Technical Report 13

Assessment of Operational Air Quality Effects

NZ TRANSPORT AGENCY
WAKA KOTAHI

MacKays to Peka Peka Expressway

Revision History

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Document Acceptance

Action	Name	Signed	Date
Prepared by	Charles Kirkby		15 February 2012
Reviewed by	Camilla Borger		15 February 2012
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on behalf of	Beca Infrastructure Ltd		

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Appendices

1. Executive summary

The NZ Transport Agency ('the NZTA') is lodging a Notice of Requirement (NOR) and resource consent applications (RCA's) to construct, operate and maintain an Expressway between MacKays Crossing and Peka Peka ('the Project') on the Kāpiti Coast.

This report, prepared by Beca Infrastructure Limited, considers the effects of discharges to air associated with the operation of the Project. A separate report (Technical Report 14, Volume 3 of the AEE) considers the effects of the construction of the proposed Expressway on air quality.

The scope and purpose of this report is to provide:

- an overview of the Project itself and of the receiving environment
- a description of the types and sources of discharges to air from motor vehicles
- an assessment of the effects of discharges to air from motor vehicles
- to discuss the requirement for ongoing monitoring and mitigation of effects.

In undertaking this assessment, Beca has followed the procedures outlined in the Ministry for the Environment's Good Practice Guide for Assessing Discharges to Air from Land Transport (MfE, 2008) (MfE Transport GPG) and the draft NZTA Standard for Producing Air Quality Assessments for State Highway Projects (NZTA, 2010).

Dispersion modelling has been used as the primary tool to quantitatively assess pollutant concentrations associated with the Project and changes in the existing roading network as a result of the Project. The dispersion model inputs of vehicle emission rates and traffic volumes have been derived using traffic modelling and emission factors from the Vehicle Emissions Prediction Model v3 (VEPM). Potential effects have been assessed by comparing predictions against relevant health-based National Environmental Standards for Air Quality (AQNES) and New Zealand Ambient Air Quality Guidelines (NZAAQG). These air quality criteria are designed to protect the health of the most vulnerable individuals in the community.

The potential air quality impacts due to operation of the proposed Expressway have been predicted for two future years – 2016 and 2026. For each of these years, the emission scenarios that have been considered are "Do Minimum" (i.e. the Project not being undertaken) and "With Project". The assessment has focused on the relative impacts that the operation of the proposed Expressway will have on air quality (i.e. "With Project" emission scenarios), when compared to the future air quality without the proposed Expressway (i.e. "Do Minimum" emission scenarios) for the same year. This represents a highly conservative, worst-case, assessment - the cumulative concentrations presented in this report assume that the contribution from roads in both 'do minimum' and 'with Project' scenarios occurs simultaneously with and is in addition to the highest measured background.

The potential effects of carbon monoxide (CO), fine particles (PM_{10} and $PM_{2.5}$), nitrogen dioxide (NO_2) and benzene have been assessed. Conservative existing (background) levels of CO, PM_{10} and NO_2 have been derived using ambient air quality data collected at a project specific monitoring location on Raumati Road, adjacent to the Project area.

The key conclusions of this air quality assessment are as follows:

- The existing ambient air quality close to the route of the proposed Expressway is typical of a mixture of rural and urban receiving environments. The rural areas are expected to have very low existing levels of air quality pollutant, while the urban areas are potentially impacted by PM_{10} emissions from home heating during winter time.
- Sensitive receptors within 200m of the Alignment of the proposed Expressway comprise residential housing and a retirement village (there are no schools, preschools or residential healthcare facilities within 200m of the proposed Alignment).
- The maximum predicted cumulative PM_{10} concentration at any receptor located more than 25m from the centreline of any section of the proposed Expressway is 36.3 $\mu g/m^3$ including background, while the maximum contribution from vehicles travelling on the proposed Expressway to cumulative PM_{10} concentrations is 2.1 µg/m3.
- Maximum ground level concentrations of all vehicle related pollutants are predicted to decrease between 2016 and 2026, largely as a consequence of predicted improvements in the vehicle fleet.
- People living within 200 metres of the proposed Expressway will have a slightly increased exposure to vehicle related contaminants as a result of the Project, compared to exposure occurring without the Project.
- Concentrations of CO, PM_{10}, $PM_{2.5}$, NO_2 and benzene, due to discharges to air associated with vehicles using the proposed Expressway, are predicted to be within the relevant health-based assessment criteria (AQNES[1] and NZAAQG[2]).
- Given the low level of effects, neither mitigation nor monitoring of operational air quality effects is required.
- The reduced level of traffic on the existing SH1, and the consequent reduction in congestion, will result in improvements in air quality in the vicinity of this road.

2. Introduction

2.1. Project background

The NZ Transport Agency ('the NZTA') is lodging a Notice of Requirement (NOR) and resource consent applications (RCA's) to construct, operate and maintain an Expressway between MacKays Crossing and Peka Peka ('the Project') on the Kāpiti Coast.

The MacKays to Peka Peka Expressway route has been identified as one of eight sections within the Wellington Northern Corridor (SH1 from Levin to the Wellington Airport) which is an identified "Road of National Significance" (RoNS) in terms of the 2009 Government Policy Statement. The overall Project location is shown in Figure 13.1 below.

[1] Resource Management (National Environmental Standards Relating to Certain Air Pollutants, Dioxins and Other Toxics) Regulations 2004 (as amended) (AQNES).

[2] New Zealand Ambient Air Quality Guidelines 2002 (NZAAQG)

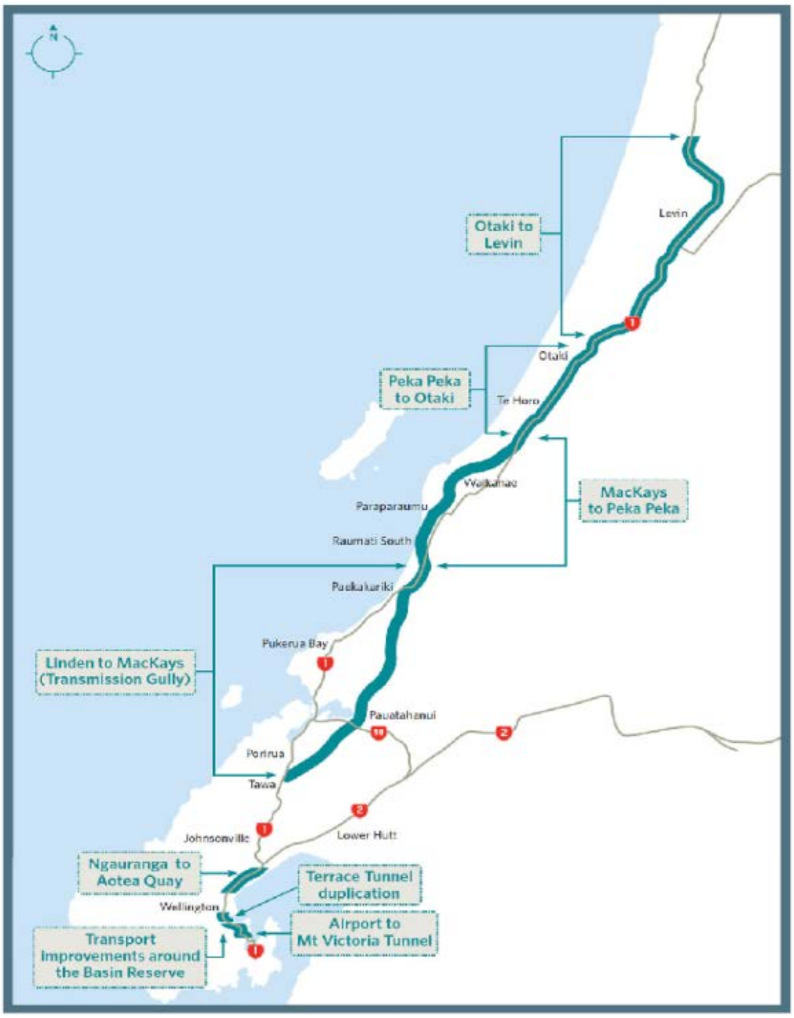

Figure 13.1: Wellington Northern Corridor

2.2. Report structure

This report details the assessment of operational air quality effects for the proposed MacKays to Peka Peka Expressway Project. The assessment of air quality effects for the Project is based on a Tier 3 assessment in the draft NZ Transport Agency (NZTA) Standard for Producing Air Quality Assessments for State Highway Project (NZTA, 2010) and the MfE Transport GPG. The purpose of a Tier 3 assessment is to determine whether a proposal is likely to result in exceedances of ambient air quality criteria, in particular the national ambient air quality standards.

This assessment report is structured as follows:

- Section 3 reviews existing land use, meteorological conditions and existing air quality in the area;
- Section 4 provides a description of the Project;
- Section 5 outlines the assessment methodology, air quality standards, guidelines and statutory matters for consideration relevant to this Project;
- Sections 6 and 7 describe the vehicle emissions modelling and dispersion modelling to predict future vehicle related emissions and to predict exposure levels to vehicle related contaminants;

- Section 8 details the interpretation and analysis of predicted air quality effects from vehicles;
- Section 9 discusses the need for post- Project monitoring and mitigation measures.

3. Existing environment

3.1. Project location and land use zoning

The entire Project area is located on the Kāpiti Coast, 40km northeast of Wellington, and will run through parts of Raumati, Paraparaumu and Waikanae. The proposed Expressway will replace the existing State Highway 1 (SH1) route between MacKays Crossing (Raumati South) and Peka Peka Road (north of Waikanae) and become part of SH1. The existing section of SH1 is likely to become a local arterial road.

The Project is broken down into the following four sectors from South to North (refer Figure 13.5 Section 4.2):

Sector 1

All land within 200m of both SH1 and the proposed Expressway in Sector 1 south of Poplar Avenue is either zoned Rural or Open Space under the Operative Kāpiti Coast District Plan (KCDP). There are no residential properties or other sensitive receptors within 200m of the proposed Expressway south of Poplar Avenue, although parts of the titles of 10 and 14 Leinster Avenue are just within this distance. The Livingstone Gardens plant nursery is within the proposed Designation.

Land in the vicinity of the proposed Expressway in Sector 1 between Poplar Avenue and Raumati Road is largely zoned either Rural or Residential under the KCDP, with the exception of land to the east of SH1, which is zoned Open Space.

There are a small number of residential properties within 200m of the proposed Alignment in Sector 1, both where the proposed Expressway crosses the end of Leinster Avenue and to the west of Raumati Road.

Sector 2

Land in the vicinity of the proposed Expressway in Sector 2 between Raumati Road and Ihakara Street is largely zoned either Rural or Residential under the KCDP. Between Ihakara Street and Kāpiti Road, land to the east of the proposed Alignment is zoned Town Centre (i.e. for the future expansion of Paraparaumu town centre), while land immediately to the west is zoned either Residential or Rural, with Airport zoning beyond that (over 200m from the proposed Alignment).

In the immediate vicinity of the Kāpiti Road intersection, land to the east of the proposed Alignment is zoned Residential, while land to the west is zoned Industrial.

Between Kāpiti Road and Mazengarb Road, land to the east of the proposed Alignment is zoned Residential. To the west of the proposed Alignment, land is zoned industrial between Kāpiti Road and the end of Te Roto Drive, while most of the remaining land between there and Mazengarb Road is zoned Residential. Parts of the Metlifecare Kāpiti Retirement Village lie within 200m of the proposed Alignment, including dwellings on Cheltenham Drive, Malvern Way, Arundel Avenue and Oxford Court.

There are a significant number of residential properties within 200m of the proposed Alignment between Raumati Road and Mazengarb Road. A number of these are within 50m of the proposed Alignment.

Makarini Street has a small neighbourhood park located between houses which will back onto the proposed Expressway in the future. Linwood Drive recreational reserve is also located within 200m, and has a children's playground adjacent to Makarini St which will be approximately 100 metres from the proposed Alignment.

The proposed Expressway will cross the Wharemauku Stream in Sector 2 and a walkway adjacent to the stream is used for recreational walking and cycling.

Sector 3

North of Mazengarb Road to the Waikanae River, almost all the land within 200m of the proposed Alignment is zoned Rural, as is land to the east of the proposed Alignment from the Waikanae River to beyond Te Moana Road, with isolated houses within 200m of the proposed Alignment. Land to the west of the proposed Alignment from the Waikanae River to beyond Te Moana Road is zoned either Rural or Residential, with a significant number of residential dwellings within 200m of the proposed Alignment.

The proposed Expressway will cross the Waikanae River in Sector 3. The river corridor is an important recreational area with walkways used for recreational walking, jogging and cycling.

Sector 4

Land within Sector 4 is almost all zoned either Rural, Open Space or Ngarara[3], with the exception of the relatively new subdivision on Ferndale Road, which is zoned Residential. The closest parts of this subdivision are approximately 100m to the east of the proposed Expressway, while there are a small number of individual houses within 200m of the proposed Alignment, particularly on Peka Peka Road.

3.2. Topography

Overview

The Project is located in a coastal plain, 1.6km wide at the southern end of the Project area, widening to about 3-4 km wide for the majority of its length. To the west and northwest is the Tasman Sea, while the land rises steeply to a height of over 400m in Tararua Ranges to the east.

Much of the coastal plain itself comprises a series of heavily vegetated sand dunes, rising in places (particularly along near the proposed Alignment itself) to about 15-18m high, while the surrounding land is typically about 4-8m above sea level. Given the undulating nature of the terrain, the proposed Expressway will in various places be elevated, at grade or slightly below grade.

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[3] The KCDP states: "*Ngarara is a special part of the Kāpiti Coast providing for a variety of residential development clusters, integrated into its rural, coastal, conservation and forest setting. The fundamental design approach underpinning Ngarara has been driven by the objective of retaining the distinctive character of the site by the careful integration of built form with its rural coastal setting.*"

The following paragraphs provide a more detailed discussion of the topography in each sector, focussing on the relationship between the proposed Expressway and residential housing. To assist with the description, screen shots from the 3D flythrough have been included to provide indicative terrain elevations.

Sector 1

The proposed Expressway is elevated as it goes over Poplar Avenue. Some residential properties within 200m of the proposed Alignment in Sector 1 located to the west of the proposed Alignment (Leinster Avenue) are elevated with respect to the proposed Expressway (refer Figure 13.2).

Figure 13.2: Screen shot of 3D flythrough, showing indicative terrain elevations north of Leinster Avenue

Sector 2

Residential receptors to the west of the proposed Alignment in Sector 2 (i.e. Quadrant Heights), immediately to the north of Raumati Road, are slightly elevated with respect to the proposed Expressway, Otherwise, the proposed Expressway is either on the same level as or slightly elevated above almost all receptors within 200m of the proposed Alignment in this Sector.

Figure 13.3: Screen shot of 3D flythrough, showing indicative terrain elevations north of Wharemauku Stream

North of the Wharemauku Stream (Figure 13.3), the proposed Alignment runs along the top of a sand dune, while the immediately surrounding land is essentially flat (i.e. heights varying by not more than 2-3 metres).

Figure 13.4: Screen shot of 3D flythrough, showing indicative terrain elevations north of Kāpiti Rd Interchange

North of Kāpiti Road, the residential streets adjacent to the proposed Expressway, (Makarini St, Greenwood Place etc) are shielded from the proposed Expressway by part of the dune system (Figure 13.4).

Sector 3

Immediately north of Mazengarb Road in Sector 3, the terrain is very similar to that between the Wharemauku Stream and Mazengarb Road in Sector 2 – essentially flat, with the proposed Expressway following the line the top of a sand dune. As noted above, there are almost no sensitive receptors in Sector 3 between Mazengarb Road and the Waikanae River.

North of the Waikanae River, the terrain becomes somewhat more complex. However, most residential development within 200m of the proposed Alignment is on essentially flat terrain.

Sector 4

As previously noted, there are very few sensitive receptors within 200m of the proposed Expressway in Sector 4. In general, most houses in this area are elevated with respect to the surrounding terrain.

3.3. Meteorology

Wind directions in the Project area are predominately northerly to northeasterly and southerly, but show a strong seasonal variation. Figure 13.5 shows a summary of wind speed and direction recorded at Paraparaumu Airport in 2008-2010, while Figure A1 shows seasonal wind roses for the same period. Paraparaumu Airport is located within one kilometre of the proposed Expressway Alignment.

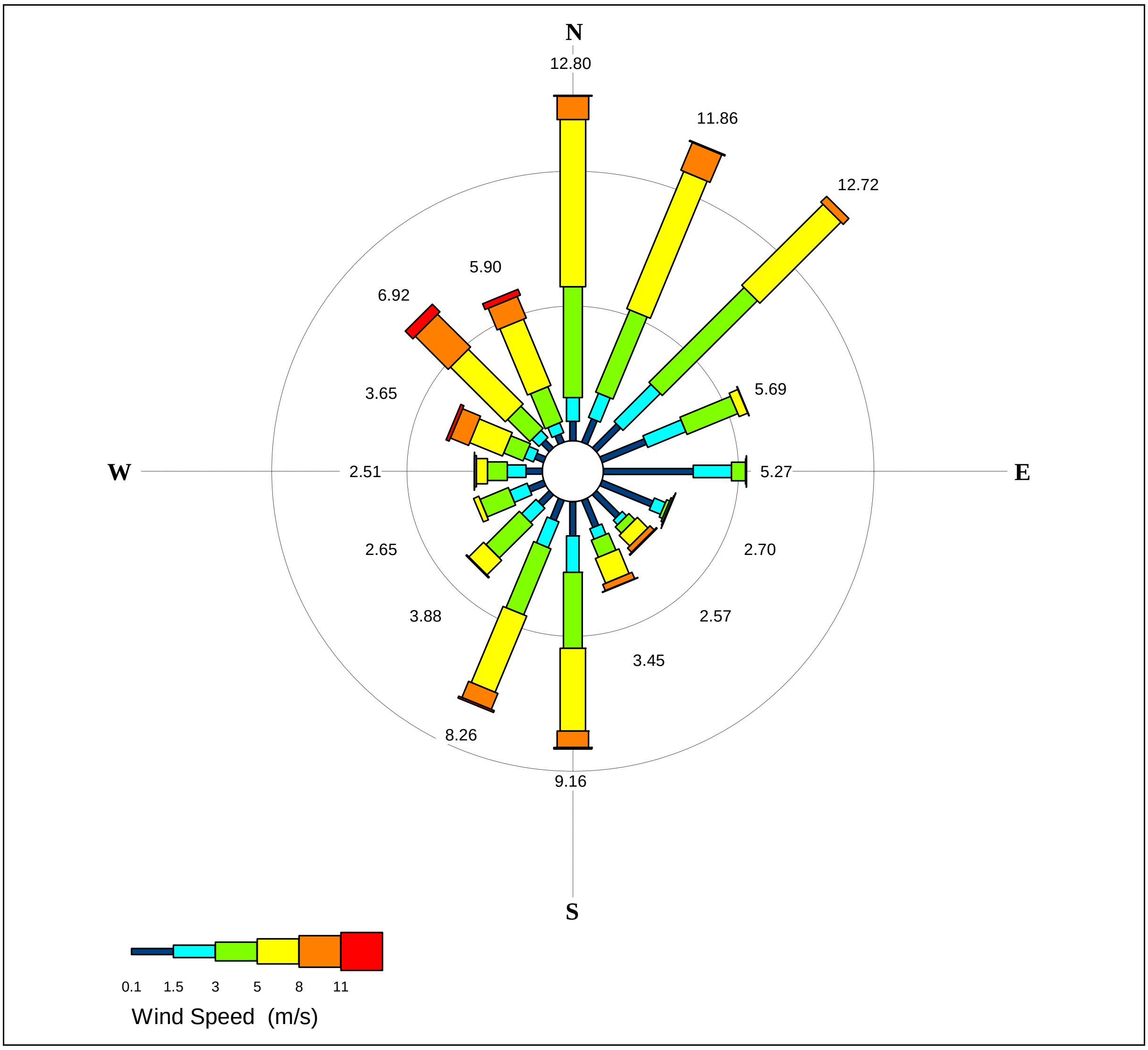

Figure 13.5: Wind speed and wind direction distribution at Paraparaumu Airport, 2008-2010

The wind speed and direction sensors at the Paraparaumu Airport meteorological monitoring site are located on relatively high ground, on a 10m high mast. Closer to ground level, wind speeds tend to be lower, although a similar pattern of wind directions is retained. Figure 13.6 compares wind roses for the Raumati Road monitoring site (refer section 3.5 of this report) and the Paraparaumu Airport meteorological monitoring site for the same period. This shows the frequency of low and moderate wind speeds (i.e. < 3m/s) recorded at Raumati Rd is much greater than the airport. The wind speed and direction sensor at the Raumati Road monitoring site is located approximately 6m above ground level.

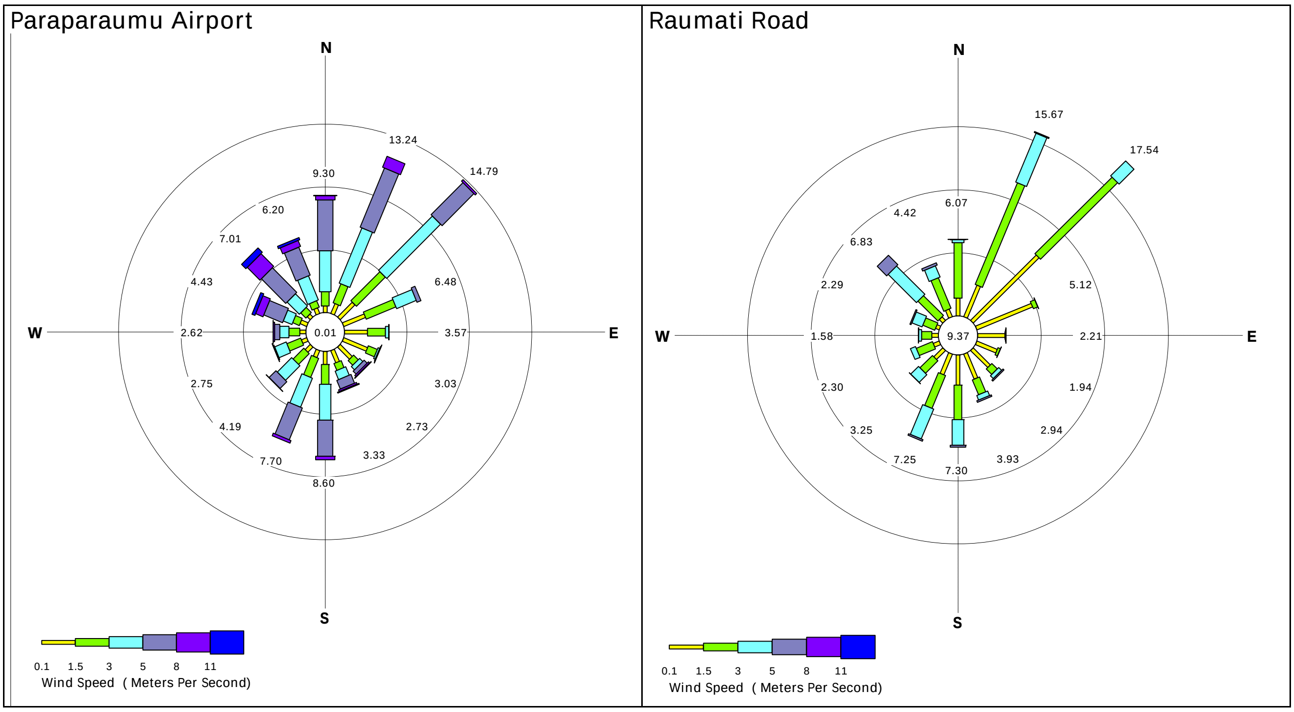

Figure 13.6: Wind speed and wind direction distribution at Paraparaumu Airport and Raumati Road monitoring sites, February-December 2011

3.4. Receptors

What is a sensitive receptor?

