

# Hamilton Emission Inventory Assessment : 1997 and 2001

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# Executive Summary

Air quality monitoring in Hamilton identifies suspended particulate (PM<sub>10</sub>) as the main contaminant of concern. Concentrations of PM<sub>10</sub> in Hamilton are generally low, with up to 3% of the annual concentrations typically within the MfE “alert” category indicating concentrations above 66% of the guideline value. In 2001, two guideline exceedences were recorded giving a 99.7 percentile concentration of 52 µg m<sup>-3</sup>.

Sources of PM<sub>10</sub> and other contaminants in Hamilton were assessed in 1997 using emission inventory methodology. This involves the assessment of contaminant discharge rates from a number of sources and quantifies them for a selected time period and area. The 1997 emission inventory was carried out in two phases: the assessment of emissions from domestic heating and motor vehicles and the assessment of emissions from industry. Results from these phases were not combined to give an overall assessment for Hamilton.

A further domestic heating emission inventory was carried out in 2001. The purpose of this assessment was to monitor changes in emissions since 1997 and to implement a number of methodological improvements. Similarly in 2002, an investigation into vehicle usage on the Hamilton road network was commissioned to provide estimates based on road network use in 2001 and projected use for 2021. The latter study is presented in detail in this report along with the estimated relative contribution of different sources in 1997 and 2001. Industrial emissions estimates for the latter are based on the 1997 study, as no update has occurred.

Collation of the 1997 emission inventory shows that 89% of the PM<sub>10</sub> emissions in Hamilton occur as a result of solid fuel burning for domestic home heating. About 10% come from motor vehicle emissions and around 1% from industry. Domestic heating and motor vehicles were each found to contribute about half of the carbon monoxide, sulphur dioxide and volatile organic compounds and motor vehicles were responsible for the majority of the nitrogen dioxide emissions (95%). The industrial contribution to other contaminants was negligible (less than 1%).

Vehicle registration data for Hamilton in 2001 indicates that around 87% of vehicles registered use petrol, 13% diesel and less than 1% use other fuels such as LPG or CNG. Around 85% of the registered vehicles are passenger cars. In 2001, around 2.5 million vehicle kilometres travelled (VKT) per day were estimated by Gabides Porter for Hamilton. Of these, about 26,000 occurred under the congested conditions that give rise to higher emission rates. Estimates for 2021 indicate an increase in VKT to just over 3 million per day. Despite this, a significant reduction in emissions of PM<sub>10</sub>, CO and VOCs is expected as a result of improved vehicle technology and fuel specifications.

Collation of the 2001 emission inventory data for home heating and motor vehicles indicates that domestic heating produces the majority (90%) of the PM<sub>10</sub> in Hamilton. The remainder is attributed to motor vehicles (9%) and industry (1%).

# 1 Introduction

Air quality monitoring in Hamilton dates back to the early 1980s with a monitoring schedule comprising of total suspended particles and lead. The programme was expanded in the late 1990s to include contaminants such as carbon monoxide, suspended particulate (particles in the air less than 10 microns in diameter) and nitrogen dioxide.

In addition, emission inventory studies were carried out to investigate the sources contributing to concentrations of contaminants. This methodology examines the contaminant discharge rates from a number of sources and quantifies them for a selected time period and area. The first emission inventory for Hamilton was carried out in 1997. This involved the collection of discharge information from domestic heating, motor vehicles and industry. While the amounts of contaminants discharged from each of these processes were assessed, the results were never collated to provide an overall picture of the relative contributions of the different sources to emissions in Hamilton.

Emissions inventories are often repeated every 3-5 years to provide information on trends in emissions sources. In 2001, domestic heating emissions in Hamilton were reassessed (Wilton, 2002) and in 2002 information was obtained on the number of vehicle kilometres travelled for the year 2001. This report presents the methodology and results of the motor vehicle emissions assessment and collates the results of the 1997 and 2001 emission inventories to provide an indication of the relative contributions of different sources to contaminant emissions in Hamilton. It should be noted industrial emissions assessments have not been updated since 1997, and the 2001 inventory relies on that existing data. Data are presented in the context of key air quality issues for Hamilton.

## 2 Air quality in Hamilton

The main air quality issue for Hamilton, based on results of monitoring to date, is concentrations of suspended particulate (PM<sub>10</sub>). Two exceedences of the 24-hour average PM<sub>10</sub> guideline of 50µg m<sup>-3</sup> have been measured in Hamilton since PM<sub>10</sub> monitoring commenced in 1998. These occurred during 2001 and gave a 99.7 percentile PM<sub>10</sub> concentration of 52µg m<sup>-3</sup> (24-hour average)<sup>1</sup>. Typically only a small proportion (up to 3%) of the PM<sub>10</sub> concentrations measured in Hamilton exceed the Ministry for the Environment's (MfE) "alert" indicator category for concentrations in excess of 66% of the guideline value.

Concentrations of carbon monoxide (CO) and nitrogen dioxide (NO<sub>2</sub>) were well within guideline values. Additional monitoring of other potential contaminants such as benzene, ozone and benzo(a)pyrene is scheduled to be carried out within the next five years.

