ Orica Adhesives and resins		Boiler		17400		17400	435,000
TM	30066	Harvey Farms		Boiler	3,500	1.8	MW	22680	567,000
				Grain Dryer		14	IBTU's/	23305.2	582,630
TM	30081	Dominion Salt		Boiler	7,100	5.6	MW	145366.56	3,634,164
TM	30081	Dominion Salt		Rotary kiln (Rotary Dryer)		640	kW	5413.32	135,333
TM	30129	Confidential Disposals		Incinerator gas fired	Assume same useage as 1996			500	12,500
Mount Maunganui	61184	PORT OF TAURANGA LIMITED		2 Quarantine Incinerators				2761.56	69,039
T	30059	PAMAC	PERRY METAL PROTECTION(B	Hot dip galvanising plant	2,630	200	kW	7,064	176,591
T	30095	Sanford Limited		Boilers (2)				32,887	822,175
T	30069	Western Bay Health		Boilers (2)	(full time)	2 x 4.1	MW	40,000	1,000,000
R	30123	Claymark Industries Ltd		Boiler Kilns (2)		(1.5 or 2.5 ?) 200 GJ/c	MW	249600	6,240,000
R	30072	Panahome NZ Ltd		Burner	600	5	MW	10800	270,000
W	30057	CHH Packagin	CHH Paperboard	Faster Wheeler Steam Boiler	5,920	(13.75kg/hr)		521,002	13,025,050
				John Thompson Boiler				51,915	1,297,875
WD	30114	Bay Milk/BOP	Todd BOPE Limited	Boiler	7736	16	MW	445594	11,139,840
				Gas turbine	8094	4.8	MW	139864	3,496,608
				Gas turbine	7379	4.8	MW	127509	3,187,728
WD	30128	Bay Milk	NZMP LTD - EDGECUMBE	Milk powder driers	Gas appliances operated by BOPE above			NA	
K	30062	CHH Tissue	CHH Consumerbrands	Boiler	Most of the time	16.7	MW	648,000	16,200,000
				Boiler	Used on Standby	8.9	MW		
				Air Heater	Most of the Time	5.8	MW		
				Air Heater	Most of the Time	4.5	MW		
				Heater	Used on cold days	0.264	MW		
				Heater	Used on cold days	0.264	MW		
				Heater	Used on cold days	0.135	MW		
				Heater	Used on cold days	0.135	MW		
				Heater	Used on cold days	0.135	MW		