The MfE Transport GPG recommends assessing the air quality effects of a proposed road on identified sensitive receptors. In this context, sensitive individuals include children and those whose health is already compromised, such as elderly persons.

Sensitive receptors, therefore, in addition to residential areas, include childcare and early learning facilities, schools, hospitals and residential care homes.

These people are generally regarded as likely to be more sensitive than the general population to the effects of vehicle exhaust emissions. The identification of specific sensitive receptors is based on both the presence of vulnerable individuals and their exposure time (the period when people might reasonably be expected to be exposed to pollutants at a specific site). The frequency and duration of exposure is related to the averaging periods used for the various assessment standards and guidelines (see Table 13.12).

In addition, areas of open space or parks used for recreational activities are classified in the MfE Transport GPG as being receiving environments of high sensitivity, although the main reason given is that, in these areas, people tend to be more aware of the air quality (i.e. are more aware of the amenity effects of air discharges such as dust and odour). However, where people, particularly children, are engaged in active recreational activities (e.g. soccer), they are likely to experience greater exposure to air pollutants. Sports fields can therefore also be identified as sensitive receptors. The duration of exposure of people in parks and recreational areas tends to be relatively short, i.e. less than an hour and certainly less than 8 hours or 24 hours, which are the relevant durations for assessing more chronic health impacts from vehicle related air quality contaminants (CO and PM_{10}).

This assessment does not include any possible effects of vehicle exhaust emissions on vehicle occupants (which are excluded from consideration under the AQNES).

Selection of receptors

Concentrations of air pollutants from vehicles on surface roads tend to decrease fairly rapidly with increasing distance from the road. For example, in 2006 the Auckland Regional Council undertook passive monitoring of NO_2 at a number of sites at varying distances from SH20 in Mangere and SH1 in Penrose, Auckland (ARC, 2008). The results of this monitoring indicated that elevated concentrations of NO2 arising from motor vehicle emissions could be detected only up to 300m from the motorway. Both of these roads have much higher traffic volumes than have been recorded for the existing SH1 in the Kāpiti Coast or are predicted for the proposed Expressway. Similarly, atmospheric dispersion models used for road sources only predict ground level concentrations out to a distance of 200m from the carriageways.

For the purposes of this assessment, residential and other sensitive receptors have only been identified if they are located within 200m of the proposed Expressway.

There are no schools, preschools or healthcare facilities within 200m of any part of the proposed Alignment of the proposed Expressway. El Rancho (an educational camp) and much of the Metlifecare Kāpiti Retirement Village, which can be regarded as a specific sensitive receptor, lie within 200m of the proposed Alignment. Several recreational reserves and parks are also within 200m, including Makarini St Reserve, Linwood Drive recreational reserve, and the corridors of both Waikanae River and Wharemauku Stream. Parks and reserves are considered to be sensitive, although less sensitive than schools or houses due to people usually only being present in reserves for short periods of time.

3.5. Existing ambient air quality

Introduction

In order to assess the impacts of the Project on future air quality, an estimate needs to be made of the state of current air quality in the Project area. This section provides a review of air quality monitoring data that can be used to estimate background pollution levels. This is based on air quality data reported by the GWRC as well as the results of monitoring undertaken specifically in support of the Project.

The entire Project area lies within the Kāpiti Coast airshed, which has been gazetted under the AQNES, because ambient concentrations of PM_{10} may exceed the AQNES threshold concentration of 50 $\mu g/m^3$ within this area. Prior to 2010, no ambient monitoring of PM_{10} had been undertaken in the airshed.

Details of ambient air quality monitoring that has been carried out within the Kāpiti Coast airshed (both by the GRWR and the NZTA), along with relevant details for monitoring undertaken elsewhere in the Wellington region that have been considered in the development of the current ambient air quality, are presented in Appendix 13.B.

Air quality monitoring

Both the GWRC and the Project team[4] have undertaken ambient air quality monitoring at sites in the Kāpiti Coast. The GWRC undertook monitoring of PM_{10} and $PM_{2.5}$ particulates at a site on Glen Road, Raumati South, approximately 1.3km west of SH1 (GWRC Raumati South site) during June and July 2010 (refer Figure 13.7), while the Project team commenced continuous pre- Project monitoring of PM_{10}, NO_x and CO at a site on Raumati Road, approximately 1km west of SH1 (Raumati Road site), within 200m of the proposed Expressway, in January 2011 (refer Figure 13.8). The two monitoring locations are predominantly urban, and not likely to be significantly impacted by existing roads. Annual average daily traffic volumes (AADT) on local roads in the vicinity of the two sites are relatively low - about 6,600 vehicles per day on Raumati Road and under 1,000 vehicles per day on Glen Road and nearby residential streets.

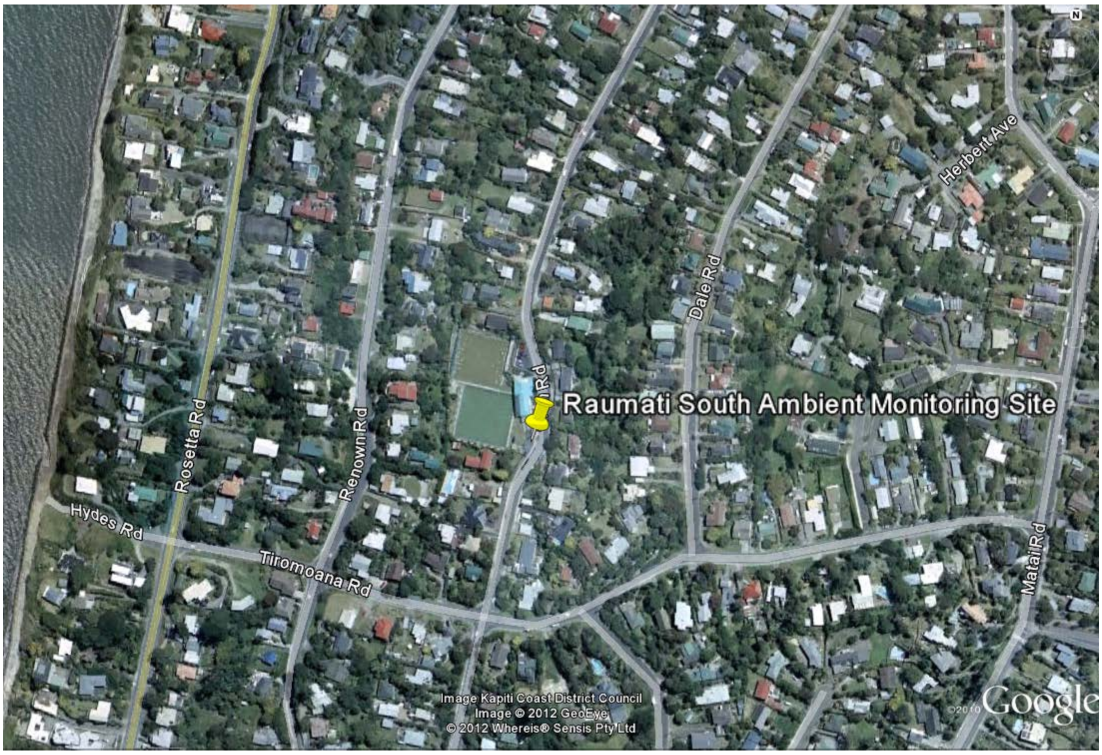

Figure 13.7: GWRC Raumati South Monitoring Site, Glen Road

[4] This Technical Report refers to the Project team as carrying out works on behalf of and as contracted by the NZTA. The NZTA is the requiring authority and the consent holder.

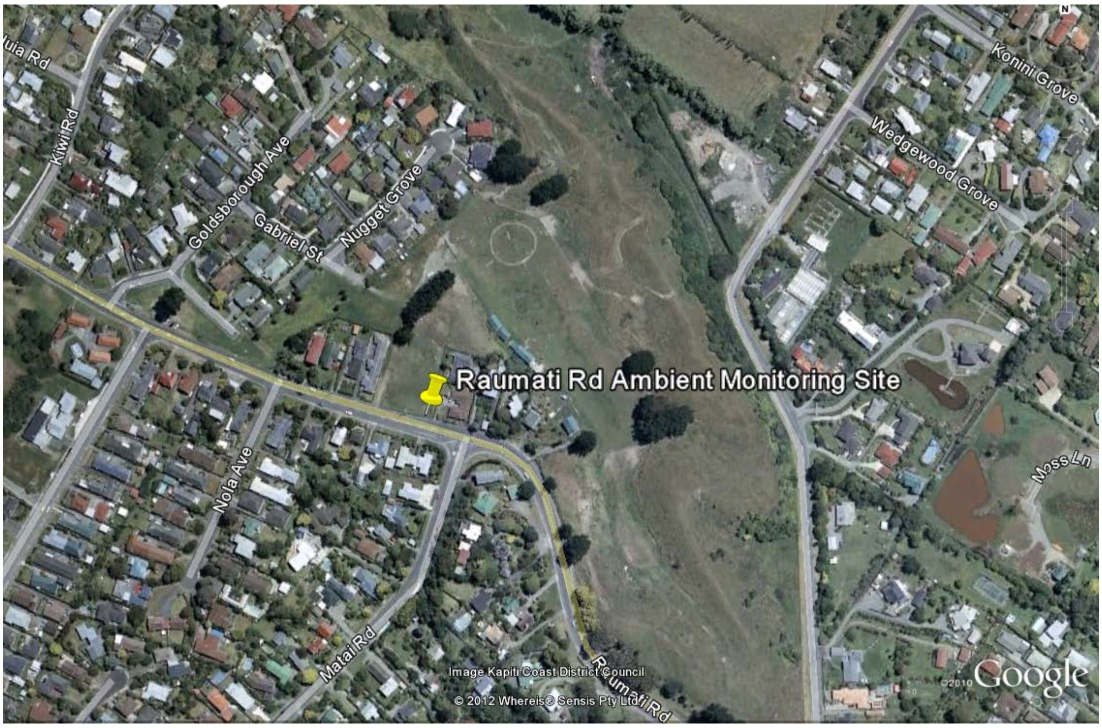

Figure 13.8: Pre- Project Monitoring Site, Raumati Rd

The NZTA also operates a national network of passive diffusion tube NO_2 monitors; one of these is located on SH1 in Paraparaumu, while several others are located on SH1 elsewhere on the Kāpiti Coast.

Air quality is continuously monitored at various sites across the Wellington region by the GWRC. Data from two of these sites (Tawa and Masterton) has been used for comparison with the (limited) results of monitoring undertaken in the Project area. The Tawa site was selected for this purpose as the only long-term continuous monitoring site on the western side of the Rimutaka Hills, while the GWRC have made a comparison between the results of PM_{10} monitoring undertaken at the GWRC Raumati South site with results from the long term site at Masterton ((GWRC, 2011).

Table 13.1 presents a summary of metadata for the various ambient air quality monitoring sites used to determine the baseline for this assessment.

Table 13.1: Relevant Datasets used for Determining Baseline and Trends in Air Quality for the Project

Site name	Location	Pollutants Monitored	Dates	Data Source
Masterton	Wairarapa College 1822753 E 5463153 N	PM_{10}, CO, NO_x [a]	2008-2011	GWRC
Tawa	Linden St 1753580 E 5442134 N	PM_{10}, CO, NO_x	2008-2011	GWRC
Raumati South [b]	Glen Road 1766688 E 5466885 N	PM_{10}, $PM_{2.5}$	2010	GWRC
Raumati Road [c]	Raumati Road 1767548 E 5468090 N	PM_{10}, CO, NO_x	2011	NZTA

Notes:

a Although CO and NO_x are monitored at the Masterton site, this data has not been used in this assessment

b The Raumati South site operated from 25 May to 2 August 2010

c The Raumati Road site commenced operating on 25 January 2011 and is due to cease operating on 31 January 2012.

Particulate matter (PM_{10})

Table 13.2 summarises the results of ambient monitoring of PM_{10} undertaken by the GWRC in Masterton, Tawa and Raumati South and by the NZTA on Raumati Road, showing the maximum 24-hour average, annual average and number of exceedances of the AQNES threshold concentration (50 µg/m^3) in each monitoring year.

A detailed comparison of PM_{10} concentrations recorded at these sites is presented in Appendix 13.B. Ambient concentrations of PM_{10} recorded at the Raumati Road monitoring site are considered to be representative of ambient air quality in the vicinity of the Project.

Table 13.2: 24- Hour and Annual Average PM_{10} Concentrations

Site name Year	Maximum 24- hour Average Concentration (µg/m^3)	Highest Annual Average Concentration (µg/m^3)	Highest Annual Number of Exceedances of AQNES (50 µg/m^3)
Masterton (2008-2011) #	66.7	14.2	5
Tawa (2008-2011) #	32.1	12.9	0
Raumati South (2010) *	61.7	-	3
Raumati Road (2011)	35.8	12.1	0

Notes:

* The Raumati South site was only operated for nine weeks during 2010, so no annual average concentration has been calculated.

Annual average concentrations for Masterton and Tawa in 2011 were calculated from data recorded to the end of July

Nitrogen dioxide

Continuous Monitoring

Table 13.3 summarises the results of ambient monitoring of NO_x undertaken by the GWRC at Tawa between 2008 and 2010 and by the NZTA in Raumati during 2011 (eleven months), showing the maximum 1-hour average, 24-hour average and annual average. No exceedances have been recorded of either the 1-hour average AQNES threshold concentration or the 24-hour average NZAAQG for NO_2 (200 µg/m³ and 100 µg/m³ respectively).

Table 13.3: 1- Hour, 24- Hour and Annual Average NO_2 and NO_x Concentrations (µg/m³)

Site	Parameter	1- hour Average Concentration		24- hour Average Concentration	Annual Average Concentration
		Maximum	99.9 Percentile	Maximum	Maximum
Tawa (2007-2009)	NO_2	52.5	47.1	34.2	14.4
	NO_x	616.8	483.7	277.5	40.0
Raumati Road (2011)	NO_2	53.0	45.3	26.6	6.8
	NO_x	518.3	262.7	97.5	14.8
AQNES	NO_2	200	200	100	100

Passive NO2 Monitoring

The NZTA operates a network of passive diffusion samplers to monitor NO_2 in the vicinity of State highways across the country. Three of these are located close to SH1 in the Wellington Region – Pauatahanui, Porirua and Paraparaumu.

Diffusion samplers are typically exposed to ambient air for periods of up to a month at a time, so cannot be used to measure short term concentrations of air pollutants. Instead, the results of such monitoring are typically expressed as annual average concentrations, which can be used to compare overall air quality at a number of locations. The results of passive NO_2 monitoring at each site are summarised in Table 13.4. These results can be compared with the World Health Organisation (WHO) annual NO_2 guideline of 40 µg/m³.

Table 13.4: Annual Average Concentrations of NO_2 at Passive NO_2 Monitoring Sites at Peak Traffic Locations in the Wellington region (µg/m³)

Site ID	Location	Distance from Major Road (metres)	Annual Average NO_2 Concentration			
			2008	2009	2010	2011*
WEL004/ WEL063	Paraparaumu: 004 - Main Rd South / Ihakara St 063 - Main Rd South / Rimutaka St	<5	17.3	18.4	18.5	19.8
WEL005	Porirua: Johnsonville Porirua Motorway / Titahi Bay Rd	50	16.8	20.2	20.2	21.8
WEL006	Pauatahanui: Paremata - Haywards Rd / Paekakariki Hill Rd	20	11.4	14.4	16.4	16.5
WEL061	Ōtaki: SH1 / Mill Road	<5	-	-	17.4	19.6

* The annual average NO_2 concentrations for 2011 have been estimated from the monthly average results for the period January – June, using a scale factor based on the relationship between monthly and annual average concentrations at each site for the years 2008-2010. This is based on an approach developed by NIWA for the assessment of the Western Ring Route: Waterview Connection Project in Auckland (Beca, 2010)

Carbon monoxide

Table 13.5 summarises the results of ambient monitoring of CO undertaken by the GWRC at Tawa between 2008 and 2010 and by the NZTA in Raumati during 2011, showing the maximum 1-hour average, running 8-hour average and annual average. No exceedances have been recorded of either the 1-hour average NZAAQG threshold concentration or the 8-hour average AQNES (30 mg/m^3 and 10 mg/m^3 respectively).

Table 13.5: Maximum 1- Hour, Running 8- Hour and Annual Average CO Concentrations (mg/m^3)

Site	Maximum 1- hour Average Concentration	Maximum Running 8- hour Average Concentration	Maximum Annual Average Concentration
Tawa (2007-2009)	4.7	4.3	0.2
Raumati Road (2011)	8.0	3.3	0.2

Summary of background concentrations

Table 13.6 presents a summary of background concentrations of PM10, NO2 and CO used for this assessment, based on the Raumati Road monitoring site data. In each case, these represent the maximum concentrations recorded over the relevant averaging period between February and July 2011. In addition to being representative values for the more 'urban' areas of the Project, these are also highly conservative values for the rural areas. This data is used in the prediction of cumulative concentrations for the urban areas of the Project.

Table 13.6: Summary of Background Concentrations of PM_{10}, NO_2 and CO

Parameter	Averaging Period	Background concentration	Relevant Standard or Guideline
PM_{10}	24 hour	36 µg/m^3	50 µg/m^3
	Annual	13 µg/m^3	20 µg/m^3
NO_2	1 hour	53 µg/m^3	200 µg/m^3
	24 hour	27 µg/m^3	100 µg/m^3
	Annual	14 µg/m^3	40 µg/m^3
CO	1 hour	8 mg/m^3	30 mg/m^3
	8 hour	3 mg/m^3	10 mg/m^3

4. Project description

4.1. Overview of Project

The Designation for the Project is proposed to generally follow the existing Western Link Road (WLR) designation, and span a length of approximately 16km from just south of Poplar Ave (chainage 1,900m) to just north of Peka Peka Road (chainage 18,050m).

The proposed MacKays to Peka Peka Expressway ('the Expressway') will provide for two lanes of traffic in each direction, connections with local roads at four interchanges, construction of new local roads and access roads to maintain local connectivity and an additional crossing of the Waikanae River.

Once completed, the proposed Expressway will become part of State Highway 1 (SH1). The existing section of SH1 between MacKays Crossing and Peka Peka is likely to become a local arterial road.

The Project will have the following principal design features:

- A four lane median divided proposed Expressway (two traffic lanes in each direction);
- An upgrade to the southern section of existing State Highway 1 (i.e. the Raumati Straight);
- Partial interchange at Poplar Avenue;
- Full interchange at Kāpiti Road;
- Four lane bridge over the Waikanae River;
- Full interchange at Te Moana Road;
- Partial interchange at Peka Peka Road;
- Grade separated overbridges and underbridges to cross local roads, watercourses and the proposed Expressway; and
- Provision of a shared cycleway/walkway and bridleway separated from the shoulder of the proposed Expressway.

The general locations of operational elements of the Project are described by chainages. A chainage refers to the distance (measured in metres) along the proposed Expressway Alignment, with chainage 1900m being the starting point of the Project at the southern end and chainage 18050m being the approximate end point of the Project at the northern end.

For a comprehensive description of the Project, refer to the full Project description in Part D, Chapters 7 and 8, Volume 2 of the AEE.

4.2. Description of Project by sector

The proposed Expressway Alignment has been divided into four geographic sectors. Each of the sectors covers a geographic area that is described in Table 13.1 and illustrated in Figure 13.9 below.

Table 13.7: Sector Description

Sector number	Sector name	Description	Chainage (m)	Length (km)
1	Raumati South	From just south of Poplar Ave to just north of Raumati Road	1900 – 4500	2.6
2	Raumati/Paraparaumu	From north of Raumati Road to north of Mazengarb Road	4500 – 8300	3.8
3	Otaihanga/Waikanae	From north of Mazengarb Road to north of Te Moana Road	8300 – 12400	4.1
4	Waikanae North	From north of Te Moana Road to Peka Peka	12400 – 18050	5.7

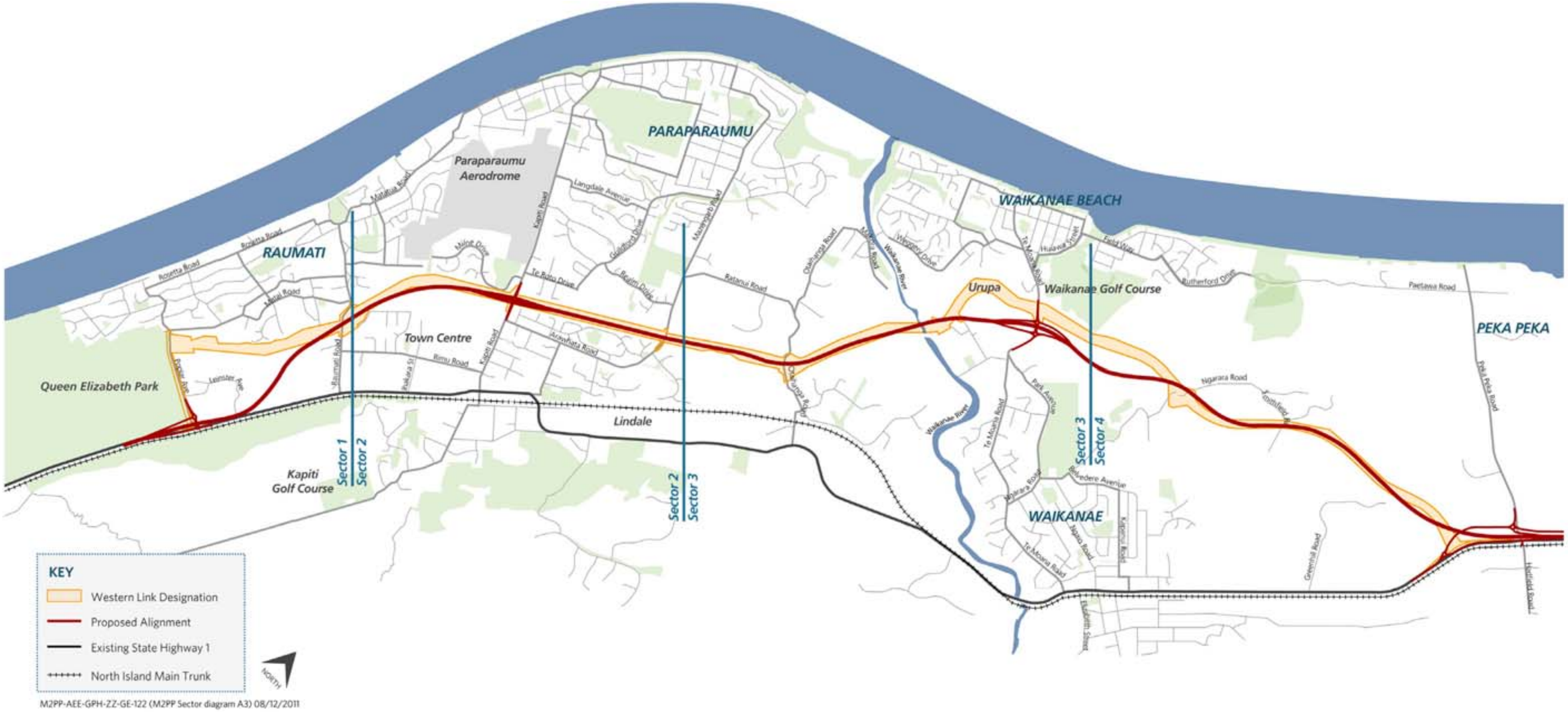

Figure 13.9: Sector Illustration

5. Methodology

5.1. Introduction

The methodology is based on the draft NZTA Air Quality Standard (NZTA, 2010) and the MfE GPG (MfE, 2008), which recommends a tiered approach to the assessment of vehicle exhaust emissions from road projects, as follows:

- Tier 1: preliminary assessment, using the NZTA Screening Tool to identify whether there are likely to be significant air quality effects
- Tier 2: screening assessment, using NZTA Screening Tool for the preferred option
- Tier 3: full assessment, with increased complexity in both traffic emission and dispersion modelling and reliance on site specific data.