Contaminants included in the Hamilton inventories are PM<sub>10</sub>, CO, NO<sub>2</sub>, sulphur dioxide (SO<sub>2</sub>), volatile organic compounds (VOC) and carbon dioxide (CO<sub>2</sub>). The inventories are well designed to examine PM<sub>10</sub> emissions as they include the main sources of these contaminants in urban areas. Volatile organic compound emissions are included because they include precursors to ozone formation. Carbon dioxide is included for its contribution to greenhouse gas emissions. However, the emission inventory does not provide a comprehensive assessment of all sources

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<sup>1</sup> The Ministry for the Environment's updated air quality guidelines suggest that the guidelines be compared to a 99.7%ile concentration in areas where guideline exceedences are not a common occurrence.



of VOC or greenhouse gas emissions. A detailed assessment of natural emissions in the Waikato (NIWA, 1999) provides further information on these emissions.

### 3 Assessment of emissions – Hamilton 1997

An assessment of emissions from domestic heating, motor vehicles and industry was carried out during 1997. Results are presented in two separate reports “*Hamilton, Te Kuiti and Tokoroa, Home heating and motor vehicle emissions inventory*” Noonan (1997a) and “*Environment Waikato Industrial Emissions Inventory*” Noonan (1997b). The first inventory assessment appears to be designed based on the urban areas of Hamilton and includes the time of day categories 6am-10am, 10am-4pm, 4pm-10pm, and 10pm-6am and wintertime emission rates. The industry data are presented as annual emission rates. Daily emissions have been estimated from these by dividing by 365 days in the year. While this may underestimate the industrial contribution on a given day, Tables 3.1 and 3.2 indicate that this source is a minor contributor to emissions of all contaminants in Hamilton and therefore does not warrant further detailed emissions assessment in this area.

Table 3.1: Total emissions in Hamilton for 1997

	PM <sub>10</sub> kg/day	CO kg/day	NO <sub>x</sub> kg/day	SO <sub>x</sub> kg/day	VOC kg/day	CO <sub>2</sub> kg/day
Domestic home heating	4187	28513	453	514	7131	578134
Motor vehicles	456	30510	9598	394	7952	997856
Industry	39	3	9	2	3	2833
Total	4682	59026	10060	910	15086	1578823

Table 3.2: Relative contribution of sources to emissions in Hamilton for 1997

	PM <sub>10</sub>	CO	NO <sub>x</sub>	SO <sub>x</sub>	VOC	CO <sub>2</sub>
Domestic home heating	89%	48%	5%	56%	47%	37%
Motor vehicles	10%	52%	95%	43%	53%	63%
Industry	1%	0%	0%	0%	0%	0%

The main contributor to PM<sub>10</sub> emissions in Hamilton based on the 1997 emission inventory is domestic solid fuel burning. This source also contributes about half of the CO, SO<sub>x</sub> and VOC emissions. The majority of the NO<sub>2</sub> emissions in Hamilton are from motor vehicles.

## 4 Assessment of emissions – Hamilton 2001

There are a few differences in methodology used between the 1997 and 2001 inventories. The most significant relates to the method used to derive data for the motor vehicle emissions assessment. In the 1997 study, limited information was available regarding traffic speeds and daily variations in vehicle kilometres travelled. These limitations were overcome in the 2001 inventory by use of level of congestion assessments and a time resolved road network model.

The main limitation of the 2001 inventory is the reliance on the 1997 industrial emissions assessment. However, an examination of resource consent applications for discharges to air does not indicate a significant increase in emissions from this source between 1997 and 2001. Also data from 1997 indicates that industrial discharges to air in Hamilton are unlikely to be a significant contributor to ambient air concentrations of contaminants.

### 4.1 Domestic home heating 2001

The 1997 emission inventory indicates that the main source of PM<sub>10</sub> emissions in Hamilton is emissions from domestic home heating. An estimate of emissions from domestic home heating was made during 2001 based on the results of a home heating survey and improved emission factors from this source. This included an estimate of additional contaminants including benzene, benzo(a)pyrene (BaP) and dioxins, although these are approximate only and should be treated with caution. A description of the methodology and detailed results of the survey and emissions assessment are presented in *“Hamilton, Tokoroa and Te Kuiti, Domestic heating emission inventory 2001”* (Wilton, 2002).

The amount of emissions of each contaminant produced by domestic fires on a typical winter's day for Hamilton is shown in Table 4.1. A breakdown by appliance type for Hamilton is shown in Table 4.2. These indicate around 3.6 tonnes of PM<sub>10</sub> are emitted by domestic solid fuel burning, per night across Hamilton, with the majority coming from open fires and older wood burners. Although this is lower than the estimate of just over 4 tonnes made in 1997, the latter study used higher emission factors for domestic heating than are currently considered appropriate for New Zealand.

Table 4.1: Daily domestic heating emissions in Hamilton

	PM <sub>10</sub> kg	CO kg	NO <sub>x</sub> kg	SO <sub>x</sub> kg	VOC kg	CO <sub>2</sub> tonnes	Benzene kg	BaP kg	Dioxin grams
Centre	187	1635	21	11	460	29	14	0.03	0.15
Hamilton East	716	6891	89	32	2007	134	70	0.18	0.63
Hospital	453	4101	47	23	1149	81	40	0.11	0.30
Mid East	627	5716	78	55	1609	121	51	0.13	0.41
Te Rapa	294	2557	25	17	697	52	24	0.07	0.13
Upper East	70	648	11	5	189	13	6	0.01	0.08
Western	693	6334	74	38	1795	128	63	0.17	0.44
Hamilton	3600	32605	397	223	9228	666	316	1	2