Table A-2 Wood Fired Industrial Plant

							2001		2001
Fuel type	District/urban centre	consent #	Site	Process	Description	Hours of operation per year	Rating	units	Fuel use, t/yr
Wood	R	30072	Panahome NZ Ltd	Maxitherm wood-waste boiler (lyttleton Eng fire tube boiler, 5 kilns)	Dutch oven, NO_x 0.8kg/hr (cyclone 10 kg/hr limit PM)	6800	6.4	MW	12970
	R	30048	CHH Timber	Boilers (2)	2 vekos grit circulation and kilns, 5 kg/hr limit PM		7200 kg/hr steam		8500
	R	60842	STEWART LOGGING LIMITED	Boilers, kilns	Dutch oven, flyash reinjection, O_2 meter	8400	1	MW	1400
	R	30085	Tachikawa	Boiler, 4 MT kilns	Spreader stoker, mechanical (6kg/hr PM Lim, actual about 4 kg/hr)	8,160	8	MW	50000
	R	30075	MAMAKU SAWMILLING CO LTD	Vekos W/W boiler (boiler 3 MT kilns)	Fluidised bed, dry shavings, oxymitter, obscuration monitor (grit recirc)	8,000	2.75	MW	7,800
	R	61497	McAlpines (Rotorua) Ltd	Boiler wet sawdust	3 kg/hr PM limit				5600
	RD	30063	Fletcher Challenge Forests Ltd	two water tube boilers	44MW max multiclone, bark boiler has wet scrubber. 7 kilns 7 more to go in over next two years. 3.5MW electrical	6800	30	MW	60795
	RD	30143	KLC LIMITED	Boiler #1	Vekos dry wood waste, Scott Eng. mechanical cyclone with fly ash reinjection (3.5 kg/hr PM, wood waste favoured, can burn coal)	1248	4.25	MW	1581
				Boiler #2	Vekos By Scotts Eng, dry wood waste (2.5 kg/hr PM), cyclone and ash recycling	6240	6	MW	11158
	T	60919	TIMBER FINISHINGS LIMITED	Boilers, kilns	Did not burn any wood waste in 2001	0	3.2	MW	0
	WBOP	61659	CLAYMARK SAWMILLS LTD	Boilers, 3 MT, 1HT kiln	7 kg/hr PM	6240	12.1	MW	22501
	WBOP	30064	H W Hooper W H Hopper	Fire tube (Boiler)	Uncontrolled (vekos (grit recirc), 2kg/hr particulate limit, 4 kilns)	8,000	6	MW	14305
	WBOP	30056	PUKEPINE SAWMILL LIMITED Te Puke	2MT kilns, 1 HT Kiln.	4.5 kg/hr limit particulate. Flue gas recirc loop sawdust drier. Cyclone control.	6240	4	MW	7438
	w	30057	CARTER HOLT HARVEY Packaging	John Thompson coal fired boiler conver	2 Sibcco R type size 20 multi-cyclone ash, followed by 2 Stairmand type high efficiency cyclones	4,760	16	MW	1,805
									13,802
	W	30057	CHH Packaging	Boiler	(standby unit)	0	0		0
	K	30068	Carter Holt Harvey Tasman	Two power boilers	Electrostatic precipitators	Wood fuel			357,111

Table A-3 Coal Fired Industrial Plant and Other

						2001			2001
District/urban centre	consent #	Site	Process	Description	Hours of operation per year	Rating	units	TJ/yr	Fuel use, t/yr
T	30069	Western Bays Health	Boilers	N/A (back up only used when gas not available)		2 x 5	MW	0	0
WE	61251	Southern Nurseries	Boiler	water tube, over feed stoker, cyclones (470 & 600kW not currently used)	8227	1.5	MW	8.706	435.3
R	61497	McAlpines (Rotorua) L	Boiler	Vekos back up boiler				28	1400
W	30057	CHH Packaging	John Thompson water tube boiler with dumping grates & spreader stoker	2 Sibcco R type size 20 multi-cyclone ash, followed by 2 Stairmand type high efficiency cyclones, bituminous coal from Rotowaro	510	14	MW	14.09	705
			John Thompson water tube boiler with dumping grates & spreader stoker	3 Sibcco R type size 20 multi-cyclone ash, followed by 2 Stairmand type high efficiency cyclones, bituminous coal from Rotowaro	510	14	MW	14.09	705

								2001		2001	
	District/urban centre	consent #	Site	new name	Process	Description	Hours of operation per year	Capacity (heat input) Btu/yr GJ/yr	units	Fuel Use (GJ) or m^3/yr of NG	units
Diesel	T	30069	WESTERN BAY HEALTH		stand by generator	N/A	0	0		0	
combustion	T	60400	Bitumix Ltd	Works Infrastructure	Burner (oil)	diesel operated	4380	300	kW/h	142,540	litres total a
					Boiler	does not produce asphalt	600	200	kW/h	290	litres pw
					afterburner		624	250	kW/h	145	litres pw

Ashpalt		Production tpy
TM	Higgins & Sons	10000
TM	Allied Asphalt	40000
R	Allied Asphalts	12000

Appendix B Pollutant Summaries by Source, District and Urban Area Basis

Table B-1 PM_{10} Winter (Tonnes / Year)