The assessment reported here represents a Tier 3 assessment. A Tier 3 approach was considered appropriate because ambient concentrations of PM_{10} measured in the Project area were elevated in winter months (GWRC, 2011) and there are a relatively large number of residential receptors within 200m of the proposed Alignment.

The results of the Tier 1 assessment are attached in Appendix 13.I.

The aim of this technical assessment is to assess the potential effects of vehicle emissions (including exhaust emissions and tyre and brake wear) on human health and the environment from vehicles using the proposed Expressway. A separate report (Technical Report 14, Volume 3 of the AEE) addresses the likely effects on the environment of discharges into air (such as dust) from the construction of the Project.

The assessment has focused on determining the relative impact the development will have on the existing air quality at sensitive receptors and areas most impacted by vehicles emissions.

5.2. Approach to the assessment of effects

The Project has been assessed against the relevant air quality standards and guidelines. The assessment of impacts has been considered within the parameters of these existing standards (rather than determining whether these levels themselves are appropriate).

The pollutants of most concern associated with vehicle emissions and which may have adverse health effects on the surrounding community are carbon monoxide (CO), nitrogen dioxide (NO_2), inhalable particulate matter (PM_{10} and $PM_{2.5}$) and benzene.

The potential air quality impacts are assessed in this report using air pollutant dispersion modelling techniques in conjunction with measured ambient air quality monitoring data. This report assesses the effects of the Project on all members of the community, particularly those considered to represent the most vulnerable, e.g. school children and the elderly or infirm. Exposure levels are predicted through modelling and compared with the AQNES and relevant human health based air quality criteria (refer Section 5.1) which are designed to protect the health of the most vulnerable individuals in the community.

A series of mathematical models have been used to derive traffic data predictions and predict air quality impacts, as described in sections 6.5 and 7.1.

The assessment has focussed on characterising the relative impact that the Project is likely to have on future air pollutant levels taking into account changes over time in the composition and performance of the vehicle fleet and predicted traffic volumes. In the analysis, the potential air quality impacts have been predicted for the projected 'year of opening' (2016) and 10 years after opening (2026). For each of these years, the emission scenarios have considered both "Do Minimum" (i.e. the Project not being undertaken) and "With Project" options. A total of four scenarios have been assessed for this report, as follows:

- **2016 With Project** – representative of the year of opening of the proposed Expressway (therefore includes the impact on traffic flows of other roading projects in the region that are scheduled for completion by 2016).
- **2016 Do Nothing** – for comparison with the 2016 With Project scenario; assumes that all other projects in the region, unrelated to the proposed Expressway, have been completed, but that the proposed Expressway itself has not been constructed.
- **2026 Do Nothing** and **2026 With Project** – representative of increased traffic volumes and likely improvements in the vehicle fleet ten years after opening; includes traffic flows, fleet composition and completed roading projects predicted for 2026.

The sensitivity of the receiving environment, predicted traffic volumes and emission rates, background concentrations, predicted ground level concentrations of contaminants and the effects of these contaminants on human health are considered in detail in Sections 3 and 6 to 8 of this report.

5.3. Air quality assessment criteria

Air quality standards and guidelines are used to assess the potential for air pollutants to give rise to adverse health or nuisance effects. The MfE Transport GPG recommends the following order of precedence when selecting suitable assessment criteria:

- New Zealand National Environmental Standards (AQNES)
- New Zealand Ambient Air Quality Guidelines (NZAAQG)
- Regional Air Quality Targets.

The October 2009 amendments to the RMA[5] strengthened the standing of the national environmental standards. In the Wellington region, the Maximum Acceptable Levels given in the regional ambient air quality guidelines (WRAAQG) are similar to the AQNES and NZAAQG. For the contaminants being considered within this assessment, there are relevant AQNES, NZAAQG and Regional Air Quality Targets[6]. These are set out in the following sections of this report.

National environmental standards for air quality

The AQNES were prepared under Sections 43 and 44 of the RMA and are designed to protect public health and the environment of New Zealand by, among other things, setting concentration limits for criteria air pollutants. These concentration limits (air quality standards) came into force on 1 September 2005.

[5] By the Resource Management (Simplifying and Streamlining) Amendment Act 2009.

[6] In the absence of these criteria, relevant overseas guidelines have been considered. These include the World Health Organisation Air Quality Guidelines.

The air quality standards that are relevant to this assessment are summarised in Table 13.8.

Table 13.8: National Environmental Standards for Ambient Air Quality

Pollutant	Threshold concentration[7]	Averaging period	Permitted exceedances (per year)
Carbon monoxide	10 mg/m^3	Rolling 8-hour	1
Fine particles (PM_{10})	50 µg/m^3	24-hour	1
Nitrogen dioxide	200 µg/m^3	1-hour	9
Notes: mg/m^3 µg/m^3	milligrams per cubic metre micrograms per cubic metre		

New Zealand ambient air quality guidelines

The Ministry for the Environment has published a set of ambient air quality guidelines (NZAAQG), which were most recently updated in 2002 (MfE, 2002). The NZAAQG that are relevant to this assessment are summarised in Table 13.9.

Table 13.9: New Zealand Ambient Air Quality Guidelines

Pollutant	Threshold Concentration	Averaging period
Carbon Monoxide	30 mg/m^3	1-hour
Fine Particles (as PM_{10})	20 µg/m^3	Annual
Fine Particles (as $PM_{2.5}$) *	25 µg/m^3	24-hour
Nitrogen dioxide	100 µg/m^3	24-hour
Benzene	3.6 µg/m^3	Annual
* Note: the $PM_{2.5}$ NZAAQG is a monitoring guideline only – that is, there is no specific requirement to achieve it (MfE, 2002).		

The NZAAQG also includes a guideline for NO_2 of 30 µg/m^3 an annual average for the protection of ecosystems. However, the supporting documentation to the NZAAQG (Stevenson, Hally, & Noonan, 2000) notes that effects on ecosytems due to exposure to oxides of nitrogen are only significant if concentrations of ozone and sulphur dioxide (SO_2) are also at or near their critical values. Although there is the potential for concentrations of ozone to be elevated in the Project area, concentrations of SO_2 are likely to be much lower than the relevant critical level (20 µg/m^3 as a winter average for forests and natural vegetation). Therefore, no further consideration has been given in this assessment to potential effects of discharges of NO_x on ecosystems.

Wellington Regional Ambient Air Quality Guidelines

The Greater Wellington Regional Council (GWRC) has also adopted regional ambient air quality guideline (RAAQG) values, which are set out in the Regional Air Quality Management Plan for the Wellington Region (2000). The Regional Air Quality Management

[7] Threshold concentrations under the AQNES apply in the open air, in places that people may be present, for the averaging period of the standard.

Plan became operational in May 2000, before either the AQNES or AAQG were published. For CO and NO_2 the RAAQG specifies both 'maximum desirable levels' and 'maximum acceptable levels'. Only 'maximum acceptable levels' are defined for particulates. Policy 4.2.1 of the air quality plan defines 'maximum desirable levels' and 'maximum acceptable levels' as follows:

- *"the are defined as the level adequate to protect the health of individuals. These levels would be applied in areas where existing activities has had a significant effect on air quality; and*
- *the are defined as the level that will provide maximum protection to the environment, taking into account existing air quality, community expectations, economic implications, and the purpose and principles of the Act. Desirable levels are appropriate guidelines or targets in rural or residential areas, and in other areas with good air quality. These levels are based on Canadian standards and do not appear in the National Ambient Air Quality Guidelines. "*

The GWRAAQG that are relevant to this assessment are summarised in Table 13.10

Table 13.10: Greater Wellington Regional Ambient Air Quality Guidelines

Pollutant	Maximum Acceptable Level	Maximum Desirable Level	Averaging period
Carbon Monoxide	10 mg/m^3	6 mg/m^3	8-hour
Fine Particles (as PM_{10})	50 µg/m^3 20 µg/m^3	N/A	24-hour Annual
Nitrogen dioxide	300 µg/m^3 100 µg/m^3	95 µg/m^3 30 µg/m^3	1-hour 24-hour

In all cases, the MAL are either the same value or higher than the equivalent AQNES or NZAAQG.

Relevant international air quality guidelines

There are a number of relevant international guidelines, particularly those promulgated by the World Health Organisation (WHO) (WHO, 2006) that should be considered.

Table 13.11 summarises the relevant WHO Air Quality Guidelines that are different from the AQNES, NZAAQG and GWRAAQG.

Table 13.11: WHO Air Quality Guidelines

Pollutant	Threshold Concentration (µg/m^3)	Averaging period
Fine particles (as $PM_{2.5}$)	10 µg/m^3	Annual
Nitrogen dioxide	40 µg/m^3	Annual

Most of the New Zealand guidelines are based on the same guideline concentrations and averaging periods as the WHO air quality guidelines.

Summary of relevant assessment criteria

Table 13.12 summarises the AQNES, NZAAQG, GWRAAQG and WHO guidelines for PM_{10}, $PM_{2.5}$, NO_2, CO and benzene that are relevant to this assessment. Due to the reductions in the permissible sulphur content of vehicle fuels over recent years, vehicle exhaust emissions are no longer regarded as a significant source of SO_2 in ambient air in New Zealand. Therefore, assessment criteria for SO_2 have not been used in this report.

Table 13.12: Assessment Criteria used in this Report

Pollutant	Averaging period	Threshold Concentration	Source of Criterion
Carbon Monoxide	1-hour 8-hour (running)* 8-hour	30 mg/m³ 10 mg/m³ 6 mg/m³	NZAAQG AQNES GWRC MDL
Fine Particles (as PM_{10})	24-hour Annual	50 µg/m³ 20 µg/m³	AQNES NZAAQG
Fine Particles (as $PM_{2.5}$) *	24-hour Annual	25 µg/m³ 10 µg/m³	AQNES WHO
Nitrogen dioxide	1-hour 24-hour Annual	200 µg/m³ 95 µg/m³ 100 µg/m³ 30 µg/m³ 40 µg/m³	AQNES GWRC MDL NZAAQG GWRC MDL NZAAQG
Benzene	Annual	3.6 µg/m³	NZAAQG
* A running 8-hour average is an average calculated every hour on the hour for that hour and the preceding 7 hours to give 1 running 8-hour average per hour			

Application of criteria to receptors

The MfE Transport GPG (p30) indicates that the ambient air quality standards should apply where people would reasonably be exposed for the standard's averaging period. Specific guidance on the applicability of the AQNES is provided in the MfE Transport GPG, as follows:

Averaging period	Locations where assessment against the Standards should apply
1 hour	This includes any outdoor areas where the public might reasonably be expected to spend one hour or longer, including pavements in shopping streets, as well as facades of any building where the public might reasonably be expected to spend one hour or longer.
24 hours and 8 hours	This includes all outdoor locations where members of the public might be regularly exposed for longer than one-hour durations (e.g., residential gardens) as well as facades of residential properties, schools, hospitals, libraries, etc.

5.4. Assessment matters

Resource Management Act 1991

The purpose and principles of the (Resource Management Act 1991) RMA are set out in Sections 5 to 8 of that Act. Of particular relevance to the assessment of effects of discharges into air from land transport activities are Sections 5(1) and 5(2)(c), which state:

"(1) The purpose of this Act is to promote the sustainable management of natural and physical resources

(2) In this Act, sustainable management means managing the use, development and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural wellbeing and for their health and safety while – …

(c) Avoiding, remedying or mitigating any adverse effects of activities on the environment."

Air is one such natural resource. Section 7 of the RMA requires consent authorities to give particular regard to those matters listed in the section. In the case of discharges into air from this particular Project, the following matters are considered relevant: maintenance and enhancement of amenity values (Section 7(c)) and maintenance and enhancement of the quality of the environment (Section 7(f)).

In the context of this Project, amenity values may be affected by discharges of construction dust and odour (which are addressed in Technical Report 14, Volume 3 of the AEE), while the quality of the environment is described in the context of effects on human health. Effects on the environment that are not associated with the direct effects of vehicle exhaust emissions on human health are considered to be outside the scope of this report. Effects on human health are considered in Section 5.4.

The relevant regional plan requirements as they relate to air discharges are described in more detail below.

Greater Wellington Regional Policy Statement

The operative Greater Wellington Regional Policy Statement (RPS) 1995 sets out the framework for the management of air quality in the region. Objectives 1 and 3 are that:

High quality air in the Region is maintained and protected, degraded air is enhanced, and there is no significant deterioration in ambient air quality in any part of the Region.

The adverse effects of the discharge of contaminants into air on human health, local or global environmental systems and public amenity are avoided, remedied or mitigated.

These objectives are carried through into the RAQMP (below).

In 2009, the GWRC notified a revised Regional Policy Statement. Decisions on submissions on this Proposed Regional Policy Statement (PRPS) were notified in May 2010. The PRPS is currently under appeal to the Environment Court.

Objectives 1 and 2 of the PRPS are that:

Discharges of odour, smoke and dust to air do not adversely affect amenity values and people's wellbeing.

Human health is protected from unacceptable levels of fine particulate matter.

Policies 1 and 2 give direction for policies and/or rules in district (policy 1) and regional (policy 2) plans that are aimed at achieving these objectives. The explanations to these policies state:

New sensitive activities should not establish near land uses or activities that generate odour, smoke or dust. The reverse is also true; new land uses and activities should be distanced from sensitive activities ... [Policy 1]

Amenity is reduced by contaminants in the air affecting people's wellbeing – such as when dust or smoke reduces visibility or soils surfaces … Protecting people's health from discharges to air includes considering the effects of fine particulate matter discharged from human activities. [Policy 2]

Greater Wellington Regional Air Quality Management Plan

The Greater Wellington Regional Air Quality Management Plan (RAQMP) identifies discharges to air from mobile sources, particularly mobile transport sources, as causing, or having the potential to cause, significant adverse effects on air quality (Issue 2.3.3).

The RAQMP contains objectives, policies and rules that address air quality impacts from a range of sources, including road construction. Objectives 4.1.1 and 4.1.2 set out the overall aims of the RAQMP, as follows:

4.1.1 High quality air in the Region is maintained and protected, degraded air is enhanced, and there is no significant deterioration in ambient air quality in any part of the Region.

4.1.2 Discharges to air in the Region are managed in a way, or at a rate which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while ensuring that adverse effects, including any adverse effects on:

- local ambient air quality;
- human health;
- amenity values;
- resources or values of significance to tangata whenua;
- the quality of ecosystems, water, and soil; and
- the global atmosphere;

are avoided, remedied or mitigated.

Objective 4.1.22 is directly related to vehicle exhaust emissions, aiming:

4.1.22 To avoid, remedy, or mitigate the adverse effects of discharges to air from mobile transport sources ...

There are no rules in the RAQMP that relate to discharges to air from motor vehicles. The "*User Guide to the Regional Rules*" (Section 5.1 of the RAQMP) specifically states:

These rules do not apply to discharges from mobile transport sources, whether or not the mobile transport source is on industrial or trade premises, and no resource consents are required for such discharges.

Kāpiti Coast District Plan

The operative Kāpiti Coast District Plan (KCDP) does not identify any specific issues associated with the effects of exhaust emissions from vehicles, although it does identify a need to reduce the effects of vehicle exhaust emissions through intensification of land use around the various town centres.

The KCDP does not contain any specific objectives, policies or rules that relate to vehicle exhaust emissions, other than policies specifically related to development proposals in the

Airport Zone and the Waikanae North Development Zone (which do not apply to this Project).

Land Transport Management Act

The Land Transport Management Act 2003 (LTMA) sets out requirements for the operation, development and funding of the land transport system. Section 94 of the LTMA states that the objective of the NZTA is to "*undertake its functions in a way that contributes to an affordable, integrated, safe, responsive, and sustainable land transport system.*" The functions of the NZTA in the context of this proposal are set out in Section 95(1) of the LTMA, while Section 96 sets out the operating principles of the NZTA. The specific principle that applies to this assessment is set out in Section 96(1)(a)(i), as follows:

"(1) In meeting its objective and undertaking its functions, the [NZTA] must—

(a) exhibit a sense of social and environmental responsibility, which includes—

(i) avoiding, to the extent reasonable in the circumstances, adverse effects on the environment; and …"

a. Government Policy Statements on Land Transport Funding

The Government Policy Statement on Land Transport Funding (GPS) sets out the government's outcomes and priorities for the land transport sector. The GPS first came into effect in 2009, while the GPS 2012 has recently been released and comes into effect in July 2012. Both the GPS 2009 and the GPS 2012 include the following short to medium term impacts that should be achieved:

- Reductions in adverse environmental effects from land transport.
- Contributions to positive health outcomes.

b. The NZTA [Transit] Environmental Plan

Where the NZTA (formerly Transit New Zealand) seeks a new or altered designation, it must take into account any air quality effects and the requirements of the AQNES.

The NZTA (Transit) Environmental Plan (Version 2 in 2008) sets out how NZTA's obligations under the LTMA are to be exercised in practice. Section 2.2 of the Environmental Plan addresses air quality issues and sets out the following objectives:

"A1 Understand the contribution of vehicle traffic to air quality.

A2 Ensure new State highway projects do not directly cause national environmental standards for ambient air quality to be exceeded.

A3 Contribute to reducing emissions where the State highway network is a significant source of exceedances of national ambient air quality standards."

A number of methods are specified to give effect to these objectives, for example:

Route Selection	Investigate, consider and prioritise route options for new or upgraded sections of State highways that avoid increasing the exposure of sensitive receivers to poor air quality.

Assessment of Effects	Assess the effects on local air quality of new or improved sections of State highways in accordance with appropriate New Zealand and overseas guidance
Design Approach	In situations where vehicles are likely to be a significant source of emissions and cause of poor air quality, design new or upgraded State highways in order to remedy and/or mitigate adverse effects. Consider design measures to reduce vehicle emissions and avoid exposure to poor air quality, for example, by: - easing congestion and improving traffic flow; - Improving vehicle performance through use of road surface treatments and smoothing techniques; - minimising the effect of road gradient and vehicle movements at intersections; - taking into account effect of vehicle speed and fleet composition and balancing this effect with function and purpose of the State highway; and ... - ensuring alignment of vehicle lanes is optimised within State highway designation to minimise exposure to vehicle-related air pollution at adjoining sensitive locations.

This assessment of effects considers the requirements of these objectives, in particular objective A2, in the context of the proposed Project.

6. Traffic modelling and vehicle emission rates

6.1. Introduction

The effects of vehicle exhaust emissions are dependent upon a number of factors, including: mass emission rates of various contaminants, meteorology, background concentrations and the sensitivity of the receiving environment. This section of the report provides information relating to the estimation of pollutant emissions from road sections based on traffic volumes predicted through the use of traffic modelling.

Traffic volumes on road links used in this assessment are summarised in Appendix 13.C, while a summary of the calculated pollutant emissions is presented in Appendix 13.E.

6.2. Indicator contaminants

Motor vehicles discharge a wide range of contaminants, many with synergistic effects. However, for practical purposes, these can usefully be reduced to a series of indicator contaminants. These are the contaminants with the highest potential to cause adverse effects, and as such, provide a general indication of emissions from vehicles. The Ministry for the Environment has identified five indicators of emissions from vehicles (MfE, 2008). They are:

- Carbon monoxide (CO)
- Oxides of nitrogen (including NO_2)
- Photochemical oxidants, including ozone

- Particulate matter (PM_{10} and sometimes $PM_{2.5}$)
- Volatile organic compounds (e.g. benzene).

Ozone is a secondary, urban air pollutant formed by reactions of nitrogen oxides and volatile organic compounds in the presence of sunlight. The other contaminants are discharged directly in motor vehicle exhaust and are the subject of this assessment. These indicators and the health effects associated with them are described briefly in Appendix 13.H.

6.3. Forecast traffic volumes

Traffic modelling methodology

Predicted traffic flows for each road link[8] in the Project area, required as key input data for this assessment, have been prepared by Beca using a regional scale model (the Wellington Transport Strategy Model) and two project specific models – a project assignment model (KTM2) and an operational model (Kāpiti Road Operational Model). Traffic flows have been provided for a base year (2010), the projected year of opening (2016) and 10 years after opening (2026) for the two Project options – 'Do Minimum' and "With Project'.

Full details of this traffic modelling are presented in Technical Report 34, Volume 3 of the AEE.

Summary of changes in traffic volumes

The traffic modelling indicates that the proposed Expressway is predicted to carry nearly 20,000 vehicles per day between the Kāpiti Road and Te Moana Road intersections. With the Project in place, the traffic flows on the existing SH1 are expected to reduce significantly in the order of 35% to 55%.

In many cases, traffic volumes on local roads are also predicted to decrease as a result of the Project. Traffic volumes are expected to increase by around 6-10% on Kāpiti Road in the vicinity of the Kāpiti Road Interchange. Poplar Avenue, east of Matai Road is expected to experience an increase in traffic of 13-15%. Due to the relatively low volume of traffic on Poplar Avenue this results in an increase of only 400-500 vehicles per day.

Traffic volumes on Park Avenue, north of Te Moana Road are predicted to increase by 72% (2,100 vehicles per day) by 2026. In 2026, Park Avenue (a secondary arterial), will carry a daily volume of 5,000.

The proposed Expressway is predicted to carry between 12 and 20% Heavy Commercial Vehicles (HCV) which is expected to significantly reduce the volume of HCV's on SH1. HCV volumes are predicted to reduce on many local roads including Te Moana Road. The volume of heavy vehicles is predicted to slightly increase on Park Avenue and Paetawa Road by 30 and 10 vehicles per day respectively in 2026.

Roads selected for modelling assessment

These changes in regional traffic flows will have a greater impact on ambient air pollutant level in areas where traffic flows are already high and where vehicle congestion or queuing

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[8] In the context of this report, a length of road is broken down into a series of links, each of which connects from one intersection to the next.

may occur, for instance busy intersections, and roads with high volumes of heavy vehicle traffic.

In order to identify the key air quality issues and affected locations on which to focus the detailed air quality assessment, the guidance in the MfE Transport GPG has been used. During the preliminary assessment phase of road transport projects (MfE Transport GPG Tier 1) recommends the use of the criteria in Table 13.13 to identity potential areas where further investigation is required. In other areas it is assumed that emissions from vehicles are highly unlikely to result in any of the air quality criteria being exceeded, even if worse case background pollutant and dispersion conditions were to occur.

Table 13.13: MfE (2008) Tier 1: Screening Threshold Criteria

Road type	Screening threshold criteria
Busy roads	Identify links where traffic is likely to be greater than 7000 vehicles per day.
Congested roads	Identify any links that may be congested, where traffic is likely to be greater than 3000 vehicles per day.
Busy intersections	Identify any busy intersections with more than 7000 vehicles per day, regardless of level of congestion.
Roads with a high flow of buses and/or heavy vehicles	Identify any links where the flow of heavy vehicles (> 3.5 tonnes) is likely to be more than 500 vehicles per day

Comparable screening criteria are also incorporated in the Tier 1 screening assessment phase of the draft NZTA standard. The draft standard also indicates a more detailed assessment may be required if any of the following apply:

- Sensitive receptors or residents are located within 200 m of the proposed development
- Part of the development is in an area likely to be in a valley, in a built up area, an urban canyon or other sheltered spot
- Whether the Project will cause traffic volumes, level of service (LoS), or average speeds on other roads in built up areas of the 'wider Project' to change by more than 10%.

The air quality assessment of the Project has focused on locations within the Project area where the MfE and NZTA initial screening criteria are predicted to be exceeded as a consequence of the proposed Project and where ambient air pollutant concentrations may also increase. These locations were selected based on road links with all of the following criteria:

- roads or intersections where traffic volumes are greater than 7,000 vehicles per day,
- traffic volumes are predicted to increase by more than 10%, and
- sensitive receptors or residents are located within 200 m of the road.