Table 4.2: Daily domestic heating emissions in Hamilton by appliance type

	Fuel tonnes	PM <sub>10</sub> kg	CO kg	NO <sub>x</sub> kg	SO <sub>x</sub> kg	VOC kg	CO <sub>2</sub> tonnes
Open fire – wood	114	1143	11430	183	23	3429	183
Open fire – coal	15	320	1218	61	76	228	40
Pre 1991 woodburner	56	726	7260	28	11	2178	89
1991-1996 woodburner	48	337	3368	24	10	1010	87
Post 1997 woodburner	81	484	4843	40	16	1211	145
Multi-fuel burner-wood	27	347	3475	13	5	1042	43
Multi-fuel burner-coal	8	234	1003	10	25	125	22
<b>Total wood</b>	<b>326</b>	<b>3037</b>	<b>30374</b>	<b>289</b>	<b>65</b>	<b>8870</b>	<b>547</b>
<b>Total coal</b>	<b>24</b>	<b>554</b>	<b>2221</b>	<b>71</b>	<b>101</b>	<b>354</b>	<b>61</b>
Gas heater	4	0	1	5	0	1	9
Oil burner	15	9	9	33	57	4	48
<b>Total</b>	<b>368</b>	<b>3600</b>	<b>32605</b>	<b>397</b>	<b>223</b>	<b>9228</b>	<b>666</b>

## 4.1.1 Comparison to 1997

Table 4.3 suggests a decrease in PM<sub>10</sub> emissions from domestic heating since 1997. However, the latter inventory used updated emission factors, based on more recent testing of appliances within New Zealand. A comparison of fuel usage and revised 1997 emission estimates (based on the latter emission factors) shows a slight increase in fuel use and PM<sub>10</sub> emissions for domestic heating in Hamilton since 1997.

Table 4.3: Comparison of 1997 and 2001 daily fuel use and PM<sub>10</sub> emissions for Hamilton

	1997 Fuel Use		1997 PM <sub>10</sub>			2001 Fuel use		2001 PM <sub>10</sub>		
	T day <sup>-1</sup>	%	kg	g ha <sup>-1</sup>	%	T day <sup>-1</sup>	%	kg	g ha <sup>-1</sup>	%
<b>Open fire</b>	120.8	39%	1343	143	39%	129.5	35%	1463	155	41%
<b>Open fire - wood</b>	108.5	35%	1085	115	31%	114.3	31%	1143	121	32%
<b>Open fire - coal</b>	12.3	4%	258	27	7%	15.2	4%	320	34	9%
<b>Total Woodburner</b>	138.7	44%	1514	161	44%	184.7	50%	1547	164	43%
<b>Multifuel burner</b>	30.9	10%	597	63	17%	35.1	10%	582	62	16%
<b>Multifuel burner - wood</b>	17.8	6%	232	25	7%	26.7	7%	347	37	10%
<b>Multifuel burner - coal</b>	13.1	4%	366	39	11%	8.4	2%	234	25	7%
<b>Gas</b>	21.4	7%	0.9	0	0%	3.8	1%	0.2	0	0%
<b>Oil</b>	1.0	0%	0.6	0	0%	15.0	4%	8.8	1	0%
<b>Total Wood</b>	265.0	85%	2830	300	82%	325.7	88%	3037	322	84%
<b>Total Coal</b>	25.4	8%	624	66	18%	23.6	6%	554	59	15%
<b>Total</b>	312.7		3456	367		368.0		3600	382	

## 4.2 Motor vehicles

### 4.2.1 Method for calculating emissions

Assessment of emissions to air from motor vehicles requires an estimate of the amount of vehicle kilometres travelled (VKT) under different levels of congestion, and the application of emission factors to these data. A road transport model for Hamilton operated and maintained by Gabbites Porter was used to estimate VKT for the year 2001 and for the year 2021.

The emission factors used to estimate motor vehicle emissions for PM<sub>10</sub>, CO, NO<sub>x</sub> and VOC were taken from the New Zealand Traffic Emission Rates (NZTER) database<sup>2</sup> based on a vehicle fleet profile derived from motor vehicle registrations for Hamilton (Table 4.4). The percentages of different vehicles are similar to the national vehicle fleet profile for 1998 described in the Ministry of Transport's Vehicle Fleet Emission Control Strategy (Table 4.5). The NZTER database was developed by the Ministry of Transport (MOT) based on measured emissions rates from actual vehicle emissions tests on New Zealand vehicles under various road/traffic conditions. Emission rates for SO<sub>x</sub> and CO<sub>2</sub> are not included in the NZTER

<sup>2</sup> With the exception of CO<sub>2</sub> emission rates which were derived for the Christchurch inventory by the Fuel and Energy Group.

database and were selected based on emission rates derived by the Fuel and Energy Group for the national vehicle fleet profile.

Table 4.4: Vehicle registrations in Hamilton (December, 2001)

	Petrol	Diesel	CNG	LPG	Other	Total
Cars	60,059	3,993	7	16	7	64,082
Light Commercial Vehicles (LCV)	3,350	2,926	1	4	1	6,282
Bus	56	257	23	3		339
Heavy truck	55	2254	<0.1	14	1	2,324
Miscellaneous	98	522	<0.1	<0.1		620
Motorcycle	1,323					1,323
Total	64,941	9,952	31	37	9	74,970
Total percentage	86.6%	13.3%	0.0%	0.0%	0.0%	100%

Table 4.5: New Zealand vehicle fleet profile from MOT (1998)<sup>3</sup>

	Petrol	Diesel	CNG	LPG	Electric	Total
Cars	1798000	103100	280	640		1902020
Light Commercial Vehicles (LCV)	212000	148600	130	230		360960
Bus	600	6600	80	170	1200	8650
Heavy truck	3200	68000	280	330		71810
Miscellaneous	6200	18600	<0.1	<0.1		24800
Motorcycle	79000					79000
Total	2099000	344900	770	1370	1200	2447240
Total percentage	85.8%	14.1%	0.0%	0.1%	0.0%	100.0%