Annual PM_{10} tonnes per year	Transport					Domestic				Industrial	TOTAL PM_{10}
	Aviation	Rail	Motor vehicles	Shipping	Total	Backyard burning	Home heating	Lawnmowing	Total		
District											
Taupo	0	0	8	0	8	0.2	0.4	0.0	1	8	16
WBOP	0	5	74	0	79	34	76	0.4	110	354	543
Tauranga	48	2	74	58	182	85	193	1.1	278	46	506
Rotorua	15	0	75	0	89	52	117	0.7	170	567	826
Whakatane	2	6	53	0	61	28	63	0.4	90	145	297
Kawerau	0	0.1	4.2	0	4	6	13	0.1	18	249	271
Opotiki	0	0	17	0	17	8	18	0.1	25	0	43
Total	64	13	305	58	441	211	480	2.8	693	1369	2503
Urban areas											
Tauranga	48	0.502	60	41	149	81	185	1.1	267	30	446
Rotorua	15	0.003	36	0.0	51	44	101	0.6	146	285	482
Whakatane	0	0	8	0.0	8	18	41	0.2	59	2	68

Table B-2 PM_{10} (Tonnes / Year)

Annual PM_{10} tonnes per year	Transport					Domestic				Industrial	TOTAL PM_{10}
	Aviation	Rail	Motor vehicles	Shipping	Total	Backyard burning	Home heating	Lawnmowing	Total		
District											
Taupo	0	0	8	0	8	0.2	0.4	0.0	1	8	16
WBOP	0	5	74	0	79	34	76	0.4	110	354	543
Tauranga	48	2	74	58	182	85	193	1.1	278	46	506
Rotorua	15	0	75	0	89	52	117	0.7	170	567	826
Whakatane	2	6	53	0	61	28	63	0.4	90	145	297
Kawerau	0	0.1	4.2	0	4	6	13	0.1	18	249	271
Opotiki	0	0	17	0	17	8	18	0.1	25	0	43
Total	64	13	305	58	441	211	480	2.8	693	1369	2503
Urban areas											
Tauranga	48	0.502	60	41	149	81	185	1.1	267	30	446
Rotorua	15	0.003	36	0.0	51	44	101	0.6	146	285	482
Whakatane	0	0	8	0.0	8	18	41	0.2	59	2	68

Table B-3 $PM_{2.5}$ (Tonnes / Year)

$PM_{2.5}$ tonnes per year	Transport					Domestic				Industrial	TOTAL $PM_{2.5}$
	Motor vehicles	Aviation	Rail	Shipping	Total	Backyard burning	Home heating	Lawnmowing	Total		
District											
Taupo	5	0	0	0	5	0.2	0.3	0.002	1	2.3	7
WBOP	44	0	4	0	49	31	71	0.3	103	183	334
Tauranga	44	48	2	54	148	79	179	1	259	32	439
Rotorua	45	15	0.03	0	59	48	109	1	158	456	673
Whakatane	32	2	5.6	0	40	26	58	0.3	84	80	204
Kawerau	3	0	0.1	0	3	5	12	0.1	17	161	181
Opotiki	10	0	0	0	10	7	16	0.1	24	0	34
Total	183	64	12	54	313	197	447	2	646	914	1873
Urban areas											
Tauranga	36	48	0.46	37.53	122	76	172	1	249	29	400
Rotorua	22	15	0.003		36	42	94	0.4	136	239	412
Whakatane	5		0.3		4.9	17	38	0.2	55	2	61

Table B-4 Carbon monoxide (Tonnes / Year)

CO tonnes per year	Transport					Domestic				Industrial	Field burning	TOTAL CO
	Motor vehicles	Aviation	Rail	Shipping	Total	Backyard burning	Home heating	Lawnmowing	Total			
District												
Taupo	249	0	0	0	249	1	3	0	4	0	NA	253
WBOP	2670	0	18	0	2688	113	702	72	888	304	NA	3880
Tauranga	3909	44	9	68	4030	284	1770	182	2237	18	NA	6284
Rotorua	3352	46	0.1	0	3398	174	1080	111	1365	1124	NA	5887
Whakatane	2188	13	24	0	2225	92	576	59	727	154	NA	3106
Kawerau	219	0	0.5	0	219	19	117	12	148	2450	NA	2817
Opotiki	603	0	0	0	603	26	161	17	204	0	NA	807
Total	13190	103	52	68	13412	708	4410	454	5573	4050	395	23430
Urban areas												
Tauranga	3448	44	2	54	3548	273	1700	175	2147	17	NA	5712
Rotorua	2072	46	0.01	0	2118	149	929	96	1174	603	NA	3895
Whakatane	443	0	0	0	443	60	374	39	473	19	NA	935