An analysis of the outputs of the traffic modelling indicates that in the "With Project" scenario, the proposed Expressway and some sections of a limited number of local roads, exceed these screening criteria in one or both of the modelled future years (2016 and 2026). These road sections are summarised in Table 13.14, with detailed results of the analysis presented in Appendix 13.D.

Table 13.14: Local Roads that Exceed Significance Criteria

Road Name	Section	Sector	Modelling Year	
			2016	2026
Poplar Ave	West of Old SH1	1		
Ihakara Rd	East of Rimu Rd	2		
Ihakara Rd	West of Rimu Rd	2		
Arawhata Rd	North of Tutanekai St	2		
Mazengarb Rd	East of Realm Rd	2		
Amohia St	North of Old SH1	2		
Kāpiti Rd	West of Milne Cres	2		
Kāpiti Rd	West of Te Roro Drive	2		
Kāpiti Rd	East of Hurley Rd	2		
Kāpiti Rd	West of Hurley Rd	2		
Te Moana Rd*	West of Marae Lane	3		
Ngarara Rd	North of Park Ave	4		
Park Ave	East of Walton Rd	4		

*Traffic volumes on this section of Te Moana Rd reduce significantly (39 - 43%) however there is a small but significant increase in HCVs.

Dispersion modelling undertaken for this assessment focussed on those sections of the proposed Expressway that are closest to residential or other sensitive areas. The only sections of the proposed Expressway where residential or other sensitive receptors are located within 50m of the proposed Alignment are in the vicinity of the eastern end of Leinster Avenue (Sector 1) and between Ihakara Street and Mazengarb Road (Sector 2). In order to make a representative assessment of the effects of emissions from vehicles using these sections of the proposed Expressway, the following local roads were also included in the dispersion model:

- SH1 north and south of Leinster Avenue (Sector 1), because receptors are already impacted by traffic emissions from this road and traffic volumes are predicted to decrease as a result of the opening of the proposed Expressway
- Kāpiti Road between Arawhata Road and Milne Drive (Sector 2), which has the highest traffic volumes of any section of road in the Project area. In the immediate vicinity of the Kāpiti Road Intersection, the LoS on Kāpiti Road is predicted to significantly decrease in 'with Project' scenarios, as a result of the installation of a controlled junction (with traffic lights) on a previously open stretch of road.

Each road link has been modelled as a single line source, with the overall mixing width based on the number of lanes and an aggregate two-way traffic flow calculated from the sum of one-way flows predicted by traffic modelling. The same diurnal flow profile has been assumed for all road links (refer section 6.3). In the model configuration it has been assumed that each individual lane is approximately 3.5m in width.

Other local roads listed in Table 13.14 have not been included in the detailed dispersion modelling. Given the predicted traffic volumes on Kāpiti Road and on the proposed Expressway between Kāpiti Road and Mazengarb Road (Sector 2) (up to 31,000 and

21,000 vehicles per day respectively), this is likely to represent a 'worst case' for the effects of traffic emissions within the Project area. Traffic volumes on Kāpiti Road may at times be greater than those on the proposed Expressway (and greater than on any other local road in the Project area) and there are a number of residential receptors in close proximity to the interchange. Traffic volumes on the proposed Expressway between Kāpiti Road and Te Moana Road (Sectors 2 and 3) are predicted to be higher than on any other part of the new route.

Traffic data inputs to modelling

The traffic models generate average weekday traffic flows for three time periods – AM Peak, PM Peak and interpeak (IP), along with the numbers of HCV's and average vehicle speed for each period. These time periods were defined as:

- AM Peak: 07:00-09:00
- PM Peak: 16:00-18:00
- Interpeak: 09:00-16:00.

These AM Peak, PM Peak and IP hourly flows have been used to generate average hourly flows and average mass emission rates for PM_{10} (grams per vehicle kilometre, g/km) for each hour of the day, based on an 'average' weekday. This has been done as follows:

- 1-hour AM Peak, PM Peak and IP traffic volumes were used to generate a total AADT for each link using the following factors (taken from the traffic modelling output):

  AM Peak HCV x 1.76

  AM Peak non-HCV x 1.86

  PM Peak HCV x 2.50

  PM Peak non-HCV x 1.99

  IP HCV x 13.57

  IP non-HCV x 9.93.
- Hourly flow factors were derived from the results of automatic traffic counts on SH1, measured north of Elizabeth Street, Waikanae in 2009.
- Hourly traffic volumes outside the modelled peak periods (AM and PM) were calculated from the IP hourly flow using these factors.
- Hourly traffic volumes during the AM and PM peak periods were estimated by halving the 2-hour AM and PM Peak traffic numbers.

Figure 13.10 illustrates the average weekday and weekend hourly flow profiles recorded on SH1 in Waikanae, while the factors derived from the weekday profile are summarised in Table 13.15.

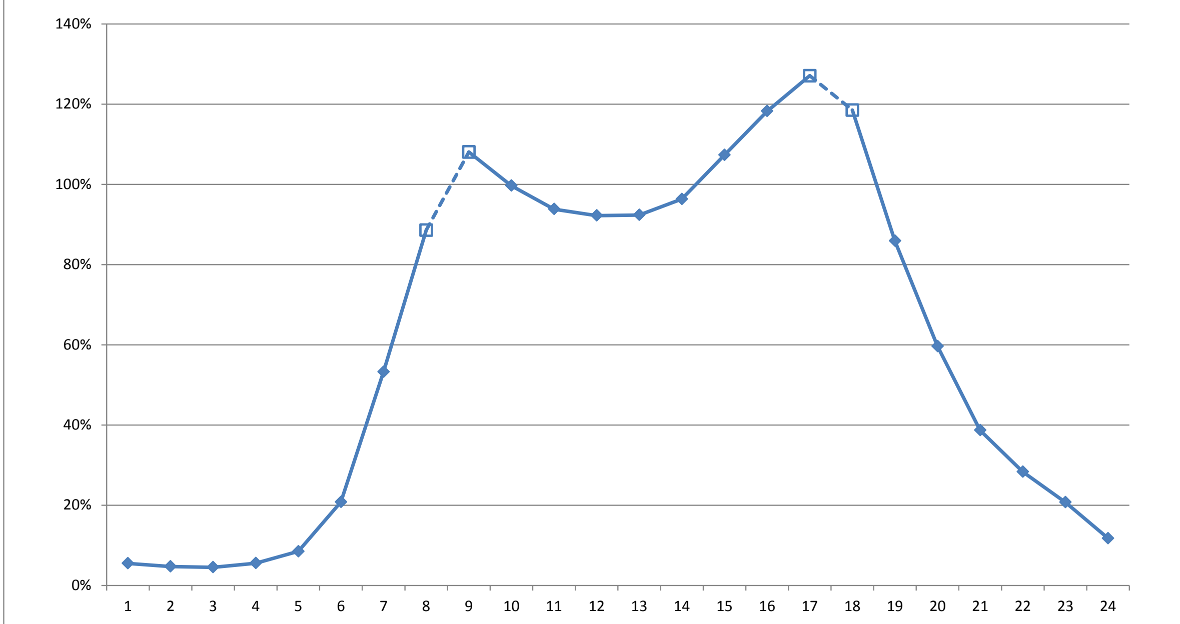

Figure 13.10: Average weekday and weekend hourly flow profiles on SH1 in Waikanae

Table 13.15: 24- Hour Traffic Flow Factors

Hour	Weekday Factor	Hour	Weekday Factor
00:00 - 01:00	5%	12:00 - 13:00	92%
01:00 - 02:00	5%	13:00 - 14:00	96%
02-00 - 03:00	5%	14:00 - 15:00	107%
03:00 - 04:00	6%	15:00 - 16:00	118%
04:00 - 05:00	8%	16:00 - 17:00	PM
05:00 - 06:00	21%	17:00 - 18:00	PM
06:00 - 07:00	53%	18:00 - 19:00	86%
07:00 - 08:00	AM	19:00 - 20:00	60%
08:00 - 09:00	AM	20:00 - 21:00	39%
09:00 - 10:00	100%	21:00 - 22:00	28%
10:00 - 11:00	94%	22:00 - 23:00	21%
11:00 - 12:00	92%	23:00 - 00:00	12%

A summary of hourly traffic volumes, percentage HCVs and average speeds (AM Peak, PM Peak and IP) and Annual Average Daily Traffic (AADT) for each link used in this assessment, for each scenario, is presented in Appendix 13.C. Appendix 13.C also includes predicted traffic volumes, average speeds and %HCV for a number of other roads in the vicinity of the Project, although the effects of vehicle emissions from traffic on these roads have only been modelled for Kāpiti Road in the vicinity of the Kāpiti Road intersection and existing SH1 in the vicinity of Leinster Avenue.

High traffic day

The traffic modelling data represents the average weekday peak periods (AM, PM and interpeak). As recommended in the MfE GPG (MfE, 2008), a prediction of likely traffic volumes on a "high traffic day" has also been carried out. In order to undertake a sensitivity analysis, the traffic modellers have assessed a theoretical "high traffic day" scenario based on actual traffic count data measured on SH1 at Waikanae in 2009. Note there is no formal definition of "high traffic" conditions, however the 90th percentile has been as assessed as being broadly representative of such conditions.

This analysis has shown that, using different input assumptions, the traffic flows could be 10% higher on a "high traffic" day than the average weekday periods.

As the proposed Expressway is designed with more than sufficient capacity to be free flowing during the predicted peak AM and PM vehicle flows in 2026, it is also predicted to be free flowing on a "high traffic day" scenario.

The effects of a high traffic day scenario on air quality are assessed in Section 8.7.

6.4. Factors which affect vehicle emission rates

The volume and concentrations of vehicle emissions depend on a number of factors as described below. Section 6.5 describes the calculation of predicted vehicle emission rates for the various Project scenarios.

Vehicle age

- Relatively old vehicle fleet in comparison to other countries
- Older vehicles tend to have higher emission levels for both CO and NO_x; as vehicle emissions deteriorate with age
- Average ages (NZTA, 2010):
  - cars – 13.3 years
  - trucks – 13.6 years
  - buses – 13.2 years.

Catalytic converters

- Emissions of CO, VOC and NO_x from a catalytic converter equipped petrol vehicle are approximately ten times lower than an equivalent non catalyst equipped vehicle.
- Catalytic converters do not reduce the level of PM_{10} discharged from vehicles.
- Older vehicles tend not to have catalytic converters (Metcalfe, 2009)
- Majority of newer cars (e.g. petrol vehicles manufactured since 2000) are assumed to have catalytic converters installed.

Vehicle speed

- Maintaining a steady flow of traffic will produce fewer pollutants than stop/start traffic.
- In general:
  - Reducing traffic speed reduces emissions of CO and PM_{10}
  - NO_x emissions increase slightly with speed.

- The proposed Expressway is designed to achieve Level of Service B[9], in 2026.

Fuel

- Most cars in New Zealand are fuelled by petrol
- The number of diesel cars and commercial vehicles is forecast to continue to increase
- The removal of lead from petrol in 1996 and the lowering of sulphur in diesel from 2002 have resulted in a significant improvement in the emission of these contaminants
- Diesel vehicles produce emissions with different concentrations of pollutants than those produced by petrol vehicles. Particulate emissions especially are significantly higher.

Proportion of heavy vehicles

- Heavy vehicles (usually diesel fuelled) have relatively higher emissions of particulate matter per kilometre travelled compared to light vehicles.
- As described in Section 6.3, the proposed Expressway is predicted to carry between 12 and 20% HCVs which is expected to significantly reduce the volume of HCV's on SH1.

Journey length and vehicle mileage

- Vehicle exhaust emissions tend to be highest when the engine is cold ('cold start') and decrease substantially once the engine has warmed up.
- This is especially true of vehicles fitted with catalytic converters – these tend to be ineffective until they have reached operating temperature.
- Vehicles with high mileage (especially older vehicles) are likely to have increased exhaust emissions compared to new vehicles, as engine wear increases and catalytic converter efficiency decreases.

Road surface and gradient

- Road surfaces of all the roads considered in this assessment are asphalt. Therefore, no correction has been made for the effects of road surface.
- Within the Project area, the terrain is relatively level, without any significant hills that would significantly affect vehicle exhaust emissions on the proposed Expressway. Therefore, road gradients have not been considered in this assessment.

6.5. Forecast emission rates

Vehicle emissions prediction model

Detailed emissions factors have been derived from VEPM v3 (Metcalfe, 2009). The VEPM (Vehicle Emissions Prediction Model) database calculates emissions factors for European origin vehicles and also draws on emissions data from New Zealand, the Japan Clean Air Program, the European Environment Agency (COPERT III), and the European Program on Emissions, Fuels and Engine Technologies (EPEFE). The model provides a comprehensive emissions database covering the range of vehicle types available in the New Zealand fleet.

[9] According to the Austroads Guide, Level of Service B will be achieved if the maximum flow (passenger cars per hour per lane) is less than 1,100 with a free flow speed of 100kph. (ref Assessment of Transport Effects)

VEPM was developed by the Energy and Fuels Research Unit, University of Auckland, for the Auckland Regional Council, based on NZ vehicle fleet profiles and the best available emission factors. It is widely accepted as appropriate for vehicle emission modelling in NZ.

Vehicle fleet profile

Predicted vehicles emission rates were calculated using VEPM's default vehicle fleet composition for the year of opening 2016 and the projected year of 2026.

The percentage of light and heavy vehicles on each link was varied according to the traffic model outputs. The relative distribution of sub-categories of light and heavy vehicles within two classifications was assumed to be the same as those predicted by VEPM. The percentage of buses is assumed to be constant and equal to the VEPM default value of 0.6% for the entire network.

The fleet profile in VEPM is based on vehicle kilometres travelled (VKT) for the New Zealand vehicle fleet; there is no published data for VKT for the Wellington fleet. The national fleet has a higher proportion of HCVs (4.0%) and diesel powered cars and LCVs (15.1%) than the Wellington fleet (2.3% and 11.1% respectively)[10]. Diesel powered vehicles tend to emit more PM_{10} and NO_x per vehicle kilometre than similar vehicles with petrol engines. Assuming that VKT for light and heavy diesel vehicles are higher for the national fleet than for the regional Wellington vehicle fleet, the use of the VEPM default fleet profile represents a conservative approach.

Non exhaust emission factors

VEPM provides the option to calculate brake and tyre wear particulate emissions based on the average number of wheels for each vehicle class. In this case the model default settings were used for the purposes of the modelling assessment.

Due to the high level of uncertainty associated with these emission factors, it is also recommended that a sensitivity analysis be undertaken. This has not been carried out at this stage; however, the brake and tyre wear emission calculated by VEPM increase the PM_{10} emissions by 20 - 50% depending on the average speed.

Catalytic converters in VEPM

VEPM assumes a percentage of cars with non-functioning catalytic converters for vehicles aged between 1980 and 1997. This is a percentage of the total number of cars manufactured with catalytic converters. The default value of 15% for older cars and 0% for newer cars was used in this assessment. As this assumption is constant across all modelled scenarios, comparisons of predicted ground level concentrations between the various scenarios remain valid.

Diurnal emission profiles

Diurnal emission profiles have been constructed for each road link as discussed in section 6.3.

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[10] Wellington fleet profile provided by Deborah Ryan of Sinclair Knight Merz, based on data from Stuart Badger of the Ministry of Transport, 14 May 2010.

6.6. Forecast vehicle emission rates

Predicted pollutant emission rates

A summary of predicted PM_{10}, CO, NO_x and benzene emission rates for each of the road links used in dispersion modelling is attached at Appendix 13.E. Pollutant emission rates in Appendix 13.E are presented as grams per kilometre road per hour (g/km-hour) calculated by multiplying the predicted composite vehicle fleet emission rates by the predicted total hourly traffic volume.

Benzene emission rates

The VEPM model does not directly calculate motor vehicle benzene emission rates, instead calculating total tail pipe hydrocarbon emissions. In this analysis, benzene emission rates have been estimated using the method detailed in the MfE Transport GPG (MfE, 2008), by assuming that approximately 5.9% of total hydrocarbon emitted by vehicle exhausts is in the form of benzene. Since emissions of benzene are primarily associated with exhaust emissions from petrol engines, this approach is likely to overestimate actual benzene emission rates. The small contribution from evaporative losses has not been incorporated into the emission estimates.

7. Dispersion modelling

7.1. Choice of dispersion model

Pollutant concentrations have been predicted using the AUSROADS dispersion model. AUSROADS is a simple Gaussian dispersion model developed by the Victorian Environmental Protection Agency (EPA), based on the Californian Department of Transportation's CALINE4 dispersion model. Compared to CALINE4, AUSROADS allows for an increased number of road links and receptor points, and ability to predicted pollutant concentrations using a full year of meteorological data.

AUSROADS is widely used throughout Australasia and is recognised in the MfE Good Practice Guide for Atmospheric Dispersion Modelling (MfE, 2004).

The model incorporates specific algorithms designed to simulate the dispersion of pollutants from roads. The dispersion algorithms simulate the effects of vehicle induced turbulence, thermal turbulence and surface roughness. AUSROADS is a 'near road' model and is intended for the assessment of pollutant concentrations within a few hundred metres of a road source. As a consequence AUSROADS uses comparatively simple methods to account for terrain and structural effects on pollutant dispersion, e.g. allowing modelled road links to being classified as either elevated, depressed, or a bridge. AUSROADS does not take into consideration the effects that terrain has on pollutant dispersion, for instance the channelling of wind flows by hills or valleys. However, in this instance, terrain is unlikely to have a significant effect on pollutant dispersion near the proposed Expressway where peak pollutant levels are likely to occur. Similarly, as the buildings on either side of the proposed Expressway are mostly one or two storey structures, recirculation effects associated with urban canyons are also not expected to occur.

Models that can account for complex terrain, such as The Air Pollution Model (TAPM), CALPUFF (an advanced 'puff' dispersion model) and ADMS-Roads[11] are designed to include large-scale terrain features (such as the Tararua Ranges to the east of the Project area), rather than the 'micro-terrain' in the immediate vicinity of the proposed Expressway.

Gaussian dispersion models, such as AUSROADS, CALINE-4 and ADMS-Roads break down at very low wind speeds, which is when the poorest dispersion (and hence worst-case pollutant concentrations) tends to occur. All such models, therefore, specify minimum wind speeds that can be used – 0.5 m/s for AUSROADS, 1.0 m/s for CALINE-4 and 0.75 m/s for ADMS-Roads.

Due to the comparatively simple terrain in the Project area and the fact that regional effects are not considered in the scope of the assessment, AUSROADS is a suitable model in this instance. Dispersion modelling has been undertaken for PM_{10}, NO_x and CO.

AUSROADS does not simulate the reactions of pollutants once discharged into the atmosphere. Consequently, NO_2 concentrations have been estimated from predicted NO_x concentrations using the method detailed in Section 7.5 and Appendix 13.F.

7.2. Configuration options

AUSROADS was configured using the following options:

- Pasquill-Gifford horizontal dispersion profile
- Irwin Rural wind exponent (recommended by the Victorian EPA for rural environments)
- A surface roughness of 0.1m.

The selected surface roughness of 0.1m is representative of open, flat rural areas.

7.3. Receptor grids

Concentrations of pollutants have been predicted at a combination of receptor grids, transects[12] and discrete receptors corresponding to specific residential or commercial premises. The receptors have been defined at ground level.

7.4. Meteorological inputs

Accurate atmospheric dispersion modelling requires good meteorological information that is representative of the dispersion conditions near the emission source, and in a format that can be used by the dispersion model.

For this assessment a 1-year meteorological input file (corresponding to the year 2008) for AUSROADS was constructed using the TAPM v4 ('The Air Pollution Model') meteorological and dispersion model.

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[11] ADMS-Roads – Atmospheric Dispersion Modelling System for small road networks, developed by Cambridge Environmental Research Consultants, Cambridge, UK

[12] In this context, a transect refers to a line of discrete receptor points, at right angles to the road alignment, extending up to 200m in each direction from the centreline of the proposed Expressway outside the proposed Expressway's Designation boundary. The designated boundary of the motorway typically extends 25 - 30m from the motorway centre line.

TAPM, developed by CSIRO, is a sophisticated computer model that predicts the three dimensional meteorology and air pollutant concentrations by solving the fundamental fluid dynamic and scalar transport equations. It consists of coupled diagnostic meteorological and air pollution components that predict the air flows important to local scale air pollution, such as sea breezes, against a background of larger scale synoptic meteorological patterns (Hurley, 1999).

One of the primary functions of the TAPM model is the provision of high quality meteorological data for dispersion models where suitable onsite information is not available. Using historical synoptic scale meteorological analyses in conjunction with local land use and terrain information, TAPM can produce realistic and high quality meteorological inputs for a number of air pollutant dispersion modelling systems including AUSROADS. Validation studies show that TAPM can accurately predict localised meteorological conditions.

To help ensure that the wind fields predicted by TAPM accurately reflects the meteorological conditions near the Project, hourly wind speed and wind direction data recorded at the Paraparaumu Airport meteorological monitoring station (station ID number 8567[13]) were assimilated into the model. The AUSROADS meteorological input file was extracted from TAPM model at the approximate location of the Paraparaumu Airport AWS. At this location, wind flows predicted by TAPM will be representative of those recorded at the airport. The distribution of wind speeds and wind directions recorded at the Paraparaumu Airport for the year 2008 are representative of typical annual wind flow conditions recorded at the meteorological monitoring station.

TAPM was configured with nested grid spacings of 30, 10, 3, and 1km. The 2008 meteorological data input file was generated from the 1km spaced nested grid. Each nested grid was defined using 25 grid points in the east/west direction, 25 grid points in the north/south direction, and 25 vertical layers. Surface vegetation effects, hydrostatic pressure, rain processes and prognostic eddy dissipation options were selected in the simulation (recommended as defaults by CSIRO). Monthly deep soil moisture content was varied with respect to better simulate seasonal variations.

It is important to note that there is always a degree of uncertainty in model predictions. However, TAPM is expected to provide a reasonable statistical assessment of the dispersion conditions at each of the modelled locations.

Meteorological conditions recorded at the airport are expected to be comparable to those in the Project Area due to the proximity of the monitoring site to the Project and the comparatively flat terrain in which the monitoring site and Project are located. The Paraparaumu Airport monitoring site is located approximately 1.4km from the proposed Expressway and the Kāpiti Rd interchange, which is where worst case traffic volumes are expected to occur. Figure 13.11 shows a summary of wind speed and direction extracted from the 1-year meteorological input file for AUSROADS. This shows a similar distribution of wind directions to that recorded at Paraparumu Airport in the years 2008-2011 (refer Figure 13.12), dominated by northeasterly and southwesterly airflows (as would be expected given that data from Paraparaumu airport was used in the generation of the overall TAPM file), albeit with a higher proportion of northwesterly winds.

[13] Data sourced from the CliFlo database, www.cliflo.niwa.co.nz.