Emission factors were selected based on two driving regimes described as “suburban” and “urban”. The latter regime was used for VKTs within the central business district and the remaining areas assessed using the suburban driving emission factors. Vehicle kilometres travelled were further differentiated into three different driving conditions called Levels Of Service (LOS). The LOS categories are a representation of traffic congestion in a road corridor and include free flow (LOS category A-B), interrupted flow (LOS category C-D) and congested flow (LOS category E-F). Vehicle kilometres travelled in the latter category have the highest emission rates. The emission factors for each contaminant and each LOS category are shown in table 4.6. These are based on 13% of the VKTs occurring under cold start conditions.

<sup>3</sup> Ministry of Transport, 1998, Vehicle fleet emission control strategy – final report. Ministry of Transport.

Table 4.6: Emission factors for urban and suburban driving regimes

LOS	Suburban						Urban					
	CO g/km	CO <sub>2</sub> g/km	VOC g/km	NO <sub>x</sub> g/km	SO <sub>x</sub> g/km	PM <sub>10</sub> g/km	CO g/km	CO <sub>2</sub> g/km	VOC g/km	NO <sub>x</sub> g/km	SO <sub>x</sub> g/km	PM <sub>10</sub> g/km
<b>E-F</b>	21.55	440.88	2.92	2.24	0.22	0.24	32.60	689.45	4.77	2.88	0.28	0.22
<b>C-D</b>	16.53	382.27	2.13	2.12	0.18	0.17	20.90	525.79	2.47	2.43	0.22	0.16
<b>A-B</b>	12.48	342.29	1.95	2.02	0.17	0.15	15.31	377.93	1.98	1.92	0.17	0.12

The daily vehicle kilometres travelled (VKT) in Hamilton were calculated by Gabbites Porter using the TRACKs road network modelling system. In this model, road corridors within the study area are identified by means of a co-ordinate system and referred to as road links. The volume of traffic on the road for each road link for any given hour is represented by one of four one-hour time slots called AM, PM, IP and EV.

The volume of vehicles in each of the road links for each of these time slots, is estimated by the model. These volumes of traffic are then multiplied by the link distance to give the vehicle kilometres (VKT) for each time period. A level of service value (A-B, C-D, E-F) is allocated to each VKT estimate (for each road link and time of day category) based on the ratio of volume of traffic to the capacity of the road link to sustain motor vehicles.

Table 4.7 shows the number of VKT for each of the different time periods, for each of the different levels of congestion. These were calculated by combining the one-hour periods AM, PM, EV and IP as follows:

- 6am-10am: (2xAM +1.25xEV+ IP)
- 10am-4pm: (6 x IP)
- 4pm-10pm: (2xPM+1.25xIP+3xEV)
- 10pm-6am: (4xEV)

Table 4.7: Daily VKT breakdown by time of day and LOS for Hamilton

	Total VKT	Level of Service			Time of day			
		A-B	C-D	E-F	6am-10am	10am-4pm	4pm-10pm	10pm-6am
Hospital	217,150	161125	50087	5938	50948	74052	72483	19666
Te Rapa	563,514	401191	157929	4394	130815	200286	178797	53616
Western	417,397	345658	69724	2016	97784	144957	135777	38878
Centre	388,383	305592	77726	5065	87415	143346	119848	37774
Hamilton East	400,422	340374	51892	8156	94448	138232	131235	36507
Mid East	347,956	301933	45364	660	79833	119705	117144	31274
Upper East	128,322	120439	7882	0	29751	43590	43916	11064
<b>Hamilton</b>	<b>2,463,143</b>	<b>1,976,312</b>	<b>460,603</b>	<b>26,228</b>	<b>570,995</b>	<b>864,169</b>	<b>799,200</b>	<b>228,779</b>

Emissions for each of the time periods AM, PM, EV and IP were calculated by multiplying the VKT for each level of congestion by the appropriate emission factor (see table 4.6) and then revising the time categories to the emission inventory time periods (e.g., 6am-10am, 10am-4pm, 4pm-10pm, 10pm-6am) as described above. Equation 4.1 shows the calculation used to determine the amount of emissions for each time period.

$$\text{Equation 4.1} \quad \text{Emissions(g)} = \text{Emission Factor (g/km)} * \text{VKT (km)}$$

The emissions over a 24-hour period were calculated by totalling the emissions calculated during the four emission inventory time-periods.

## 4.2.2 Motor vehicle emissions in Hamilton

The estimated emissions from motor vehicles in Hamilton by weight (kg & tonnes) are shown in Table 4.8 and by density (g/ha & kg/ha) in Table 4.9. About 370 kilograms of PM<sub>10</sub> are emitted from motor vehicles across the whole of Hamilton equating to around 39 g/ha. The highest PM<sub>10</sub> emissions per area of land occur in the central business district (CBD) with around 81 grams of PM<sub>10</sub> per hectare. Of the seven study areas, Upper East (Flagstaff) and Hospital (Melville) experience the least amount of emissions from motor vehicles.