Table B-5 CO_2 (Tonnes / Year)

CO_2 tonnes per year	Transport					Domestic				Industrial	TOTAL CO_2
	Motor vehicles	Rail	Shipping	Aviation	Total	Backyard burning	Home heating	Lawnmowing	Total		
District											
Taupo	19769	0	0	NA	19769.45	19	74	2	95	0	19865
WBOP	195178	6707	0	NA	201886	3950	15117	377	19444	51462	273675
Tauranga	197052	3251	27925	NA	228227	9953	38096	949	48999	23367	302694
Rotorua	198015	46	0	NA	198060	6073	23246	579	29899	215158	444527
Whakatane	140921	8999	0	NA	149921	3236	12386	309	15931	86931	253703
Kawerau	11220	170	0	NA	11390	657	2515	63	3235	34653	49278
Opotiki	45932	0	0	NA	45932.18	908	3475	87	4469	0	50614
Total	808088	19173	27925	56494	911680	24797	94910	2365	122072	411571	1445323
Urban areas											
Tauranga	160421	737	19489	NA	180647	9555	36572	911	47039	22997	250683
Rotorua	96409	5	0	NA	96414	5223	19992	498	25713	107030	229157
Whakatane	20619	0	0	NA	20619	2103	8051	201	10355	29792	60766

Table B-6 Dioxin (mg I-TEQ / Year)

Dioxin	Transport (excluding aviation and shipping)			Domestic (excluding lawn mowing)			Industrial	
mg I-TEQ per year	Motor vehicles	Rail	Total	Backyard burning	Home heating	Total		TOTAL DIOXIN
District								
Taupo	0.6	0	0.6	4	0	4	0	5
WBOP	5.5	1.1	6.6	806	48	855	27	888
Tauranga	5.6	0.5	6.1	2031	122	2153	0.2	2160
Rotorua	5.6	0.0	5.6	1239	75	1314	97	1417
Whakatane	4.0	1.5	5.4	660	40	700	11	717
Kawerau	0.3	0.0	0.3	134	8	142	241	383
Opotiki	1.3	0.0	1.3	185	11	196	0	198
Total	22.8	3.1	25.9	5061	304	5365	376	5767
Urban areas								
Tauranga	4.5	0.1	4.7	1950	117	2067	0.2	2072
Rotorua	2.7	0.0	2.7	1066	64	1130	52	1185
Whakatane	0.6	0	0.6	429	26	455	0.3	456

Table B-7 NO_x (Tonnes / Year)

NOx tonnes per year	Transport					Domestic				Industrial	Biogenic		TOTAL NOx
	Motor vehicles	Aviation	Rail	Shipping	Total	Backyard burning	Home heating	Lawnmowing	Total		Vegetation	Field burning	
District													
Taupo	119	0	0	0	119	0.04	0.03	0.003	0.07	0	NA	NA	119
WBOP	1175	0	184	0	1360	8	7	1	15	36	NA	NA	1411
Tauranga	1215	258	89	477	2039	20	17	1	38	15	NA	NA	2093
Rotorua	1207	91	1.3	0	1299	12	10	1	23	141	NA	NA	1464
Whakatane	855	15	247	0	1116	7	5	0	13	43	NA	NA	1172
Kawerau	69	0	4.7	0	74	1	1	0	3	308	NA	NA	384
Opotiki	276	0	0	0	276	2	2	0	4	0	NA	NA	280
Total	4916	363	526	477	6282	51	42	4	96	543	1301	21	8243
Urban areas													
Tauranga	995	258	20	302	1575	20	16	1	37	15	NA	NA	1627
Rotorua	598	91	0.14	0	689	11	9	1	20	71	NA	NA	780
Whakatane	128	0	0	0	128	4	4	0	8	11	NA	NA	148