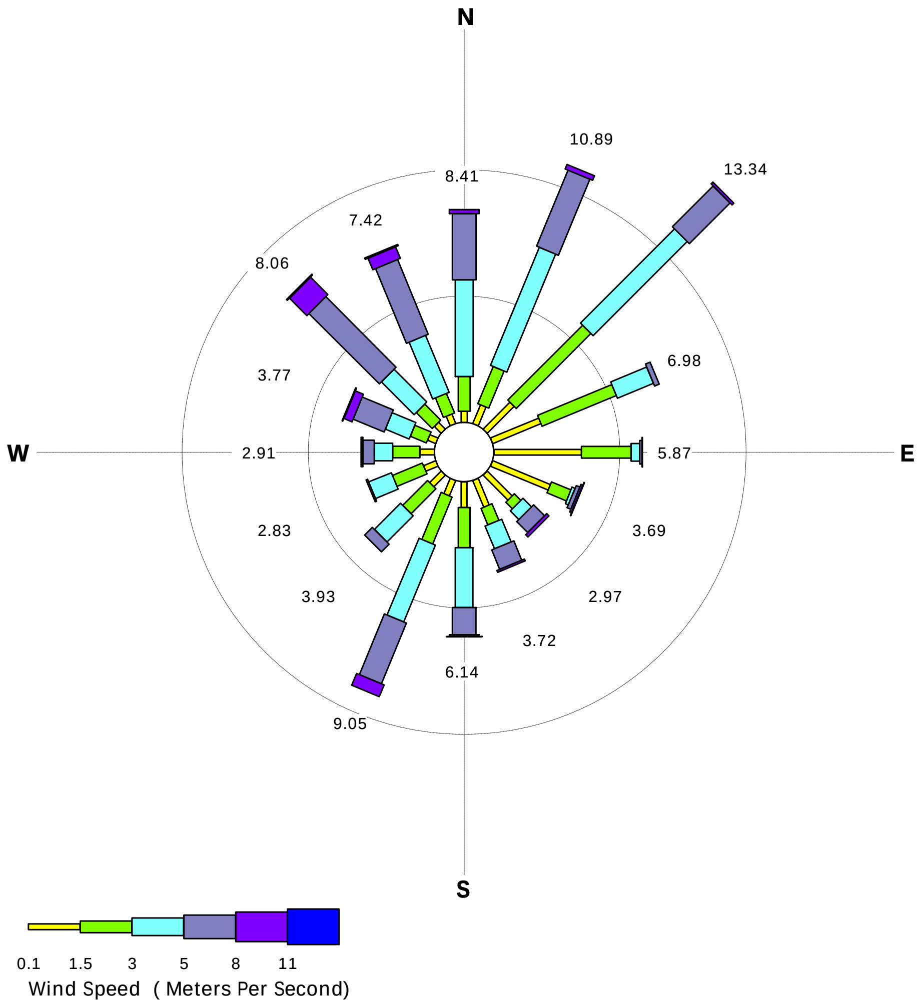

Figure 13.11: Wind speed and wind direction distributions taken from the AUSROADS meteorological input file (based on the Paraparaumu Airport monitoring station)

Figure 13.12 shows the wind speed and wind distributions for Paraparaumu Airport in 2008 and the also for the combined years 2008 to 2011. The figures show that wind flows recorded at the site for the year 2008 are representative of typical wind flows and compare well to the long term average distribution.

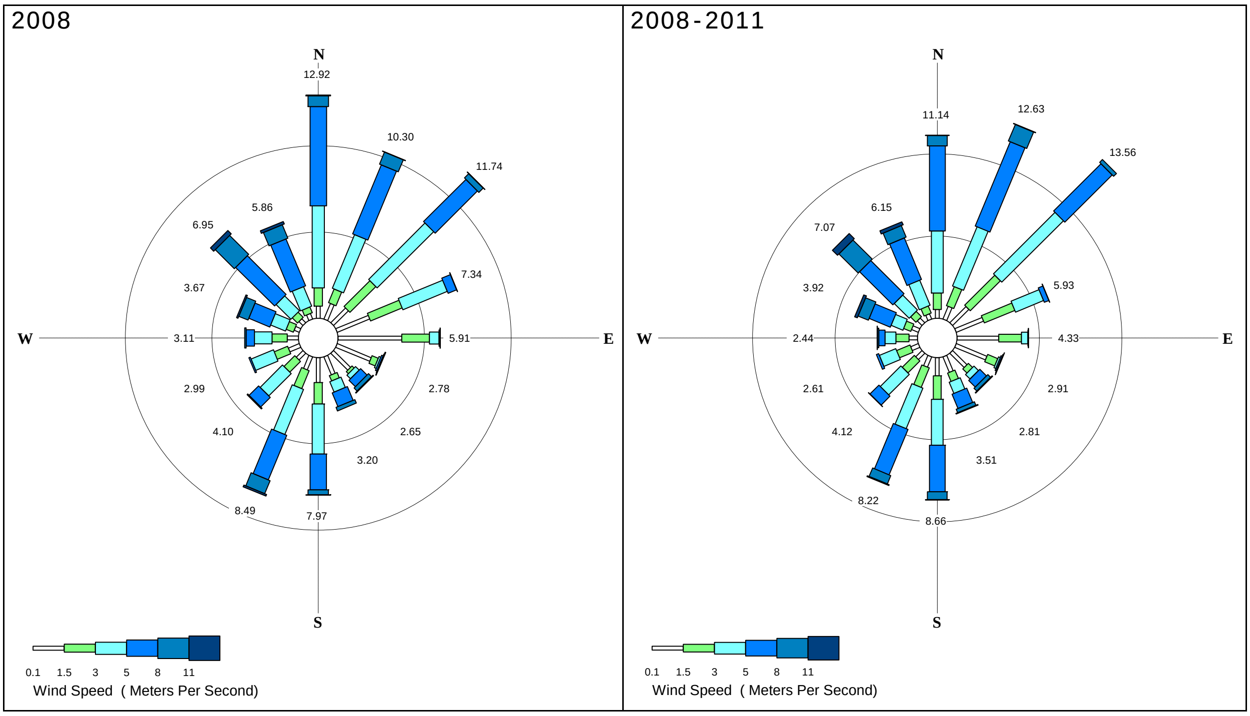

Figure 13.12: Wind speed and wind direction distributions at Paraparaumu Airport

Table 13.16 shows a statistical comparison of wind speed recorded at Paraparaumu Airport between 2008-2011 and those in the AUSROADS meteor logical input file (for the simulated year 2008) The results show a good comparison between the frequency distribution of wind speeds in the recorded at monitoring site and the AUSPLUME input file. The AUSROADS meteorological input file wind speeds are slightly lower than those recorded at the monitoring site.

It should be noted that the lowest wind speed predicted by TAPM is 0.5m/s. This limit corresponds to the lowest wind speed that the AUSROADS dispersion model can use to predict pollutant concentrations. Wind speeds in the meteorological input file which are below this limit are assumed by AUSROADS to be equal to 0.5m/s.

Table 13.16 also shows the frequency distribution of wind speeds recorded at the Raumati Road monitoring station between February and December 2011. The table show that on average, lower wind speeds were recorded at the monitoring station compared to those recorded at Paraparaumu Airport or contained within the AUSROADS input file. The differences between wind speed distributions may in part be due to difference differences in the met mast heights. Wind speeds at Raumati Rd were recorded at a height of 6m above ground level, while those at the airport were recorded at a height of 10m. Wind speeds decrease with decreasing height in response to the increasing effect of surface friction. Differences in surface roughness may also influence wind speeds. Wind speeds at the airport were recorded in a comparatively open field, which will have low a surface roughness. The Raumati Rd monitoring site was located near residential buildings, which would have a higher surface roughness and therefore greater surface friction as well as localised wind flow channellings and turbulence effects. In this case the airport data is more representative of the Project area as a whole.

Table 13.16: Statistical comparison of 1- hour average wind speeds (m/s) from the AUSROADS Meteorological Input File with those recorded at Paraparaumu Airport and the Raumati Road Monitoring Station.

	Average Wind Speeds (m/s)		
	AUSROADS	Paraparaumu	Raumati Road
Minimum	0.5	<0.1	0.2
25th Percentile	2.1	2.5	1.1
Median	3.6	4.1	2.0
75th Percentile	5.1	6.0	2.9
Maximum	11.9	16.0	8.5
Average	3.8	4.3	2.1

7.5. Assessment of Nitrogen Dioxide

The results of both passive sampling of NO_2 near SH1 in Paraparaumu and of continuous monitoring of NO_2 at Raumati Road indicate that current NO_2 concentrations in the Project area are unlikely to exceed the AQNES and GWRAQT air quality criteria level (refer to Section 3.5). However, due to the reactivity of nitrogen oxides once released in the atmosphere, and the absence of any continuous monitoring data in the area, it is difficult to estimate precisely what actual NO_2 concentrations are likely to be in the vicinity of the Project. The methodology for estimating nitrogen dioxide concentrations is detailed in Appendix 13.F.

7.6. Assumptions and Limitations

Introduction

Air quality assessments for new projects rely on statistical models to estimate likely impacts of those projects. The use of statistical models, by the very nature of those models, will introduce a degree of uncertainty into the outcomes, in addition to uncertainty in the raw data used as model inputs.

In this assessment, some raw data has been derived from measurements (e.g. ambient air quality and meteorological monitoring and traffic count data), while other data relies on the outputs from other models (e.g. traffic flows predicted by KTM2, vehicle emission rates from VEPM).

No attempt has been made to quantify the degree of uncertainty in the modelling reported in this assessment (refer section 8.8). The only difference in inputs between the ‘do minimum’ and ‘with Project’ scenarios in 2016 and 2026 is the proposed Expressway itself. Therefore, notwithstanding the inherent uncertainties in the actual results of dispersion modelling, it is reasonable to base conclusions on a comparison of the relative differences between the predicted results of this modelling, both with and without the Project.

Vehicle emissions modelling assumptions

Key assumptions in the determination of vehicle emissions for the Project were:

- In total, 4 scenarios were run: 'Do minimum' and 'With Project' for each of the years 2016 and 2026
- Vehicle emissions were modelled using the results of the traffic modelling as inputs (% HCV, total vehicles and speeds) for each link.
- The traffic flow profile on SH1 Waikanae in 2009 is representative of traffic flow profiles on all roads in the Project area.
- The outputs from the traffic modelling have been taken to be representative of 'worst-case' traffic flows for each road link. No account has been taken of abnormal events resulting in significant congestion on either the proposed Expressway or local roads.
- Average traffic speeds have been assumed to be constant for all 'interpeak' hours.
- The vehicle emission factors are a fleet average "composite" factor. The average "composite" factor is generated using a vehicle fleet profile, which assumes that the overall fleet mix in VEPM is representative of the fleet mix in the Wellington region.
- The proportion of heavy vehicles predicted to travel on roads in the study area in 2016 - 2026 is predicted from traffic modelling to range from 3% to 20%; these values have been used in VEPM. The breakdown of the different HCV categories was reached by increasing or decreasing the 4 categories of HCV in the default VEPM 2016 and 2026 proportionally, except that the proportion of buses was held at 0.6%. The other categories were then adjusted proportionally so that the total fleet composition remained as 100%.
- Non tail pipe (brake and tyre wear) particulate emission factors have been included in the modelling. VEPM provides the option to calculate brake and tyre wear particulate emissions based on the average number of wheels for each vehicle class. In this case the model default settings were used. All of the non-tail particulate emissions are assumed to be PM_{10}.
- The VEPM cold start option was used. When a vehicle is started from cold, emissions are substantially higher, until the engine and catalyst warm up. Cold start emissions were estimated in the model for each vehicle class except HCVs. Cold start emissions are affected by the user defined ambient temperature and average trip length.
- The VEPM degradation option was used. This raises the emissions from both exhaust and non-exhaust sources with the age of vehicle modelled.
- Emission factors are calculated on the predicted average vehicle speed for the modelled section of road. The VEPM model is valid for average vehicle speed between 10 - 110 km/hr. The predicted fleet emission factors therefore do not directly model emission rates near intersections which may vary as consequence of acceleration, deceleration, and engine idling.

Dispersion modelling assumptions

Key assumptions in the dispersion modelling were:

- The background concentrations derived from ambient monitoring undertaken at Raumati Road have been assumed to be representative of current and future ambient air quality in the Project area. There is year to year variability in the results of ambient air quality; in consequence, the actual baseline could be higher than the background concentrations used in this assessment.

- 2008 meteorology used in the dispersion modelling, based in part on the results of meteorological monitoring undertaken at Paraparaumu Airport, is representative of 'worst case' meteorology in the Project area.
- There is no significant change in the climate of the Kāpiti region between 2008 and 2026, i.e. the meteorological data from 2008 is representative of 2016 and 2026.
- A constant worst case background concentration for each pollutant has been added to all modelling results to determine the worst case cumulative ambient concentrations – i.e. the cumulative concentrations presented in this report assume that the contribution from roads in both 'do minimum' and with Project' scenarios occurs simultaneously with and is in addition to the highest measured background.
- Hourly vehicle flows on the proposed Expressway and local roads are assumed to vary according to the same diurnal traffic profile.

8. Assessment of operational air quality effects

This section of the report considers the effects of air pollutants caused by vehicles using the proposed Expressway, focussing on two key areas, as follows:

- Sector 1 between Poplar Road and Raumati Road
- Sector 2 between the Wharemauku Bridge and Mazengarb Road.

These sectors have been selected because they represent the worst case parts of the proposed Expressway due to close proximity of sensitive receptors (residential housing) and, in the case of Sector 2, the highest predicted traffic volumes compared to any other part of the Project area. Any adverse effects on air quality arising from the operation of the proposed Expressway in these Sectors will be at least as great as or greater than those in either Sector 3 or Sector 4.

Atmospheric dispersion modelling has been used to predict the maximum ground level concentrations of PM_{10}, NO_2, CO and benzene at specific receptors and at increasing distances from the proposed Alignment.

Cumulative concentrations of PM_{10}, NO_2 and CO have been calculated by adding the maximum concentrations predicted by dispersion modelling to the assumed maximum background concentration listed in

The predicted maximum cumulative concentrations assumed that worst case background concentrations occur during the period when the contribution from the Project is predicted to be greatest. Predicted cumulative concentrations are therefore expected to be conservative and are likely to overestimate actual ground level concentrations.

The following sections of the report present the highest concentrations of PM_{10}, NO_2, CO and benzene predicted to occur at specific receptors in each sector and the concentrations of PM_{10}, NO_2, CO and benzene predicted to occur at different distances from the centreline of the proposed Expressway. Detailed dispersion modelling results at each specific discrete receptor are presented in Appendix 13.F. Although the air quality standard for NO_2 is stated as the 99.9th percentile of 1-hour average concentrations, a conservative approach has been taken in this assessment of reporting only the maximum predicted concentrations.

8.1. Sector 1

Dispersion modelling results

Dispersion modelling was undertaken for the proposed Expressway between Poplar Avenue and Raumati Road in Sector 1. Dispersion modelling was not carried out in the proposed Expressway south of Poplar Avenue, as there are no residential or other sensitive receptors within 200m of the proposed Expressway in this area. Locations of each of the specific receptors and the 'transects' of increasing distances from the proposed Alignment are presented in Figure 13.13.

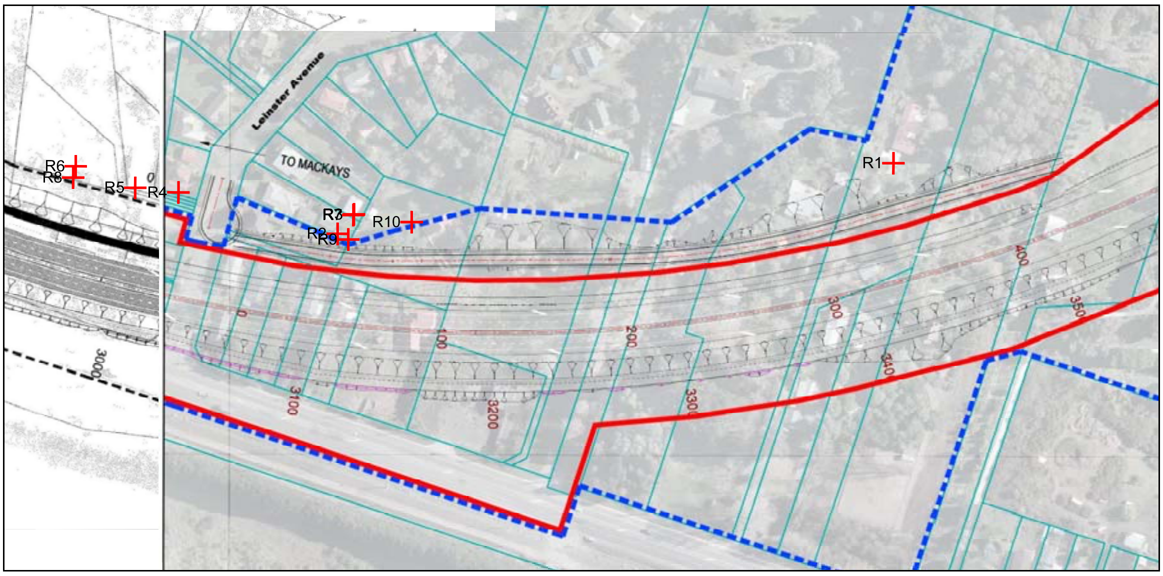

Figure 13.13: Location of discrete receptors close to the proposed Expressway in the vicinity of Leinster Avenue

In Figure 13.13, the red crosses indicate the locations of discrete receptors used for dispersion modelling, while the broken blue and continuous red lines represent the boundaries of the construction and operational Designations respectively.

Table 13.17 summarises the maximum predicted incremental and cumulative concentrations of PM_{10}, NO_2, CO and benzene predicted to occur at the most affected specific receptors close to the proposed Expressway in Sector 1 (residential premises at the eastern end of Leinster Avenue). Table 13.18 and Table 13.19 summarise the maximum predicted incremental and cumulative concentrations of PM_{10} with increasing distance from the proposed Expressway at two locations in Sector 1: near Leinster Avenue (Table 13.18) and Raumati Road (Table 13.19).

The results show predicted maximum incremental concentrations slightly increase in all of the 'with Project' emission scenarios compared to the 'Do Minimum' for the same year. At the most impacted potential receptors located 25 – 50 m from the motorway centreline, 24-hour average PM_{10} concentrations are predicted to increase by 1.4 µg/m^3 between '2026 Do Minimum' and '2026 With Project' options.

Table 13.17: Maximum predicted incremental and cumulative concentrations of PM_{10}, NO_2, CO and benzene predicted for the most affected specific receptors in Sector 1.

Parameter	Averaging Period	Scenario			
		2016		2026	
		Do Minimum	With Project	Do Minimum	With Project
Predicted maximum incremental concentrations					
PM_{10} (µg/m³)	24-hour	0.70	1.17	0.66	1.13
	Annual	0.18	0.35	0.16	0.34
NO_x (µg/m³)	1-hour	32.8	52.1	26.6	39.9
	24-hour	7.62	12.50	6.29	9.46
	Annual	1.93	3.74	1.56	2.84
CO (mg/m³)	1-hour	0.12	0.20	0.05	0.08
	8-hour	0.05	0.07	0.01	0.03
Benzene (µg/m³)	Annual	0.027	0.045	0.021	0.032
Predicted maximum cumulative concentrations					
PM_{10} (µg/m³)	24-hour	34.7	35.2	34.7	35.1
	Annual	13.2	13.4	13.2	13.3
NO_2 (µg/m³)	1-hour	56.3	58.2	55.7	57.0
	24-hour	27.8	28.3	27.6	27.9
	Annual	15.9	17.7	15.6	16.8
CO (mg/m³)	1-hour	8.12	8.20	8.05	8.08
	8-hour	3.05	3.07	3.01	3.03

Table 13.18: Maximum predicted incremental and cumulative 24- hour average concentrations of PM_{10} associated with motor vehicle emissions from the proposed Expressway near Leinster Avenue.

Distance from proposed Expressway Centreline	Scenario			
	2016		2026	
	Do Minimum	With Project	Do Minimum	With Project
Predicted maximum incremental concentrations				
25-50m	0.83	1.70	0.77	1.65
50-100m	0.65	1.08	0.60	1.05
100-150m	0.45	0.67	0.41	0.65
150-200m	0.34	0.51	0.30	0.49
Predicted maximum cumulative concentrations				
25-50m	34.8	35.7	34.8	35.7
50-100m	34.65	35.1	34.6	35.1
100-150m	34.5	34.7	34.4	34.7
150-200m	34.3	34.5	34.3	34.5

Table 13.19: Maximum predicted incremental and cumulative 24- hour average concentrations of PM_{10} associated with motor vehicle emissions from the proposed Expressway near Raumati Road.

Distance from proposed Expressway Centreline	Scenario			
	2016		2026	
	Do Minimum	With Project	Do Minimum	With Project
Predicted maximum incremental concentrations				
25-50m	0.13	1.49	0.12	1.46
50-100m	0.14	0.93	0.13	0.91
100-150m	0.14	0.60	0.13	0.58
150-200m	0.13	0.45	0.12	0.43
Predicted maximum cumulative concentrations				
25-50m	36.13	37.49	36.12	37.46
50-100m	36.14	36.93	36.13	36.91
100-150m	36.14	36.60	36.13	36.58
150-200m	36.13	36.45	36.12	36.43

Figure 13.14 shows a graphical representation of the relative contributions of background sources, existing SH1 and the proposed Expressway to 24-hour average concentrations of PM_{10}. Figure 13.18 shows that the predicted contributions from the proposed Expressway to the existing ambient air quality air are minor in comparison to existing background levels.

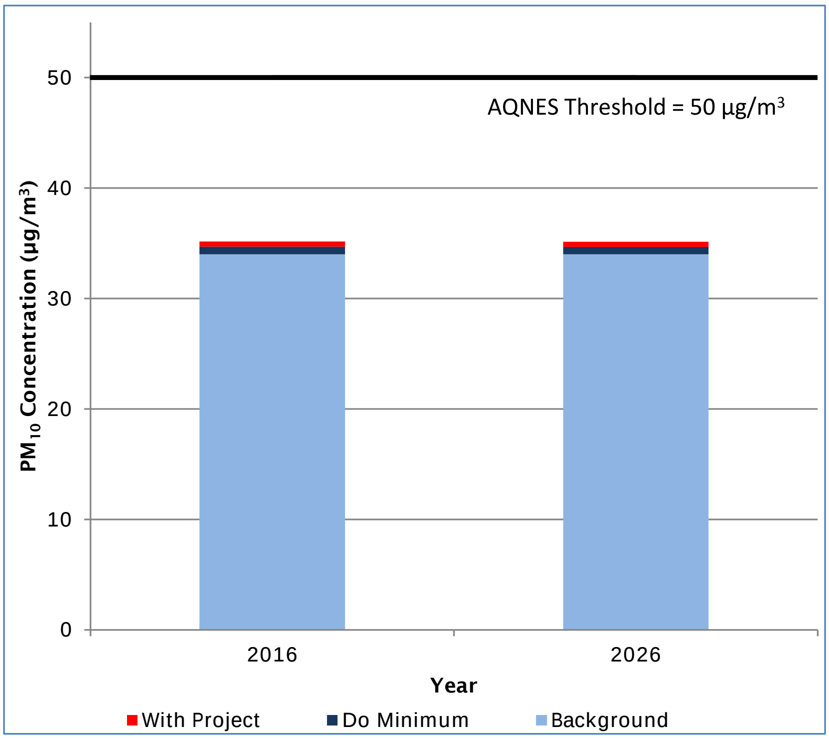

Figure 13.14: Predicted Maximum Cumulative 24- hour Average PM_{10} Concentrations Associated with Motor Vehicle Emissions in Sector 1
(25m from Centreline of proposed Expressway near Leinster Avenue)

Figure 13.15 shows maximum predicted 1-hour average NO_2 concentrations across a transect extending 200m either side of the centreline of the proposed Expressway in Sector 1, along with the approximate location of the closest parts of the proposed cycleway/walkway. The maximum incremental NO_2 concentration to which users of the cycleway/walkway are likely to be exposed in this sector is less than 6 µg/m³ as a 1-hour average.