Table 4.8: Estimated daily motor vehicle emissions (by weight) for Hamilton for 2001

2001	PM <sub>10</sub> (kg)					CO (kg)					NO <sub>x</sub> (kg)				
Area	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total PM <sub>10</sub> (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total NO <sub>x</sub> (kg)
Hospital	8	11	12	3	34	696	1004	1022	246	2967	104	151	149	40	444
Te Rapa	20	31	28	8	88	1803	2725	2516	669	7714	268	410	368	108	1154
Western	15	22	21	6	64	1299	1905	1821	485	5511	199	295	277	78	849
Centre	11	19	16	5	51	1457	2394	2039	578	6468	178	292	248	73	791
Hamilton East	15	21	21	5	62	1250	1786	1791	456	5283	192	280	269	74	814
Mid East	12	18	18	5	53	1045	1515	1583	390	4533	162	242	239	63	706
Upper East	5	7	7	2	19	382	544	569	138	1634	60	88	89	22	259
<b>Total Hamilton</b>	<b>86</b>	<b>129</b>	<b>122</b>	<b>33</b>	<b>371</b>	<b>7,932</b>	<b>11,873</b>	<b>11,342</b>	<b>2,963</b>	<b>34,111</b>	<b>1,165</b>	<b>1,758</b>	<b>1,639</b>	<b>458</b>	<b>5,019</b>
2001	SO <sub>x</sub> (kg)					VOC (kg)					CO <sub>2</sub> (t)				
Area	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total SO <sub>x</sub> (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total VOC (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO <sub>2</sub> (t)
Hospital	9	13	13	3	37	103	148	150	38	439	21	44	30	7	101
Te Rapa	23	34	31	9	97	263	401	364	105	1133	52	105	71	18	247
Western	17	25	23	7	71	194	287	272	76	830	42	94	57	13	206
Centre	16	26	22	6	70	185	305	258	75	823	43	104	60	14	221
Hamilton East	16	23	23	6	68	188	274	265	71	799	41	98	57	12	208
Mid East	14	20	20	5	59	158	235	234	61	688	35	84	50	11	180
Upper East	5	7	7	2	22	59	85	87	22	252	13	34	19	4	70
<b>Total Hamilton</b>	<b>99</b>	<b>149</b>	<b>139</b>	<b>38</b>	<b>425</b>	<b>1,150</b>	<b>1,735</b>	<b>1,630</b>	<b>448</b>	<b>4,963</b>	<b>248</b>	<b>562</b>	<b>344</b>	<b>80</b>	<b>1,233</b>



Table 4.9: Estimated daily motor vehicle emissions (g/ha) for Hamilton for 2001

2001	PM <sub>10</sub> (g/ha)					CO (g/ha)					NO <sub>x</sub> (g/ha)				
Area	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total PM <sub>10</sub> (g/ha)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO (g/ha)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total NO <sub>x</sub> (g/ha)
Hospital	6	8	9	2	25	510	735	749	180	2173	76	111	109	29	325
Te Rapa	9	14	12	4	38	788	1190	1099	292	3369	117	179	161	47	504
Western	11	16	16	4	47	963	1412	1350	360	4085	148	218	205	58	629
Centre	18	30	25	7	81	2319	3810	3244	920	10293	284	465	395	116	1259
Hamilton East	13	19	18	5	55	1110	1587	1591	405	4692	171	249	239	65	723
Mid East	10	15	15	4	43	841	1219	1274	314	3648	131	195	193	51	568
Upper East	3	5	5	1	14	269	383	401	97	1151	42	62	63	16	183
<b>Total Hamilton</b>	<b>9</b>	<b>14</b>	<b>13</b>	<b>4</b>	<b>39</b>	<b>842</b>	<b>1,260</b>	<b>1,204</b>	<b>315</b>	<b>3,621</b>	<b>124</b>	<b>187</b>	<b>174</b>	<b>49</b>	<b>533</b>
2001	SO <sub>x</sub> (g/ha)					VOC (g/ha)					CO <sub>2</sub> (kg/ha)				
Area	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total SO <sub>x</sub> (g/ha)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total VOC (g/ha)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO <sub>2</sub> (kg/ha)
Hospital	6	9	9	2	27	75	108	110	28	321	15	32	22	5	74
Te Rapa	10	15	14	4	42	115	175	159	46	495	23	46	31	8	108
Western	12	18	17	5	53	144	213	201	56	615	31	70	42	10	153
Centre	25	41	35	10	112	295	485	410	119	1309	69	165	95	23	352
Hamilton East	14	21	20	5	61	167	244	236	63	710	37	87	50	11	185
Mid East	11	16	16	4	48	127	189	189	49	554	28	68	40	9	145
Upper East	4	5	5	1	15	41	60	61	15	178	9	24	13	3	49
<b>Total Hamilton</b>	<b>10</b>	<b>16</b>	<b>15</b>	<b>4</b>	<b>45</b>	<b>122</b>	<b>184</b>	<b>173</b>	<b>48</b>	<b>527</b>	<b>26</b>	<b>60</b>	<b>36</b>	<b>8</b>	<b>131</b>

### 4.2.3 Motor vehicle projections to 2021

Projected increases in VKT for the year 2021 were also carried out as part of the assessment. The projections were based on two scenarios; a do nothing different option (Table 4.10) and the implementation of road network improvements (Table 4.11). The estimated emissions for both scenarios are presented in tables 4.13 and 4.14 based on the emission rates from Table 4.12, which are based on the estimated national vehicle fleet profile for 2021.

Emissions estimates for both scenarios indicate significant reductions in emissions of PM<sub>10</sub>, CO and VOCs are expected to occur by 2021. This is a function of the lower emission rates produced by the NZTER model for 2021 and is associated with national improvements in vehicle technology and fuels.