Table B-8 Sulphur dioxide (Tonnes / Year)

SO_2 tonnes per year	Transport					Domestic				Industrial	TOTAL SO_2
	Motor vehicles	Aviation	Shipping	rail	Total	Backyard burning	Home heating	Lawnmowing	Total		
District											
Taupo	12	0	0	0	12	0.0	0	0.0001	0.02	0	12
WBOP	115	0	0	9	124	1	3	0.02	5	35	164
Tauranga	116	0.1	390	4	510	3	8	0.04	11	745	1266
Rotorua	117	0.1	0	0	117	2	5	0.02	7	127	251
Whakatane	83	0.0	0	12	95	1	3	0.01	4	19	117
Kawerau	7	0	0	0	7	0.2	1	0.003	1	6	14
Opotiki	27	0	0	0	27	0.3	1	0.004	1	0	28
Total	477	0.2	390	25	891	8	20	0.1	29	932	1852
Urban areas					0						
Tauranga	95	0.1	257	0.5	352	3	8	0.04	11	745	1107
Rotorua	57	0.1	0	0	57	2	4	0.02	6	66	129
Whakatane	12	0	0	0	12	1	2	0.01	2	0.1	15

Table B-9 Volatile Organic Compounds (Tonnes / Year)

VOC tonnes per year	Transport					Domestic &commercial					Industrial	Biogenic	TOTAL VOC
	Motor vehicles	Rail	Shipping	Aviation	Total	Backyard burning	Home heating	Lawnmowing	NMVOCs	Total			
District													
Taupo	34	0	0	0	34	0	1	0	1.8	3	0	NA	37
WBOP	376	7	0	0	383	12	200	16	372	600	7	NA	990
Tauranga	624	3	23	27	678	29	504	41	885	1459	2	NA	2139
Rotorua	511	0	0	25	536	18	308	25	594	945	26	NA	1507
Whakatane	324	9	0	7	340	9	164	13	319	506	5	NA	851
Kawerau	35	0.2	0	0	35	2	33	3	68	106	55	NA	196
Opotiki	83	0	0	0	83	3	46	4	90	142	0	NA	225
Total	1987	19	23	59	2089	73	1256	103	2329	3761	95	41557	47502
Urban areas													
Tauranga	561	0.7	20	27	609	28	484	40	849	1401	1.8	NA	2012
Rotorua	337	0.0	0	25	362	15	265	22	511	812	13.9	NA	1189
Whakatane	72	0.0	0	0	72	6	107	9	208	329	1.3	NA	402

Table B-10 Acetaldehyde (Tonnes / Year)

Acetaldehyde tonnes per year	Transport					Domestic				Industrial	TOTAL ACETALDEHYDE
	Motor vehicles	Aviation	Rail	Shipping	Total	Backyard burning	Home heating	Lawnmowing	Total		
District											
Taupo	1	0	0	0	1	NA	NA	0.1	0.1	0	1
WBOP	10	0	2	0	12	NA	NA	16	16	0.0001	28
Tauranga	16	1.3	1	0.8	19	NA	NA	41	41	0	60
Rotorua	13	1.2	0.0	0	14	NA	NA	25	25	0.0004	40
Whakatane	8	0	3	0	11	NA	NA	13	13	0.0004	25
Kawerau	1	0	0.0	0	1	NA	NA	3	3	0	4
Opotiki	2	0	0	0	2	NA	NA	4	4	0	6
Total	51	2.7	6	0.8	60	NA	NA	103	103	0.001	163
Urban areas											
Tauranga	14	1.3	0.2	0.65	17	NA	NA	40	40	0	56
Rotorua	9	1.2	0.0	0	9.8	NA	NA	22	22	0	32
Whakatane	2	0	0.0	0	1.9	NA	NA	9	9	0	11