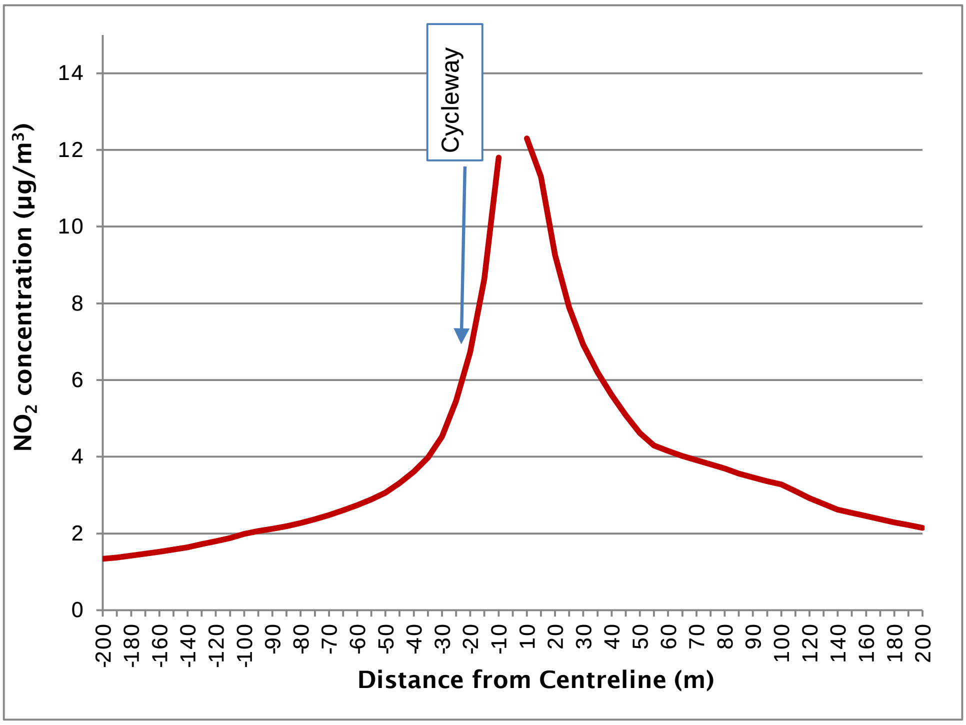

Figure 13.15: Predicted Maximum 1- hour Average NO_2 Concentrations Associated with Motor Vehicle Emissions in Sector 1

Summary of effects in Sector 1

Predicted cumulative concentrations of PM_{10} for each of the modelled emission scenarios are all considerably less than the AQNES of 50 µg/m³ (24-hour average) and the NZAAQG of 20 µg/m³ (annual average). The maximum contribution from the proposed Expressway in 2016 is predicted to be comparatively small (3.0% of the AQNES threshold).

Predicted cumulative 1-hour average NO_2 concentrations for each of the modelled emission scenarios are all considerably less than the 1-hour average AQNES of 200 µg/m³ and the GWRC MDL of 95 µg/m³. Predicted cumulative 24-hour average NO_2 concentrations for each of the modelled emission scenarios are all considerably less than the 24-hour average NZAAQG of 100 µg/m³ and also lower than both the GWRC MDL of 30 µg/m³ and the (annual average) WHO AQG of 40 µg/m³. The maximum contribution from the Project is predicted to be comparatively small (5.2% of the AQNES threshold).

Predicted cumulative 1-hour average CO concentrations for each of the modelled emission scenario are all considerably less than the NZAAQG of 30 mg/m³, and also less than the running 8-hour average AQNES of 10 mg/m³. Predicted cumulative 1-hour average CO concentrations for each of the modelled emission scenarios are lower than the GWRC MDL of 6 µg/m³The maximum contribution from the Project is predicted to be very small (0.7% of the NZAAQG).

The predicted incremental annual average benzene concentrations for each of the modelled emission scenarios are all less than 1.2% of the NZAAQG of 3.6 µg/m³.

8.2. Sector 2

Dispersion modelling results

Table 13.20 to Table 13.21 summarises the maximum predicted incremental and cumulative concentrations of PM_{10}, NO_2, CO and benzene predicted to occur at the most affected specific receptors in Sector 2. These have been assessed in three groups – residential premises near Kāpiti Road (Table 13.20); residential premises near the proposed Expressway (Table 13.21); and commercial premises (Table 13.21). Residential and commercial premises have been reported separately, since commercial premises are generally considered to be less sensitive to air quality impacts than residential locations; due to a lower likelihood of exposure for 24 hours at commercial premises. Locations of each of the specific receptors are presented in Figure 13.16.

Figure 13.16: Location of discrete receptors in the Kāpiti Road interchange model

In Figure 13.16, the green crosses indicate the locations of discrete receptors used for dispersion modelling.

Table 13.22 summarises the maximum predicted incremental and cumulative concentrations of PM_{10} with increasing distance from the proposed Expressway at a location between Kāpiti Road and Mazengarb Road. Figure 13.17 shows a graphical representation of the relative contributions of background sources traffic on Kāpiti Rd and the proposed Expressway to 24-hour average concentrations of PM_{10} (at the most affected residential receptors near Kāpiti Road).

The results show predicted maximum incremental concentrations slightly increase in all of the 'with Project' emission scenarios compared to the 'Do Minimum' for the same year. At the most impacted receptors located 25 – 50 m from the motorway centreline, 24-hour average PM_{10} concentrations are predicted to increase by 2.0 µg/m^3 between '2026 Do Minimum' and '2026 With Project' options.

The closest houses in the Metlifecare Kāpiti Retirement Village to the Project are located approximately 50m from the centreline of the proposed Expressway. At these houses, 24-hour average PM_{10} concentrations are predicted to increase by 1.1 µg/m^3 between '2026 Do Minimum' and '2026 With Project' options.

'Contour plots' of maximum predicted ground level concentrations of PM_{10} in this part of Sector 2 both with and without the Project for the 2016 modelling year (which represents the 'worst case' predictions) are shown in Figure 13.18.

Table 13.20: Maximum predicted incremental and cumulative concentrations of PM_{10}, NO_2, CO and benzene predicted for the most affected residential receptors near Kāpiti Road in Sector 2.

Parameter	Averaging Period	Scenario			
		2016		2026	
		Do Minimum	With Project	Do Minimum	With Project
Predicted maximum incremental concentrations					
PM_{10} (µg/m^3)	24-hour	2.84	3.42	2.51	2.90
	Annual	0.70	0.99	0.77	0.86
NO_x (µg/m^3)	1-hour	95.1	99.9	82.4	74.7
	24-hour	30.1	34.9	22.7	26.4
	Annual	8.1	10.1	6.3	7.8
CO (mg/m^3)	1-hour	0.41	0.61	0.30	0.29
	8-hour	0.25	0.40	0.17	0.18
Benzene (µg/m^3)	Annual	0.18	0.25	0.16	0.18
Predicted maximum cumulative concentrations					
PM_{10} (µg/m^3)	24-hour	38.8	39.4	38.5	38.9
	Annual	13.7	14.0	13.8	13.9
NO_2 (µg/m^3)	1-hour	62.5	63.0	61.2	60.5
	24-hour	30.0	30.5	29.3	29.6
	Annual	22.1	24.1	20.3	21.8
CO (mg/m^3)	1-hour	8.4	8.6	8.3	8.3
	8-hour	3.3	3.4	3.2	3.2

Table 13.21: Maximum predicted incremental and cumulative concentrations of PM_{10}, NO_2, CO and benzene predicted for the most affected residential receptors near the proposed Expressway in Sector 2.

Parameter	Averaging Period	Scenario			
		2016		2026	
		Do Minimum	With Project	Do Minimum	With Project
Predicted maximum incremental concentrations					
PM_{10} (µg/m^3)	24-hour	0.67	1.56	0.58	1.41
	Annual	0.13	0.44	0.14	0.42
NO_x (µg/m^3)	1-hour	23.4	56.5	18.5	49.9
	24-hour	7.1	16.1	5.3	13.5
	Annual	1.5	4.8	1.2	4.1
CO (mg/m^3)	1-hour	0.10	0.29	0.05	0.14
	8-hour	0.06	0.18	0.03	0.09
Benzene (µg/m^3)	Annual	0.03	0.09	0.03	0.07

Predicted maximum cumulative concentrations					
PM_{10} (µg/m^3)	24-hour	36.7	37.6	36.6	37.4
	Annual	13.1	13.4	13.1	13.4
NO_2 (µg/m^3)	1-hour	55.3	58.6	54.9	58.0
	24-hour	27.7	28.6	27.5	28.4
	Annual	15.5	18.8	15.2	18.1
CO (mg/m^3)	1-hour	8.1	8.3	8.1	8.1
	8-hour	3.1	3.2	3.0	3.1

Table 13.22: Maximum predicted incremental and cumulative concentrations of PM_{10}, NO_2, CO and benzene predicted for the most affected commercial receptors near Kāpiti Road in Sector 2.

Parameter	Averaging Period	Scenario			
		2016		2026	
		Do Minimum	With Project	Do Minimum	With Project
Predicted maximum incremental concentrations					
PM_{10} (µg/m^3)	24-hour	3.69	4.33	3.28	3.85
	Annual	1.05	1.12	1.20	1.00
NO_x (µg/m^3)	1-hour	148.8	165.9	117.5	133.3
	24-hour	39.2	45.8	29.7	35.9
	Annual	12.7	11.9	9.6	9.4
CO (mg/m^3)	1-hour	0.61	0.73	0.28	0.35
	8-hour	0.29	0.37	0.13	0.17
Benzene (µg/m^3)	Annual	0.28	0.26	0.19	0.18

Predicted maximum cumulative concentrations					
PM_{10} (µg/m³)	24-hour	39.7	40.3	39.3	39.9
	Annual	14.1	14.1	14.2	14.0
NO_2 (µg/m³)	1-hour	67.9	69.6	64.8	66.3
	24-hour	30.9	31.6	30.0	30.6
	Annual	26.7	25.9	23.6	23.4
CO (mg/m³)	1-hour	8.6	8.7	8.3	8.3
	8-hour	3.3	3.4	3.1	3.2

Table 13.23: Maximum predicted incremental and cumulative 24- hour average concentrations of PM_{10} associated with motor vehicle emissions from the proposed Expressway between Kāpiti Road and Mazengarb Road Avenue.

Distance from proposed Expressway Centreline	Scenario			
	2016		2026	
	Do Minimum	With Project	Do Minimum	With Project
Predicted maximum incremental concentrations				
25-50m	-	1.9	-	2.0
50-100m	-	1.07	-	1.11
100-150m	-	0.59	-	0.59
150-200m	-	0.42	-	0.42
Predicted maximum cumulative concentrations				
25-50m	36.0	37.9	36.0	36.0
50-100m	36.0	37.1	36.0	37.1
100-150m	36.0	36.6	36.0	36.6
150-200m	36.0	36.4	36.0	36.4

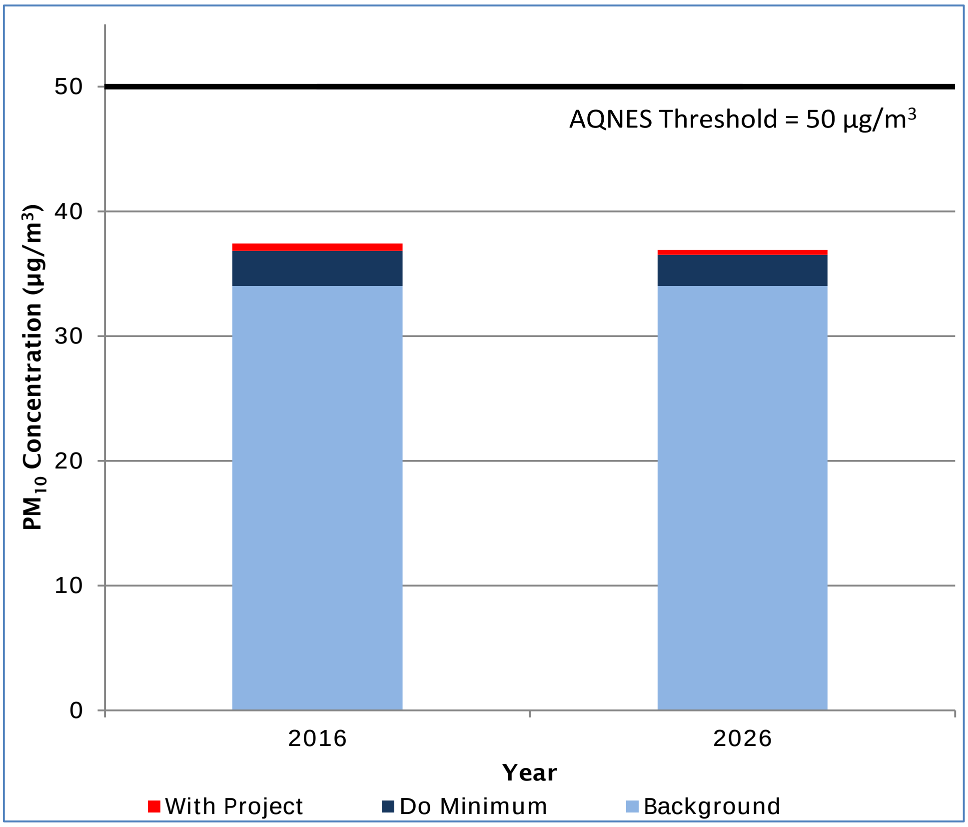

Figure 13.17: Predicted Maximum 24- hour Average PM_{10} Concentrations Associated with Motor Vehicle Emissions in Sector 2

(Residential Premises near Kāpiti Road)

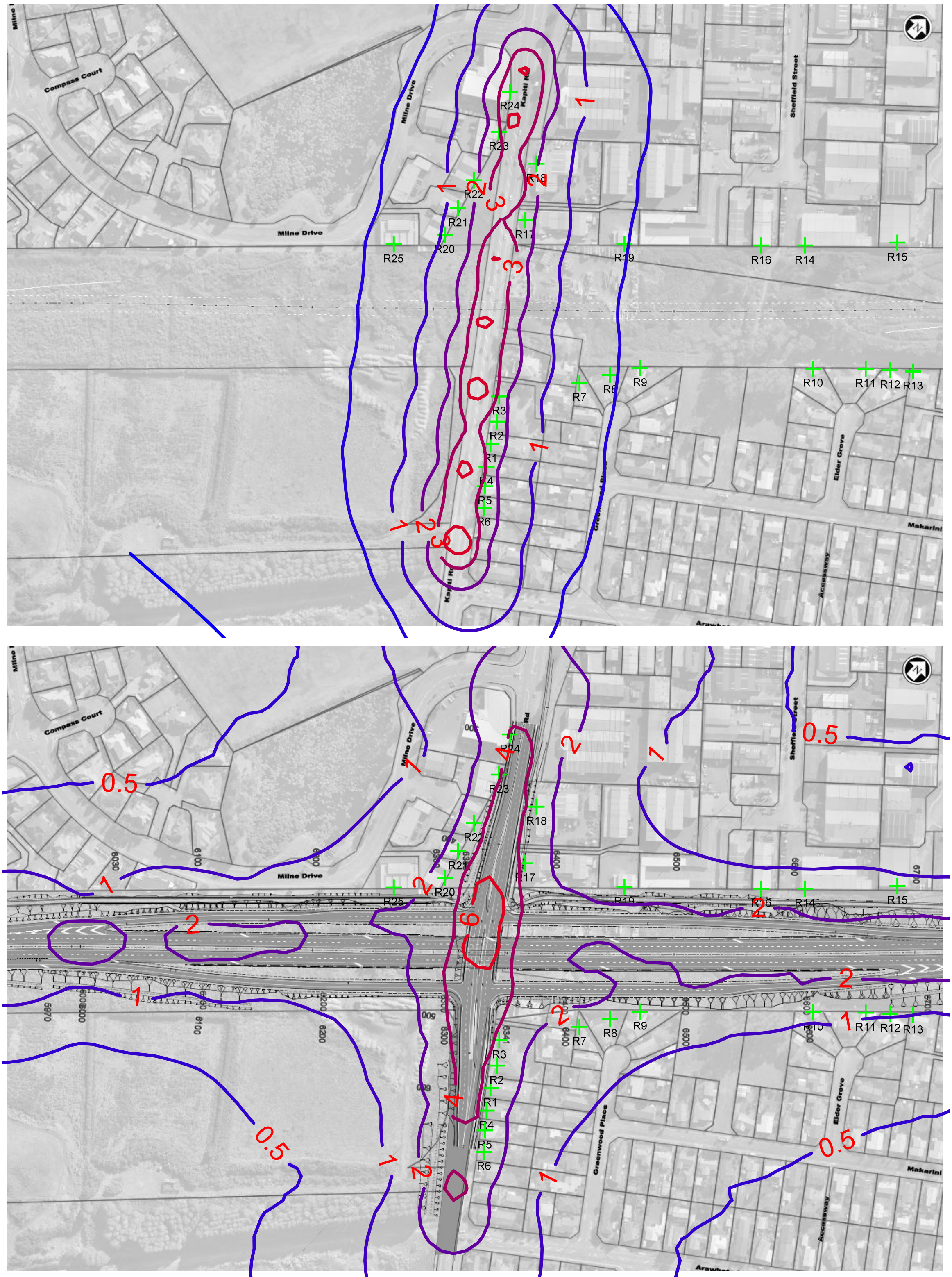

Figure 13.18: Predicted maximum 24-hour average PM_{10} concentrations at Kāpiti Rd Interchange for the 2016 "Do Minimum" (top) and "With Project" (bottom) scenarios

Figure 13.19 shows maximum predicted 1-hour average NO_2 concentrations across a transect extending 200m either side of the centreline of the proposed Expressway between Kāpiti Road and Mazengarb Road in Sector 2, along with the approximate location of the closest parts of the proposed cycleway/walkway. The maximum incremental NO_2 concentration to which uses of the cycleway/walkway are likely to be exposed in this sector is less than 7 µg/m³ as a 1-hour average.

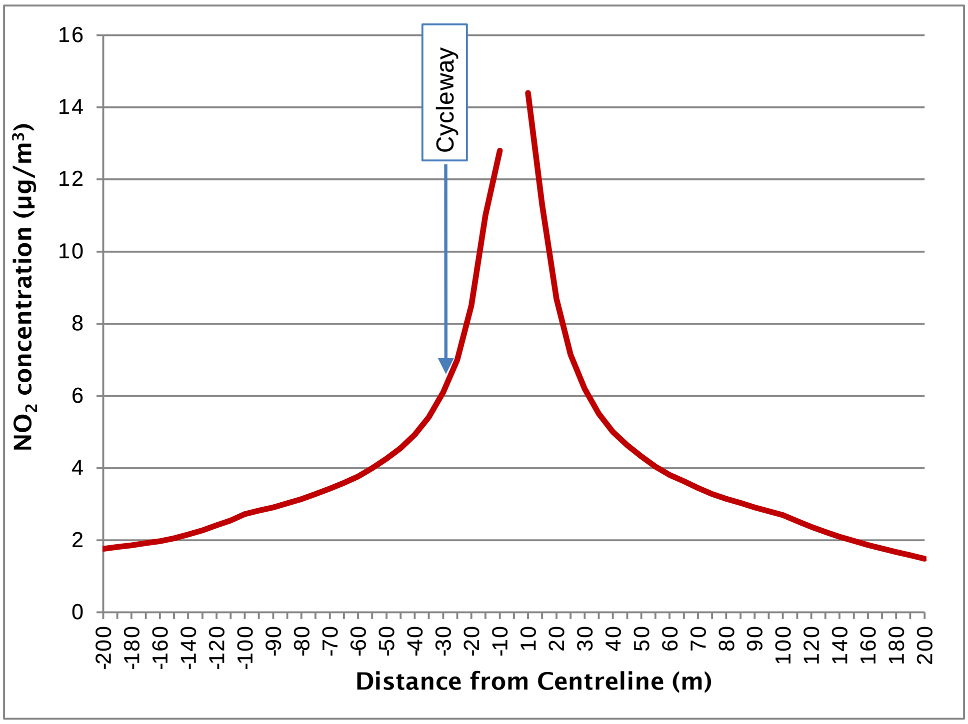

Figure 13.19: Predicted Maximum 1- hour Average NO_2 Concentrations Associated with Motor Vehicle Emissions in Sector 2

Summary of effects in Sector 2

Predicted cumulative concentrations of PM_{10} for each of the modelled emission scenarios are all considerably less than the AQNES of 50 µg/m³ (24-hour average) and the NZAAQG of 20 µg/m³ (annual average). The maximum contribution from the proposed Expressway is predicted to be 4.2% of the AQNES threshold.

Predicted cumulative 1-hour average NO_2 concentrations for each of the modelled emission scenarios are all considerably less than the 1-hour average AQNES of 200 µg/m³, and GWRC Maximum Desirable Level of 95 µg/m³. Predicted cumulative 24-hour average NO_2 concentrations for each of the modelled emission scenarios are all considerably less than the 24-hour average NZAAQG of 100 µg/m³, while predicted cumulative annual average concentrations are considerably less the WHO AQG of 40 µg/m³. The maximum contribution from the Project is predicted to be 8.3% of the AQNES threshold.

Although the highest cumulative 24-hour average NO_2 concentrations are marginally higher that the GWRC MDL of 30 µg/m³, it should be noted that this guideline is intended to "*provide maximum protection to the environment, taking into account existing air quality …*" Cumulative 24-hour average NO_2 concentrations are substantially lower that the GWRC Maximum Acceptable Level of 100 µg/m³, which is defined as being "*adequate to protect the health of individuals*" and apply where "*existing activities [*have*] a significant effect on air quality*". The two main contributions to predicted concentrations of air pollutants in this area are the existing ambient background concentrations and traffic on Kāpiti Road itself.

Predicted cumulative 1-hour average CO concentrations for each of the modelled emission scenario are all considerably less than the NZAAQG of 30 mg/m^3, while predicted cumulative 8-hour average concentrations are less than the running 8-hour average AQNES of 10 mg/m^3 and the GWRC MDL of 6 mg/m^3. The maximum contribution from the Project is predicted to be 2.4% of the NZAAQG.

The predicted incremental annual average benzene concentrations for each of the modelled emission scenarios are all less than 7.3% of the NZAAQG of 3.6 µg/m^3.

Maximum cumulative concentrations of all pollutants are lower than all the relevant assessment criteria (including the GWRC MDL for NO_2 as a 24-hour average) within the Metlifecare Kāpiti Retirement Village.

The output of the traffic modelling identified that, in addition to Kāpiti Road and the proposed Expressway, traffic volumes on Arawhata Road and Mazengarb Road are also likely to exceed the 'significance criteria' listed in section 6.3. These roads have not been included in the dispersion modelling; however, even for the 'worst-case' exposure for any receptor along these roads (e.g. 3 Arawhata Road, located at the junction of Arawhata Road and Kāpiti Road), the maximum increase in 24-hour average PM_{10} concentrations as a result of the operation of the proposed Expressway and consequent changes in traffic flows would be less than about 3 µg/m^3; and would not cause an exceedance of the AQNES threshold concentration for PM_{10}.

8.3. Sector 3

Dispersion modelling has not been undertaken in Sector 3. Predicted traffic volumes on the proposed Expressway between Mazengarb Road and Te Moana Road are the same as those between Kāpiti Road and Mazengarb Road, while predicted traffic volumes on Te Moana Road are significantly lower than those on Kāpiti Road. The closest receptors to any part of the Alignment of the proposed Expressway in Sector 3 are located approximately 75m from the centreline.

The output of the traffic modelling identified that traffic volumes on Park Avenue and Ngarara Road (north of Park Ave) are also likely to exceed the 'significance criteria' listed in section 6.3. These roads have not been included in the dispersion modelling; however, even for the 'worst-case' exposure for any receptor along these roads, the maximum increase in 24-hour average PM_{10} concentrations as a result of the operation of the proposed Expressway and consequent changes in traffic flows would be less than 2 µg/m^3; and would not cause an exceedance of the AQNES threshold concentration for PM_{10}.

As a result, concentrations of air pollutants caused by vehicle emissions in this area will be similar to or lower than those predicted for Sector 2.

8.4. Sector 4

Dispersion modelling has not been undertaken in Sector 4. Predicted traffic volumes on the proposed Expressway between Mazengarb Road and Te Moana Road are similar to those in Sector 1 between Poplar Avenue and Raumati Road, while predicted traffic volumes on the local roads in the sector are relatively low. The closest receptors to any part of the Alignment of the proposed Expressway in Sector 4 are located approximately 75m from the centreline (in the vicinity of Peka Peka Road).

As a result, concentrations of air pollutants caused by vehicle emissions in this area will be similar to or lower than those predicted for Sector 1.