The improved roading scenario is based on the introduction of two major bypasses and associated connections within Hamilton as well as subsequent revisions to some intersections. While these measures will reduce travel time, and hence are viewed as improvements, the impact on total VKTs and contaminant emissions is minimal. In fact, the number of VKTs that occur under the congested conditions increases with the proposed improvements. The overall emissions estimates are similar for both roading scenarios.

Table 4.10: Daily VKT breakdown by time of day and LOS for Hamilton for 2021 (no change in roading)

	Total VKT	Level of Service			Time of day			
		A-B	C-D	E-F	6am-10am	10am-4pm	4pm-10pm	10pm-6am
Hospital	246,174	157830	77159	11184	60580	92358	81028	12209
Te Rapa	862,312	429100	282012	151200	208948	339505	267213	46647
Western	476,080	354888	94047	27145	116705	182793	152041	24541
Centre	404,097	280081	113667	10349	94447	164279	123865	21505
Hamilton East	441,963	327517	100607	13839	110288	165808	142885	22982
Mid East	449,362	300392	131189	17780	110280	168245	148354	22483
Upper East	270,449	208662	51130	10656	65944	100201	91114	13190
<b>Total Hamilton</b>	<b>3,150,436</b>	<b>2,058,470</b>	<b>849,813</b>	<b>242,153</b>	<b>767,191</b>	<b>1,213,189</b>	<b>1,006,500</b>	<b>163,556</b>

Table 4.11: Daily VKT breakdown by time of day and LOS for Hamilton for 2021 (improved roading)

	Total VKT	Level of Service			Time of day			
		A-B	C-D	E-F	6am-10am	10am-4pm	4pm-10pm	10pm-6am
Hospital	230,735	155149	66997	8590	57111	85920	76214	11490
Te Rapa	858,719	543772	169798	145149	204227	341233	268758	44501
Western	520,333	355328	122225	42780	126712	202197	165529	25894
Centre	390,544	275732	106193	8619	91701	158359	119428	21055
Hamilton East	406,853	325549	68378	12926	99863	152580	133735	20675
Mid East	470,598	324407	120044	26147	114874	177531	155394	22800
Upper East	260,692	181830	52491	26370	63806	97862	86184	12839
<b>Total Hamilton</b>	<b>3,138,473</b>	<b>2,161,767</b>	<b>706,125</b>	<b>270,581</b>	<b>758,294</b>	<b>1,215,683</b>	<b>1,005,242</b>	<b>159,254</b>

Table 4.12: Emission factors for urban and suburban driving regimes for 2021

LOS	Suburban						Urban					
	CO g/km	CO <sub>2</sub> g/km	VOC g/km	NO <sub>x</sub> g/km	SO <sub>x</sub> g/km	PM <sub>10</sub> g/km	CO g/km	CO <sub>2</sub> g/km	VOC g/km	NO <sub>x</sub> g/km	SO <sub>x</sub> g/km	PM <sub>10</sub> g/km
<b>E-F</b>	5.75	474.75	1.18	1.41	0.276	0.044	12.88	716.52	2.73	1.86	0.392	0.064
<b>C-D</b>	4.42	402.75	1.00	1.38	0.231	0.033	5.74	550.16	0.89	1.47	0.310	0.043
<b>A-B</b>	4.05	362.57	0.92	1.28	0.211	0.029	4.82	402.75	0.80	1.25	0.250	0.035

Table 4.13: Estimated daily motor vehicle emissions at 2021 assuming no roading measures

2001	PM <sub>10</sub>					CO					NO <sub>x</sub>				
Area	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total PM <sub>10</sub> (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total NO <sub>x</sub> (kg)
Hospital	2	3	3	0	8	260	383	352	49	1044	80	121	108	16	324
Te Rapa	7	11	9	1	28	950	1505	1208	189	3852	281	454	358	60	1152
Western	4	6	5	1	15	495	770	643	99	2008	153	239	200	31	623
Centre	4	6	5	1	15	501	853	678	104	2136	125	216	167	27	536
Hamilton East	3	5	4	1	13	466	683	607	93	1850	145	215	188	29	578
Mid East	3	5	5	1	14	473	693	641	91	1898	146	219	197	29	591
Upper East	2	3	3	0	8	282	411	385	53	1132	86	130	120	17	353
<b>Total Hamilton</b>	<b>25</b>	<b>38</b>	<b>33</b>	<b>5</b>	<b>101</b>	<b>3,426</b>	<b>5,299</b>	<b>4,515</b>	<b>678</b>	<b>13,919</b>	<b>1,017</b>	<b>1,593</b>	<b>1,338</b>	<b>209</b>	<b>4,157</b>
2001	SO <sub>x</sub>					VOC					CO <sub>2</sub>				
Area	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total SO <sub>x</sub> (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total VOC (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO <sub>2</sub> (t)
Hospital	13	20	18	3	54	58	87	79	11	235	26	50	35	4	115
Te Rapa	48	77	62	10	197	210	335	267	43	854	85	143	109	17	354
Western	26	40	33	5	104	111	173	145	23	452	53	119	68	9	249
Centre	26	44	34	5	109	83	140	113	17	353	49	113	66	9	237
Hamilton East	24	36	32	5	96	105	155	137	21	417	49	103	63	8	223
Mid East	24	36	33	5	99	106	157	144	21	428	47	94	64	8	213
Upper East	15	21	20	3	59	63	93	87	12	255	30	67	41	5	142
<b>Total Hamilton</b>	<b>176</b>	<b>275</b>	<b>232</b>	<b>35</b>	<b>719</b>	<b>736</b>	<b>1,139</b>	<b>970</b>	<b>148</b>	<b>2,993</b>	<b>339</b>	<b>688</b>	<b>445</b>	<b>60</b>	<b>1,532</b>