Table B-11 Benzene (Tonnes / Year)

Benzene tonnes per year	Transport					Domestic				Industrial	Waste	TOTAL BENZENE
	Motor vehicles	Aviation	Rail	Shipping	Total	Backyard burning	Home heating	Lawnmowing	Total		Landfills & wastewater	
District												
Taupo	2	0	0	0	2	0.01	0.03	0.40	0.4	0	0	2
WBOP	22	0	0.1	0	22	1.3	6.7	82	90	0.0003	0.01	112
Tauranga	36	0.5	0.1	0.4	37	3.4	16.9	207	227	10.0	0.02	275
Rotorua	30	0.5	0.001	0	30	2.1	10.3	126	139	2.4	0.02	171
Whakatane	19	0.1	0.2	0	19	1.1	5.5	67	74	0	0.01	93
Kawerau	2	0	0.003	0	2	0.2	1.1	14	15	0	0	17
Opotiki	5	0	0	0	5	0.3	1.5	19	21	0	0.002	26
Total	115	1.1	0.3	0.4	117	8.4	42.1	516	567	12.4	0.06	696
Urban areas												0
Tauranga	33	1	0.01	0.4	33	3.3	16.2	199	218	10	0	262
Rotorua	20	0.5	0.00	0	20	1.8	8.9	109	119	2.4	0	142
Whakatane	4	0	0.00	0	4	0.7	3.6	44	48	0	0	52

Table B-12 Formaldehyde (Tonnes / Year)

Formaldehyde	Transport					Domestic				Industrial	TOTAL FORMALDEHYDE
tonnes per year	Motor vehicles	Aviation	Rail	Shipping	Total	Backyard burning	Home heating	Lawnmowing	Total		
District											
Taupo	1	0	0	0	1	NA	NA	0.2	0.2	0	1
WBOP	9	0	1	0	10	NA	NA	33	33	0.002	43
Tauranga	16	4	0	2.3	22	NA	NA	83	83	1.7	107
Rotorua	13	4	0	0	17	NA	NA	51	51	0.02	67
Whakatane	8	1	1	0	10	NA	NA	27	27	0.04	37
Kawerau	1	0	0.0	0	1	NA	NA	5	5	0.4	7
Opotiki	2	0	0	0	2	NA	NA	8	8	0	10
Total	50	9	2	2.3	63	NA	NA	206	206	2.2	271
Urban areas											
Tauranga	14	4	0.2	1.9	20.3	NA	NA	80	80	1.7	102
Rotorua	8	4	0	0	12	NA	NA	43	43	0.01	56
Whakatane	2	0	0.04	0	1.85	NA	NA	18	18	0.02	19

Table B-13 1-3 Butadiene (Tonnes / Year)

1-3 Butadiene	Transport					Domestic				TOTAL 1-3 BUTADIENE
tonnes per year	Motor vehicles	Aviation	Rail	Shipping	Total	Backyard burning	Home heating	Lawnmowing	Total	
District										
Taupo	0.2	0	0.0	0	0.2	NA	NA	0.2	0	0
WBOP	2	0	0.1	0	2	NA	NA	49	49	52
Tauranga	4	0.5	0.1	0.4	4	NA	NA	124	124	129
Rotorua	3	0.5	0.0007	0	3	NA	NA	76	76	79
Whakatane	2	0.1	0.1	0	2	NA	NA	40	40	43
Kawerau	0.2	0	0.0	0	0.2	NA	NA	8	8	8
Opotiki	0.5	0	0.0	0	0.5	NA	NA	11	11	12
Total	11	1	0.3	0.4	13	NA	NA	310	310	323
Urban areas										
Tauranga	3	0.5	0.01	0.31	4.0	NA	NA	119	119	123
Rotorua	2	0.5	0.00	0.00	2.4	NA	NA	65	65	68
Whakatane	0	0	0.00	0.00	0.4	NA	NA	26	26	27