8.5. $PM_{2.5}$ particulate concentrations

A proportion of the PM_{10} emitted from vehicle will be fine particulates with diameters less than 2.5 micrometres ($PM_{2.5}$). Fine particulates have the ability to penetrate deeper into the lungs and therefore have a greater potential to cause respiratory diseases compared to larger particulates. No long term ambient monitoring of $PM_{2.5}$ has been conducted in the Wellington region. A very limited amount of data was collected at the Raumati south site in the period 25 May to 2 August 2010; however this is not considered to be representative of the Project area as a whole (refer Appendix 13.B for detailed discussion) .

Currently there is no AQNES, AAQG or RAAQG for $PM_{2.5}$. Therefore the potential impact of $PM_{2.5}$ emissions has not been assessed in the report. However, an indication of maximum 24-hour average incremental $PM_{2.5}$ levels has been derived based on predicted PM_{10} concentrations. Emissions of $PM_{2.5}$ from traffic have been estimated as the proportion of particulates emitted from vehicle exhausts. Larger particles only are expected to be emitted from tyre and brake wear.

Approximately 55-60% of total particulates emitted from vehicles are estimated to be emitted from vehicle exhausts (based on emission factors in VEPM. Therefore, at the most affected sensitive receptors, the maximum 24-hour average incremental $PM_{2.5}$ concentration for the 2026 'with Project' emissions scenario is estimated to be 1.2 $\mu g/m^3$. (i.e. 60% of the predicted maximum PM_{10} concentration of 2.0 $\mu g/m^3$).

Due to the lack of background data it is not possible to accurately predict cumulative $PM_{2.5}$ concentrations.

8.6. Regional cumulative effects

As the effects of the Project are predicted to be minor, no quantitative assessment of overall community scale exposure has been carried out. However, the following provides a qualitative discussion of the likely regional impacts and thus community exposure.

Regional scale impacts on the Kāpiti airshed will be insignificant, despite a slight increase in vehicle kilometres travelled overall. This is due to improvements in traffic flow through the Project area, combined with the continuing improvements in vehicle emissions generally. The Project will not affect Greater Wellington Regional Council's ability to issue future resource consents within the airshed.

The Project is forecast to improve the overall performance of the road network by improving average vehicle speeds, and reducing traveling times. From an air quality perspective the most important regional effect of the Project is associated with the diversion of a significant proportion of the traffic from the existing SH1 to the proposed Expressway.

Total heavy commercial vehicle movements within the region are also forecast to increase regardless of whether the Project is built or not. Heavy commercial vehicles are higher emitters of pollutants per vehicle kilometre travelled than light vehicles. The Project is predicted to reduce the volume of heavy commercial vehicle traffic using the existing SH1 route as the proposed Expressway becomes the preferred freight transportation corridor.

The Project is expected to result in improved traffic conditions and reduce traffic along the existing SH1 route, and consequently lower vehicle emissions and exposure for residents and commercial premises located next to SH1. Improvement in the level of service at several key local road intersections which link into the existing SH1 are also expected to improve air pollutant levels in adjacent areas.

Higher pollutant concentrations are expected to occur in areas near the proposed Expressway. Changes in traffic patterns within the network will result in increases in traffic volumes on some roads which connect to the proposed Expressway. In areas where the public could be exposed for extended periods of time, maximum predicted pollutant concentrations are less than air quality criteria limits.

8.7. High traffic day

As discussed in Section 6.3 a high traffic day could increase the predicted daily weekday traffic volumes by 10%. A 10% increase in traffic essentially raises the vehicle emissions by approximately 10%, with a consequent increase in effects due to those emissions of 10%. The scale of this effect is shown in Table 13.24 by estimating the impact of a high traffic day on the maximum concentrations at the worst case location for receptors close to the proposed Expressway between Kāpiti Road and Mazengarb Road Avenue, for just one key parameter – 24 hour PM_{10}.

Table 13.24: Effects of a high traffic day on maximum predicted incremental and cumulative 24- hour average concentrations of PM_{10}

Distance from proposed Expressway Centreline	2026 Do Minimum	2026 With Project	2026 With Project + 10%
Predicted maximum incremental concentrations			
25-50m	-	2.0	2.2
Predicted maximum cumulative concentrations			
25-50m	36.0	36.0	36.2

8.8. Assessment of uncertainty

Given the current state of knowledge regarding emissions and atmospheric dispersion (as noted in the MfE Transport GPG) it is not possible to provide a quantitative assessment of the level of uncertainty surrounding the results of this assessment. Uncertainties arise from a number of areas, including:

- The spatial and temporal representativeness of ambient air quality monitoring
- The spatial representativeness of meteorological monitoring
- The use of a number of layers of mathematical models – the results of meteorological and traffic modelling (which are based on observational data) are used as inputs to emission and dispersion models,

To compensate for this, a conservative approach has been taken, where the maximum 24-hour and highest 99.9th percentile 1-hour average concentrations of pollutants predicted by dispersion modelling have been added to background concentrations based on the maxima derived from ambient monitoring. It should also be noted that, even if actual ground level concentrations of vehicle-related air pollutants were twice those predicted by the dispersion modelling, they would be unlikely to cause exceedences of any health-based air quality standard or guideline and the effects would still be minor.

8.9. Summary of operational effects

The highest predicted contribution from vehicles using the proposed Expressway to ground level concentrations of air pollutants are less than 10% of any of the relevant, health-based standards and guidelines, while the highest predicted contribution to 24-hour average PM_{10} concentrations is less than 5% of the AQNES. The highest cumulative concentrations of air pollutants (i.e. including the contributions from background sources, existing roads and the proposed Expressway) are all significantly lower than the relevant, health-based standards and guidelines.

It can therefore be concluded that motor vehicle emissions associated with the operation of the proposed MacKays to Peka Peka Expressway are unlikely to cause adverse effects on human health or the environment. Any adverse effects that may occur can be regarded as minimal.

9. Post Project air quality monitoring and mitigation

The assessment of effects described in section 8 of this report concluded that vehicle emissions associated with the operation of the proposed Expressway are unlikely to cause exceedances of any relevant air discharge assessment criterion or to cause more than minimal adverse effects on human health or the environment. Therefore, it is considered that no mitigation of effects is required.

Given the low relative predicted contribution of vehicles using the proposed Expressway to ambient concentrations of pollutants, it is reasonable to consider that ongoing monitoring of vehicle exhaust emissions associated with the Project is not required.

10. Consideration of alternatives

Section 171(1)(b) of the RMA requires that consideration be given to alternative sites, routes, or methods of undertaking the work for which a designation is being sought.

Air quality was one of a large number of factors considered in the multicriteria analysis (MCA) undertaken to inform the final route selection during the scoping stages of the proposed Expressway. Comments in relation to the air quality considerations are presented in the *M2PP Options Report* (2011). This air quality assessment does not assess these alternative route options or alignments.

At the Project scoping stage, air quality was one of the early issues identified during the constraints analysis of route options. Workshops were held with technical specialists with the aim of identifying key constraints for the route option analysis. Four Expressway route options were identified, analysed and assessed. A multi-criteria assessment (MCA) was undertaken to assess each of the options against a suite of criteria fulfilling the Project objectives and statutory requirements.

The options included following an existing designation, following the existing State highway, and two other modified routes. When short listing Project route options, the Project air quality representative gave preference to routes that moved the road away from sensitive receptors. The existing WLR designation option passed close to two local primary schools (within 100 metres), and would have required the relocation of one school due to construction impacts. In the MCA analysis air quality was rated for each option. The MCA assessment confirmed Route 1, which follows an alignment at the southern end that does not significantly impact the two local schools.

11. Summary and conclusions

This report has assessed the effects on air quality of the Project on all members of the community; particularly those considered to represent the most vulnerable (e.g. school children and the elderly or infirm). Dispersion modelling has been used as the primary tool to quantitatively assess pollutant concentrations in the study area.

The GWRC has classified eight airsheds in the Wellington region where the PM_{10} standard is regularly breached, or are considered to have potential to breach the AQNES. The Project will affect the Kāpiti airshed, which is one of these gazetted airsheds. This assessment has considered the impacts on the Kāpiti airshed as a result of the Project.

The key conclusions of the report can be summarised as follows:

- The maximum predicted cumulative PM_{10} concentration at any receptor located more than 25m from the centreline of any section of the proposed Expressway is 38.3 $\mu g/m^3$ including background, while the maximum incremental contribution from the proposed Expressway to cumulative PM_{10} concentrations is 2.0 $\mu g/m^3$.
- The highest PM_{10} concentrations are predicted to occur at commercial premises close to Kāpiti Road; however the cumulative concentrations are all predicted to be within the relevant air quality criteria. These locations are already impacted by vehicle emissions due to high traffic volumes and the addition of the proposed Expressway makes only a slight increase in incremental PM_{10} concentrations.
- Maximum ground level concentrations of all pollutants are predicted to decrease between 2016 and 2026, largely as a consequence of predicted improvements in the vehicle fleet.
- Maximum ground level concentrations of all pollutants are, in general, predicted to be higher in all 'With Project' scenarios than in 'Do Minimum' scenarios for the same modelling year.
- Changes in traffic volumes on local roads, including the significant increases in vehicle numbers on some roads (e.g. Kāpiti Road, Poplar Avenue, Mazengarb Road, Park Avenue) are unlikely to have a significant impact on concentrations of air pollutants at nearby receptors.
- The reduced level of traffic on the existing SH1 and the consequent reduction in congestion will result in improvements in air quality in the vicinity of this road.
- The results of dispersion modelling indicate that discharges of air pollutants caused by vehicles using the proposed Expressway are unlikely to cause exceedances of any relevant air discharge assessment criterion at any nearby sensitive receptor. It can therefore be inferred that discharges of air pollutants caused by vehicles using the proposed Expressway are also unlikely to cause more than minimal adverse effects on human health or the environment in the surrounding area.
- The Project is not predicted to impact the GWRC's ability to issue future resource consents within the Kāpiti airshed, as the regional effects of the Project on the airshed are minor.
- Given the low level of effects, neither mitigation nor monitoring of operational air quality effects is required.

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Glossary

Abbreviation	Definition	Comment
AADT	Annual Average Daily Total	-
AAQG	Ambient Air Quality Guidelines	Guidelines published by the Ministry for the Environment
AQNES	Air Quality National Environmental Standards	New Zealand National Environmental Standards
ARTEMIS	Assessment and Reliability of Transport Emission Models and Inventory Systems	Used to integrate road gradient into the emission rates calculations.
Atmospheric stability	A measure of the atmosphere's tendency to encourage or deter vertical motion.	Determined by changes in air temperature and humidity with height.
AUSROADS	Atmospheric dispersion model	Roadway dispersion model developed by the Victoria EPA
Background pollutant levels	Refers to existing pollutant levels without the contribution from the Project.	-
CSIRO	Commonwealth Scientific and Industrial Research Organisation	-
CO	Carbon monoxide	-
GIS	Geographical Information System	-
GPG	Good Practice Guide	Assessment guidelines published by the Ministry for the Environment
GWRC	Greater Wellington Regional Council	-
HCV	Heavy Commercial Vehicle	-
LCV	Light Commercial Vehicle	-
Line Source	Used to represent vehicle emissions from road source in the dispersion model	-
Link	Representative of road section in the traffic model	Each link is defined by a starting and ending node points
MfE	Ministry for the Environment	-
mg/m^3	concentration in milligrams per cubic metre	One milligram is one thousandth of a gram
$\mu g/m^3$	concentration in micrograms per cubic metre	One microgram is one millionth of a gram
Neutral atmosphere	When the vertical movement of air is neither assisted nor inhibited by the thermal structure of the atmosphere.	Typical of overcast conditions and/or high wind speeds. May occur during the day or night
NO_x	Nitrogen oxides ($NO + NO_2$)	-
NO	Nitric oxide	-
NO_2	Nitrogen dioxide	-

Abbreviation	Definition	Comment
Node	A geographic points in the traffic model used to define used to define the end points of links	-
PM_{10}	Airborne particulate matter with a diameter less than 10 micrometres	-
$PM_{2.5}$	Airborne particulate matter with a diameter less than 2.5 micrometres	-
RAAQG	Regional Ambient Air Quality Guidelines	-
RMA	Resource Management Act 1991	-
SATURN	Traffic prediction model	-
Stable atmosphere	When the air has little or no tendency to rise and so there is very little vertical movement. A lifted parcel of air will be cooler than its surroundings and so will tend to sink back to its original height	Typical of cool cloudless winter nights with low wind speeds when surface inversions may form
TAPM	The Air Pollution Model	Advanced meteorological and air dispersion model developed by CSIRO
TSP	Total Suspended Particulate	-
USEPA	United States Environmental Protection Agency	-
Unstable atmosphere	When the air is able to rise easily. A lifted parcel of air will be warmer than its surroundings and will keep rising with increasing speed	Typical of hot cloudless summer days when there is a high level of convective heating
VEPM	Vehicle Emission Prediction Model	Vehicle fleet profile prediction and emission rate evaluation
WHO	World Health Organisation	-

Appendix 13.A

Seasonal Windroses

Seasonal wind speed and wind direction distribution at Paraparaumu Airport

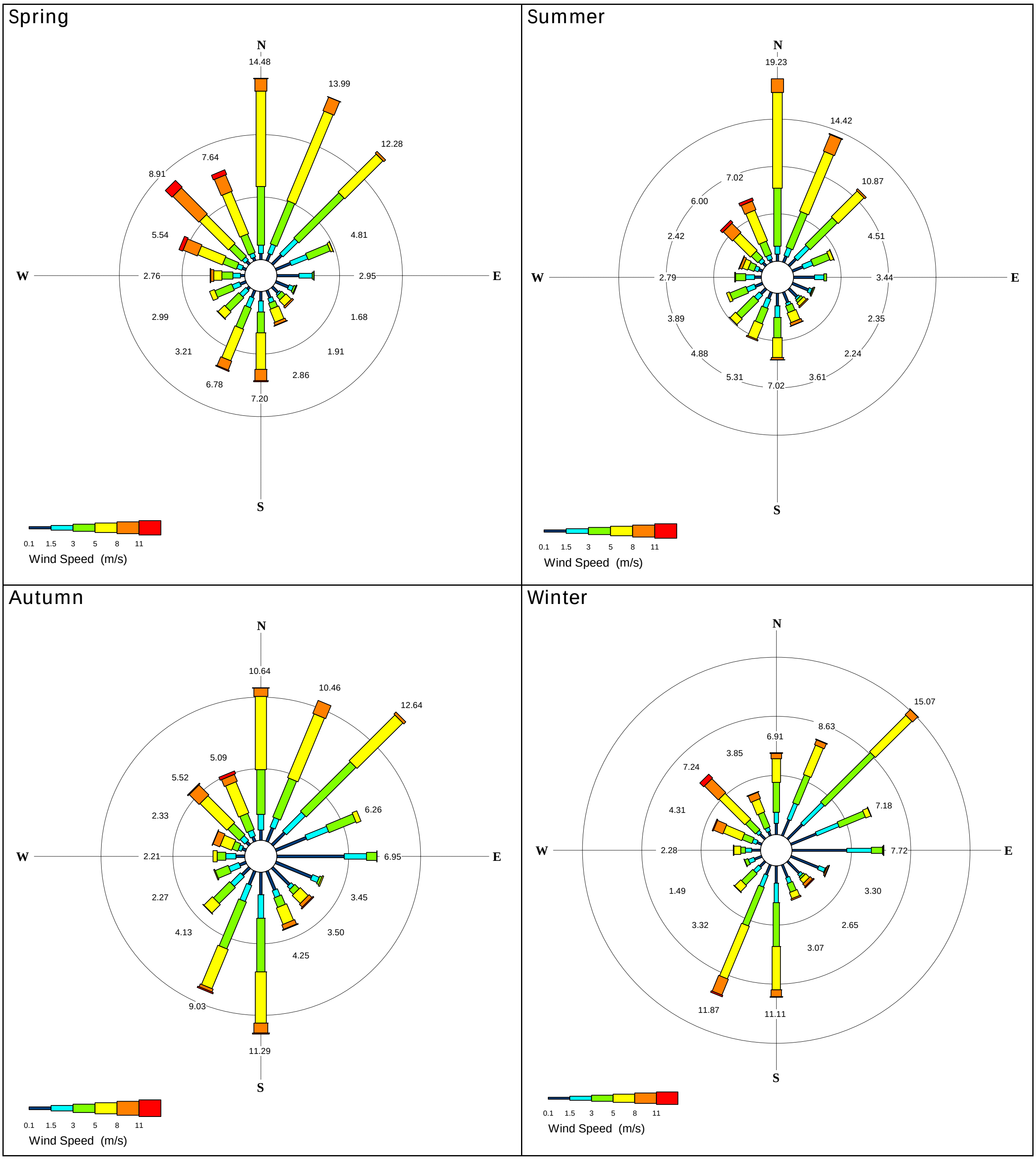

Figure A1: Seasonal wind speed and wind direction distribution at Paraparaumu Airport, 2008-2010

Appendix 13.B

Comparison of Ambient Air Quality Monitoring Sites

Comparison of PM_{10} Concentrations Recorded at the Ambient Air Quality Monitoring Sites

Table B1 summarises the results of ambient monitoring of PM_{10} undertaken by the GWRC in Masterton, Tawa and Raumati South and by the NZTA on Raumati Road, showing the maximum 24-hour average, annual average and number of exceedances of the AQNES threshold concentration (50 µg/m^3) in each monitoring year.

Table B1: 24- Hour and Annual Average PM_{10} and $PM_{2.5}$ Concentrations

Site name Year	Parameter	Maximum 24- hour Average Concentration (µg/m^3)	Highest Annual Average Concentration (µg/m^3)	Highest Annual Number of Exceedances of AQNES
Masterton (2008-2011) #	PM_{10}	66.7	14.2	5
Tawa (2008-2011) #	PM_{10}	32.1	12.9	0
Raumati South (2010) *	PM_{10}	61.7	-	3
Raumati South (2010) *	$PM_{2.5}$	54.6	-	N/A
Raumati Road (2011)	PM_{10}	35.8	12.6	0

Notes:

* The Raumati South site was only operated for nine weeks during 2010, so no annual average concentration has been calculated.

Annual average concentrations for 2011 have been calculated from data recorded to the end of July for Masterton and Tawa

The highest concentrations of PM_{10} recorded at the GWRC Raumati South site during winter 2010 were similar to those recorded at Masterton, despite the differences between the two sites in terms of location and topography. Significantly higher concentrations of PM_{10} were recorded at the Raumati South site in 2010 than at the Raumati Road site during the equivalent months in 2011. Conversely, maximum 24-hour average and annual average concentrations at the Raumati Road site are comparable to those recorded at Tawa. As shown in Figure B1, there is clear evidence of a relationship between 24-hour average concentrations of PM_{10} recorded at the Raumati Road site with those recorded at the Tawa site (albeit with a relatively low coefficient of correlation of 0.61), whereas there is no similar relationship with the results from the Masterton site.

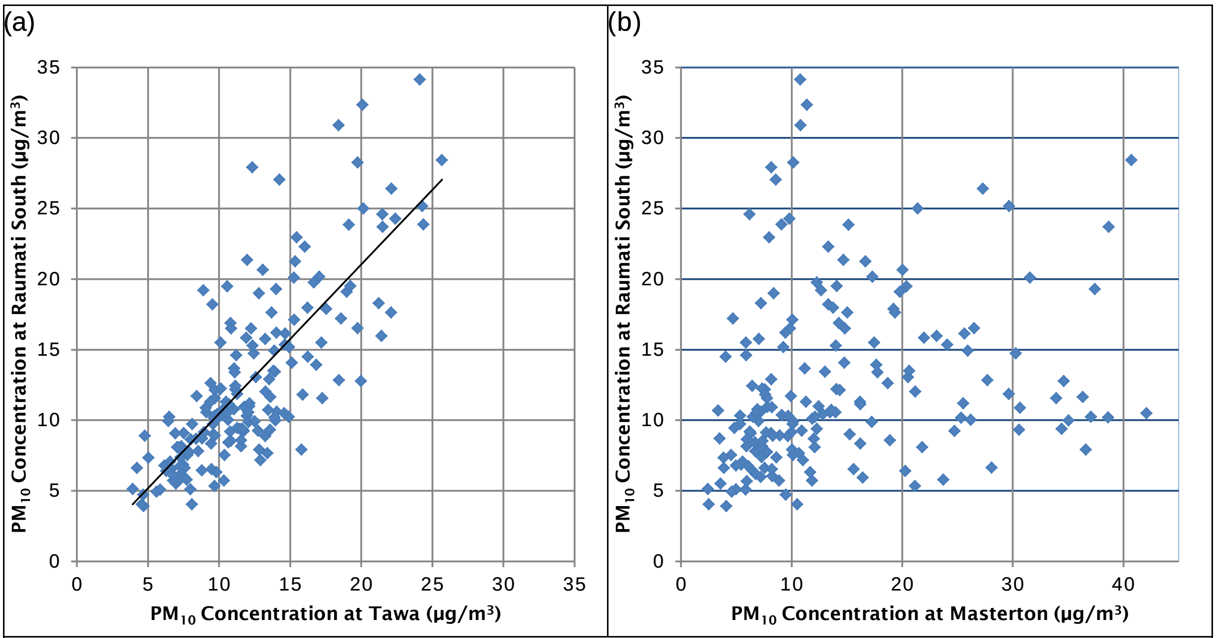

Figure B1: Comparison of 24- Hour Average PM_{10} Concentrations at Raumati Road with (a) Tawa and (b) Masterton

No exceedances of the AQNES threshold concentration for PM_{10} have been recorded at the Tawa monitoring site. Given the apparent relationship between the results recorded at the Tawa site and the Raumati Road site during 2011, it is reasonable to conclude that exceedances of the AQNES threshold concentration for PM_{10} are also unlikely to occur at the Raumati Road site.

Maximum concentrations of PM_{10} recorded at the Raumati Road site in 2011 are substantially lower than those recorded at the GWRC Raumati South site in 2010. The GWRC have published a detailed analysis of the results of monitoring undertaken at the GWRC Raumati South site, which clearly indicates a link to domestic solid fuel heating (GWRC, 2011). That study found that 24-hour average concentrations of fine particulate matter ($PM_{2.5}$ and, to a lesser extent, PM_{10}) were inversely related to daily mean and hourly minimum temperatures, daily mean wind speed and daily percentage of calms (hourly average wind speeds less than 0.5 m/s). This indicates that maximum PM_{10} concentrations at the GWRC Raumati South site occurred on cold, calm days when domestic fires for home heating were more likely to be in use.

A similar analysis has been undertaken for the monitoring results from Masterton (2008-2010), Tawa (2009-2010) and Raumati Road (2011). Figures B2 to B4 are scatter plots showing, for each of these sites, the relationship between 24-hour average PM_{10} concentrations and daily average temperature (Figure B2), daily minimum (hourly) temperature (Figure B3), daily average wind speed (Figure B4).