Table 4.14: Estimated daily motor vehicle emissions at 2021 assuming improved roading

2001	PM <sub>10</sub>					CO					NO <sub>x</sub>				
Area	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total PM <sub>10</sub> (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total NO <sub>x</sub> (kg)
Hospital	2	3	2	0	7	242	356	329	46	973	75	112	101	15	303
Te Rapa	7	11	9	1	28	909	1507	1189	180	3785	271	451	357	57	1136
Western	4	6	5	1	16	547	864	709	105	2224	167	265	218	33	684
Centre	3	6	5	1	15	481	819	649	101	2050	122	208	160	26	516
Hamilton East	3	5	4	1	12	419	626	565	84	1694	131	197	176	27	530
Mid East	4	5	5	1	15	490	736	676	92	1994	152	231	206	29	618
Upper East	2	3	3	0	8	277	415	375	52	1119	84	128	114	16	343
<b>Total Hamilton</b>	<b>25</b>	<b>39</b>	<b>33</b>	<b>5</b>	<b>101</b>	<b>3,363</b>	<b>5,323</b>	<b>4,492</b>	<b>661</b>	<b>13,839</b>	<b>1,002</b>	<b>1,593</b>	<b>1,332</b>	<b>204</b>	<b>4,130</b>
2001	SO <sub>x</sub>					VOC					CO <sub>2</sub>				
Area	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total SO <sub>x</sub> (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total VOC (kg)	6am-10am	10am-4pm	4pm-10pm	10pm-6am	Total CO <sub>2</sub> (t)
Hospital	13	19	17	2	51	55	81	74	11	219	24	49	33	4	110
Te Rapa	46	77	61	9	194	201	334	264	41	840	91	200	119	16	427
Western	28	45	37	5	115	122	194	159	24	499	56	121	72	9	259
Centre	25	42	33	5	105	79	134	108	17	338	48	107	63	8	226
Hamilton East	22	33	29	4	88	94	142	127	19	382	46	105	61	7	219
Mid East	25	38	35	5	103	110	166	151	21	448	50	101	68	8	227
Upper East	14	21	19	3	58	62	93	84	12	250	28	59	38	5	130
<b>Total Hamilton</b>	<b>174</b>	<b>275</b>	<b>231</b>	<b>34</b>	<b>714</b>	<b>723</b>	<b>1,144</b>	<b>967</b>	<b>144</b>	<b>2,977</b>	<b>343</b>	<b>741</b>	<b>453</b>	<b>59</b>	<b>1,597</b>

## 4.3 Combined emissions for 2001

The combined emission estimates for domestic heating, motor vehicles and industry in Hamilton in 2001 is shown in Table 4.15. Because no spatial distribution data were available for industry an even spread across each area was assumed. This is unlikely in reality but allows a rough assessment of overall variations in emissions within Hamilton.

Table 4.15: Total daily emissions in Hamilton (2001)

	PM <sub>10</sub>		CO		Nox		SO <sub>x</sub>		VOC		CO <sub>2</sub>	
	kg	%	kg	%	kg	%	Kg	%	kg	%	t	%
<b>Centre (CBD)</b>												
Domestic heating	187	77%	1635	20%	21	3%	11	14%	460	36%	29	12%
Motor vehicles	51	21%	6468	80%	791	97%	70	86%	823	64%	221	88%
Industry	5.6	2%	0.4	0%	1.3	0%	0.3	0%	0.4	0%	0	0%
<b>Hamilton East</b>												
Domestic heating	716	91%	6891	57%	89	10%	32	32%	2007	72%	134	39%
Motor vehicles	62	8%	5283	43%	814	90%	68	68%	799	28%	208	61%
Industry	5.6	1%	0.4	0%	1.3	0%	0.3	0%	0.4	0%	0	0%
<b>Hospital (Melville)</b>												
Domestic heating	453	92%	4101	58%	47	10%	23	38%	1149	72%	81	44%
Motor vehicles	34	7%	2967	42%	444	90%	37	61%	439	28%	101	55%
Industry	5.6	1%	0.4	0%	1.3	0%	0.3	0%	0.4	0%	0	0%
<b>Mid East (Claudlands)</b>												
Domestic heating	627	91%	5716	56%	78	10%	55	48%	1609	70%	121	40%
Motor vehicles	53	8%	4533	44%	706	90%	59	52%	688	30%	180	60%
Industry	5.6	1%	0.4	0%	1.3	0%	0.3	0%	0.4	0%	0	0%
<b>Te Rapa</b>												
Domestic heating	294	76%	2557	25%	25	2%	17	15%	697	38%	52	17%
Motor vehicles	88	23%	7714	75%	1154	98%	97	85%	1133	62%	247	82%
Industry	5.6	1%	0.4	0%	1.3	0%	0.3	0%	0.4	0%	0	0%
<b>Upper East (Flagstaff)</b>												
Domestic heating	70	74%	648	28%	11	4%	5	18%	189	43%	13	16%
Motor vehicles	19	20%	1634	72%	259	95%	22	81%	252	57%	70	84%
Industry	5.6	6%	0.4	0%	1.3	0%	0.3	1%	0.4	0%	0	0%
<b>Western (Frankton)</b>												
Domestic heating	693	91%	6334	53%	74	8%	38	35%	1795	68%	128	38%
Motor vehicles	64	8%	5511	47%	849	92%	71	65%	830	32%	206	62%
Industry	5.6	1%	0.4	0%	1.3	0%	0.3	0%	0.4	0%	0	0%
<b>Hamilton</b>												
Domestic heating	3600	90%	32605	49%	397	7%	223	34%	9228	65%	666	35%
Motor vehicles	371	9%	34111	51%	5019	93%	425	65%	4963	35%	1233	65%
Industry (1997)	39	1%	3	0%	9	0%	2	0%	3	0%	3	0%
<b>Total</b>	<b>4010</b>		<b>66719</b>		<b>5425</b>		<b>650</b>		<b>14194</b>		<b>1902</b>	

Across the whole of Hamilton, the main source of PM<sub>10</sub> emissions is domestic heating contributing around 90%. Motor vehicles contribute 9% across the whole of Hamilton with

industry making up the remainder. In the areas of the CBD, Upper East, and Te Rapa, motor vehicles contribute around 20% of the PM<sub>10</sub>. Figure 4.1 illustrates the relative contribution of each source to contaminant emissions for 2001.

Motor vehicles contribute the majority of the NO<sub>x</sub> and SO<sub>x</sub>, about half of the CO and 39% of the VOCs. Domestic heating is the main source of PM<sub>10</sub> and VOCs and contributes about half of the CO and a third of the SO<sub>x</sub>. Domestic heating contributes about one-third and motor vehicles two thirds of the CO<sub>2</sub> emissions.

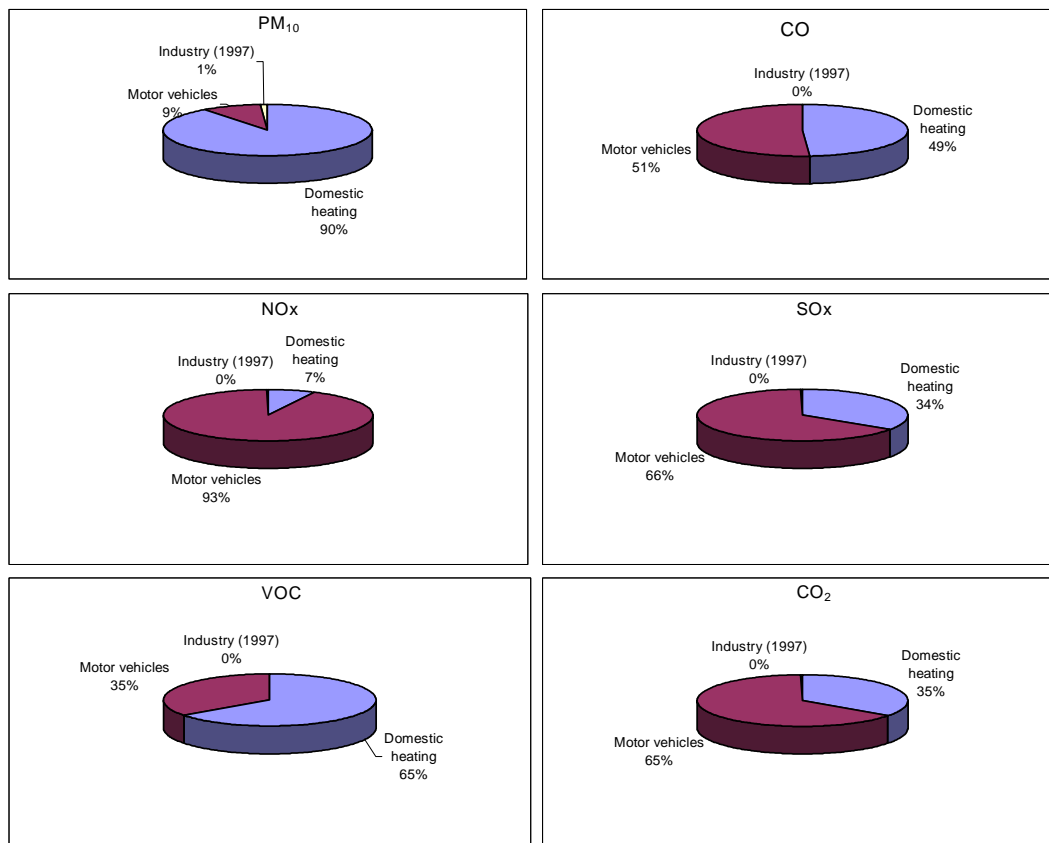


Figure 4.1: Source contributions to contaminant emissions in Hamilton

## 5 Conclusions

Air quality monitoring in Hamilton indicates that for most of the time the air is very clean. However, at times during the winter months the air does become degraded. The main contaminant of concern is PM<sub>10</sub>. Concentrations of PM<sub>10</sub> have exceeded the ambient air quality guideline twice since 1998 and have breached the “alert” category (greater than 66% of the guideline) on up to 3% of the days monitored each year. Concentrations of other contaminants measured (NO<sub>2</sub> and CO) are well within guideline values.

Sources of PM<sub>10</sub> in Hamilton have been examined in 1997 and 2001 using an emission inventory. This included an assessment of emissions from domestic heating, motor vehicles and industry. The 2001 study indicates that domestic heating is the main source of PM<sub>10</sub> contributing 90% of the daily PM<sub>10</sub> emissions during the winter months. Motor vehicles contribute about 9% of the PM<sub>10</sub> emissions and industrial processes produce the remainder.

A comparison of the two inventories indicates no significant changes in emissions from domestic fires or motor vehicles since 1997.

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