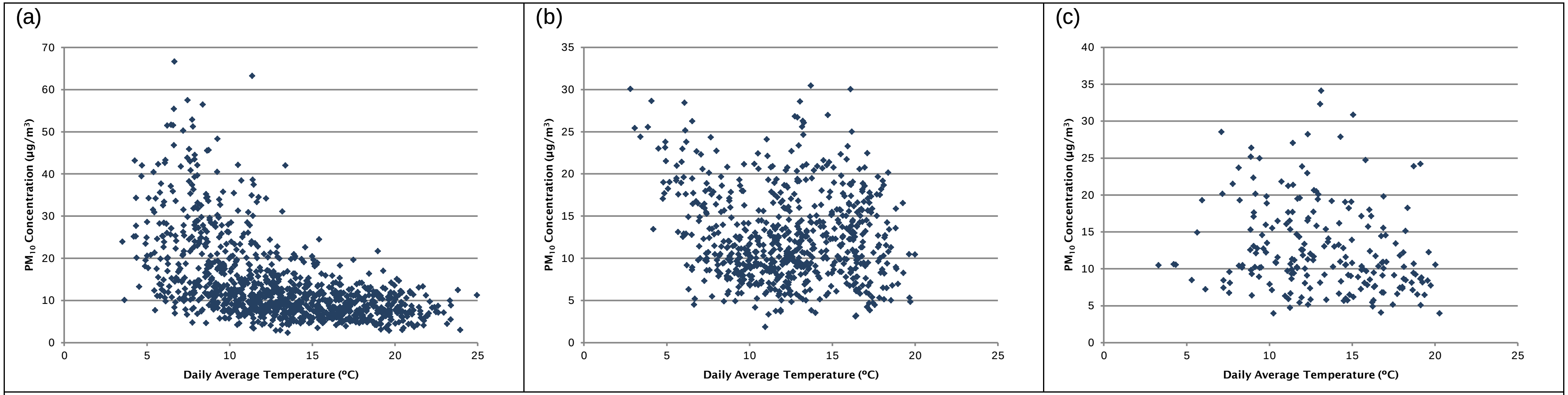

Figure B2: Scatter Plots of 24- Hour Average PM_{10} Concentrations vs. Daily Average Temp. for Masterton (a), Tawa (b) and Raumati Road (c)

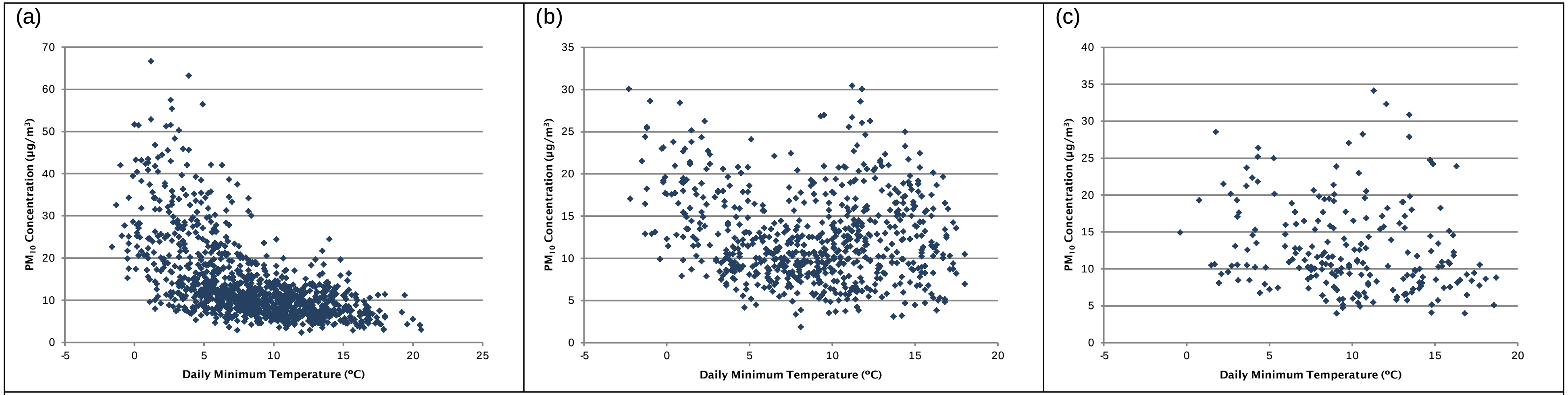

Figure B3: Scatter Plots of 24- Hour Average PM_{10} Concentrations vs. Daily Min. Temp. for Masterton (a), Tawa (b) and Raumati Road (c)

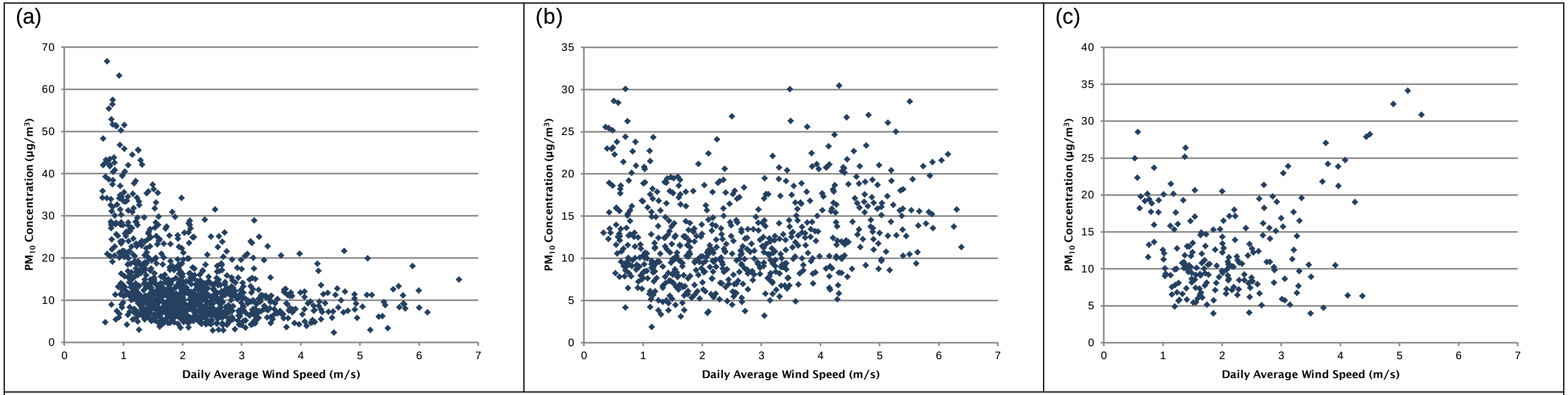

Figure B4: Scatter Plots of 24- Hour Average PM_{10} Concentrations vs. Daily Average Wind Speed for Masterton (a), Tawa (b) and Raumati Road (c)

Figures B2 to B4 show that PM_{10} concentrations at Masterton are strongly inversely related to temperature and wind speed, similar to the relationship observed at the GWRC Raumati South monitoring site. Therefore the Masterton site is also likely to be recording PM_{10} concentrations impacts by domestic solid fuel heating.

However, no such relationship is apparent for either the Tawa or the Raumati Road sites – in fact, the maximum 24-hour average PM_{10} concentration recorded at the Raumati Road site between February and July 2011 coincided with one of the highest daily average wind speeds recorded at that site. This indicates that this peak concentration is likely to be due to dust or salt spray, rather than combustion sources.

The GWRC report into the GWRC Raumati South monitoring campaign notes that air quality at the site may be heavily influenced by the local topography. The GWRC Raumati South site was located in a shallow depression, which is likely to be affected by night-time 'drainage flows' from the surrounding residential areas. Similar influences are unlikely to be observed in the vicinity of the proposed Expressway, largely because, in those locations where 'drainage flows' may occur, there are relatively few sources of domestic heating or other emissions that would contribute to ambient concentrations of PM_{10} (refer section 3.2 of the main body of this report)

The National Institute of Water and Atmospheric Research (NIWA) have developed an internet tool showing the density of solid-fuelled (coal and wood) domestic heating emissions of PM_{10}, based on data from the 2006 census (NIWA, 2009). This indicates that PM_{10} emissions from domestic heating are in excess of 400 g/ha/day in the census mesh blocks surrounding the GWRC Raumati South monitoring site, but are substantially lower in most mesh blocks in the immediate vicinity (i.e. within 100m) of the proposed Expressway (refer Figure B5).

PM_{10} emissions from domestic heating are estimated to be in the range 150-220 g/ha/day in the immediate vicinity of the Raumati Road monitoring site and in excess of 400 g/ha/day in the mesh block immediately to the south of the site (across Raumati Road) and in excess of 300 g/ha/day in mesh blocks to the northeast. These emission rates are similar to the estimated emission rates in the vicinity of the proposed Expressway in the remainder of Sectors 1 and 2 and somewhat higher than those in all other Sectors of the Project (refer Figures B5 and B6).

For these reasons, especially considering the proximity of the Raumati Road monitoring site to the Project, ambient concentrations of PM_{10} recorded at that site are much more representative of ambient air quality in the vicinity of the Project than those recorded at the Raumati South site.

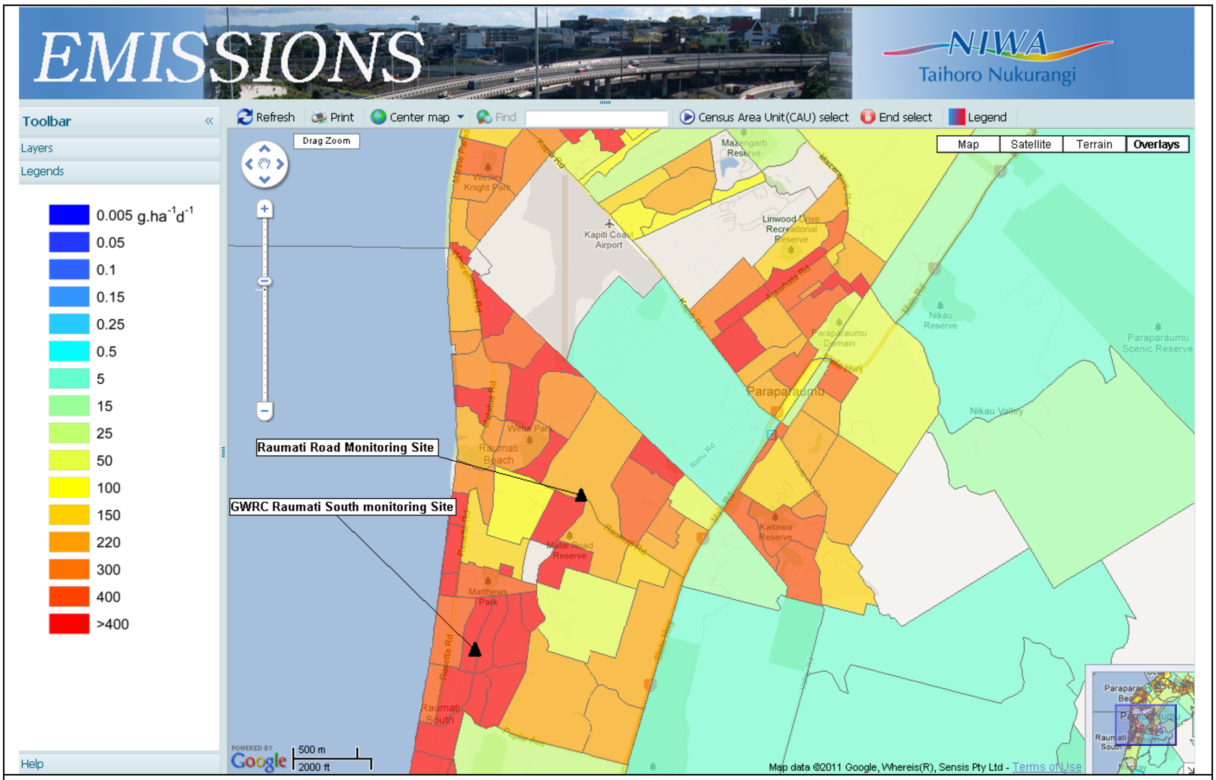

Figure B5: Estimated Domestic Heating PM_{10} Emissions – Sectors 1 and 2

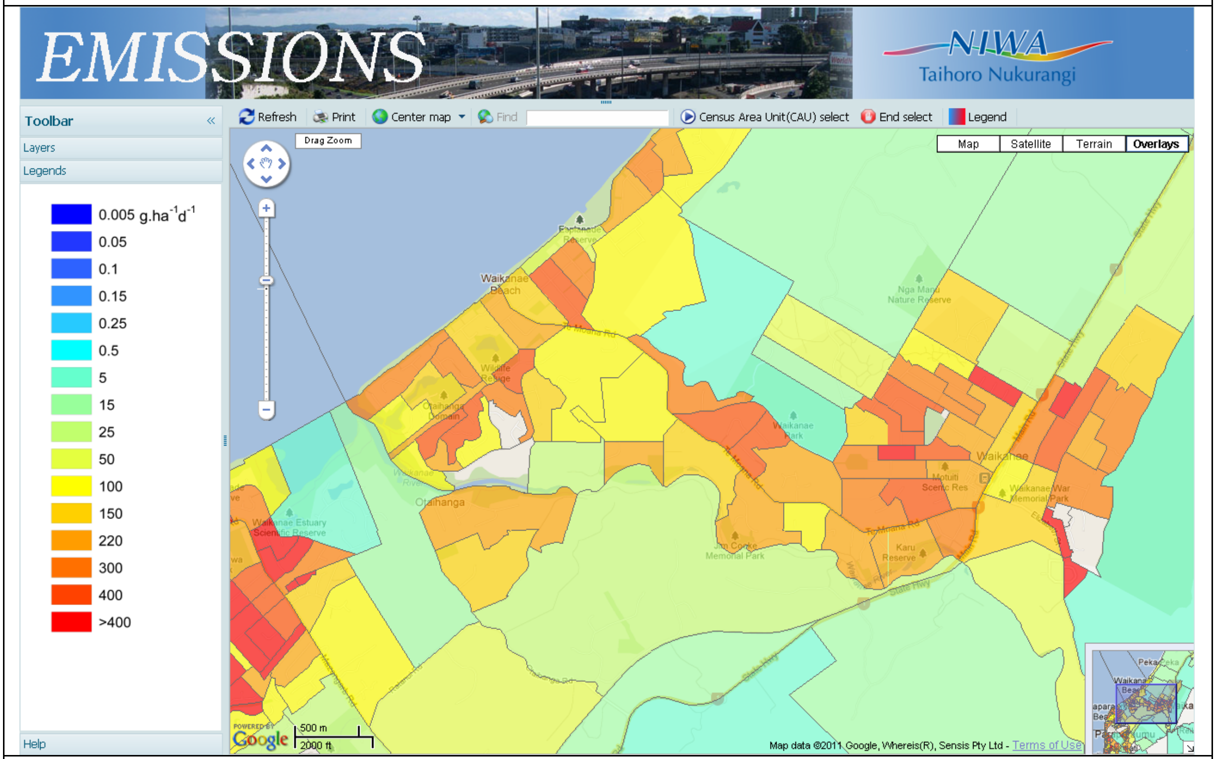

Figure B5: Estimated Domestic Heating PM_{10} Emissions – Sectors 3 and 4

Figure B7 shows a comparison of the winter (May-August) diurnal profiles of PM_{10} concentrations recorded at the Masterton, Tawa and Raumati Road monitoring sites. The peak concentrations occurring at night time and early morning, which illustrates the significant contribution of night-time domestic heating to concentrations of PM_{10} recorded at the Masterton site, and the lower contribution from domestic heating at the Raumati Road and Tawa sites. Monitoring sites that are impacted by vehicle emissions would typically show a distinctive PM_{10} (and NO_2) peak around morning rush hour period from 7-9am.

For the purposes of this assessment, a PM_{10} background concentration of 36 µg/m³ as a 24-hour average has been assumed, corresponding to the maximum 24-hour average concentration recorded at the Raumati Road monitoring site between February and December 2011. In addition to being a representative value for the more 'urban' areas of the Project, this is also a highly conservative value for the rural area

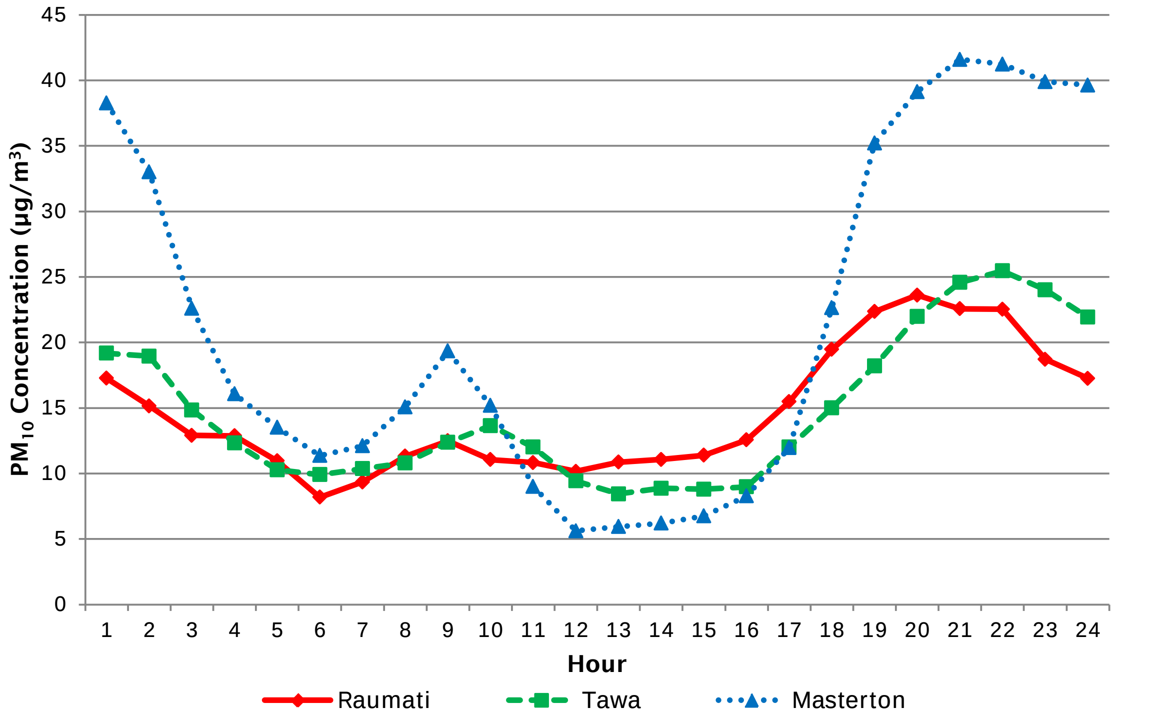

Figure B7: Diurnal Profiles of Winter PM_{10} Concentrations Recorded at the Masterton, Tawa and Raumati Road Monitoring Sites (µg/m³)

Appendix 13.C

Traffic Modelling Outputs

Table C1: 1- hour traffic flows for each link used in assessment

Road Section	Period	2016		2026		2041	
		Do Min	With Project	Do Min	With Project	Do Min	With Project
Expressway							
South of Poplar Avenue	AM Peak	-	2105	-	2538	-	2659
	IP	-	1378	-	1571	-	1594
	PM Peak	-	2407	-	2797	-	2830
Poplar Avenue to Kāpiti Road Interchange	AM Peak	-	1125	-	1347	-	1428
	IP	-	727	-	811	-	811
	PM Peak	-	1194	-	1433	-	1439
Kāpiti Road Interchange – Northbound Off-Ramp	AM Peak	-	136	-	169	-	195
	IP	-	101	-	123	-	120
	PM Peak	-	351	-	414	-	427
Kāpiti Road Interchange – Northbound On-Ramp	AM Peak	-	224	-	286	-	291
	IP	-	287	-	367	-	385
	PM Peak	-	370	-	521	-	543
Kāpiti Road Interchange – Southbound Off-Ramp	AM Peak	-	451	-	693	-	735
	IP	-	243	-	330	-	353
	PM Peak	-	235	-	296	-	317
Kāpiti Road Interchange – Southbound On-Ramp	AM Peak	-	291	-	307	-	323
	IP	-	99	-	102	-	95
	PM Peak	-	95	-	142	-	128
Kāpiti Road Interchange to Te Moana Interchange	AM Peak	-	1372	-	1849	-	1936
	IP	-	1056	-	1284	-	1333
	PM Peak	-	1353	-	1693	-	1744
Te Moana Interchange to Peka Peka Road	AM Peak	-	896	-	1153	-	1185
	IP	-	662	-	766	-	788
	PM Peak	-	885	-	1019	-	1035

Road Section	Period	2016		2026		2041	
		Do Min	With Project	Do Min	With Project	Do Min	With Project
SH1							
South of Poplar Avenue	AM Peak	2052	2105	2374	2538	2448	2659
	IP	1356	1378	1538	1571	1560	1594
	PM Peak	2269	2407	2576	2797	2573	2830
Poplar Avenue to Raumati Road	AM Peak	2194	1113	2510	1320	2569	1362
	IP	1481	766	1684	900	1703	931
	PM Peak	2396	1491	2543	1690	2494	1735
Ngaio Road to Hadfield Road	AM Peak	1527	766	1849	946	1913	988
	IP	1244	597	1410	694	1457	715
	PM Peak	1564	799	1777	936	1777	965
North of Hadfield Road	AM Peak	1484	694	1780	810	1812	831
	IP	1063	512	1195	569	1222	581
	PM Peak	1424	714	1743	808	1743	828
Local Roads							
Kāpiti Road West of Arawhata Road	AM Peak	1660	1652	1740	1703	1804	1792
	IP	2024	2061	2147	2180	2232	2201
	PM Peak	1825	1845	1543	2045	1543	2108
Kāpiti Road East of Milne Crescent	AM Peak	1067	1240	1247	1456	1322	1558
	IP	1296	1394	1507	1563	1599	1634
	PM Peak	1128	1370	1232	1692	1232	1812
Kāpiti Road Milne Crescent to Te Roto Drive	AM Peak	1627	1820	1762	2014	1830	2127
	IP	1934	1984	2085	2161	2169	2195
	PM Peak	1684	1951	1735	2237	1735	2331
Milne Drive	AM Peak	321	277	233	226	242	235
	IP	265	221	247	236	268	256
	PM Peak	336	295	186	298	186	314
Te Moana Road west of Walton Road	AM Peak	445	323	514	370	525	393
	IP	356	251	421	278	435	293
	PM Peak	376	289	527	318	527	329

Table C2: %HCV for each link used in assessment

Road Section	Period	2016		2026		2041	
		Do Min	With Project	Do Min	With Project	Do Min	With Project
Expressway							
South of Poplar Avenue	AM Peak	-	11%	-	13%	-	13%
	IP	-	13%	-	17%	-	18%
	PM Peak	-	5%	-	7%	-	8%
Poplar Avenue to Kāpiti Road Interchange	AM Peak	-	9%	-	10%	-	11%
	IP	-	14%	-	16%	-	17%
	PM Peak	-	4%	-	6%	-	6%
Kāpiti Road Interchange – Northbound Off-Ramp	AM Peak	-	12%	-	19%	-	24%
	IP	-	9%	-	13%	-	15%
	PM Peak	-	3%	-	7%	-	8%
Kāpiti Road Interchange – Northbound On-Ramp	AM Peak	-	7%	-	10%	-	11%
	IP	-	6%	-	9%	-	9%
	PM Peak	-	5%	-	7%	-	8%
Kāpiti Road Interchange – Southbound Off-Ramp	AM Peak	-	5%	-	7%	-	7%
	IP	-	6%	-	10%	-	10%
	PM Peak	-	6%	-	9%	-	9%
Kāpiti Road Interchange – Southbound On-Ramp	AM Peak	-	5%	-	7%	-	7%
	IP	-	9%	-	14%	-	16%
	PM Peak	-	5%	-	8%	-	11%
Kāpiti Road Interchange to Te Moana Interchange	AM Peak	-	8%	-	8%	-	9%
	IP	-	11%	-	13%	-	13%
	PM Peak	-	5%	-	6%	-	6%
Te Moana Interchange to Peka Peka Road	AM Peak	-	11%	-	13%	-	14%
	IP	-	15%	-	19%	-	21%
	PM Peak	-	6%	-	9%	-	10%

Road Section	Period	2016		2026		2041	
		Do Min	With Project	Do Min	With Project	Do Min	With Project
SH1							
South of Poplar Avenue	AM Peak	11%	11%	14%	13%	14%	13%
	IP	13%	13%	17%	17%	18%	18%
	PM Peak	5%	5%	8%	7%	9%	8%
Poplar Avenue to Raumati Road	AM Peak	11%	12%	13%	16%	14%	16%
	IP	13%	12%	16%	16%	17%	17%
	PM Peak	5%	5%	7%	7%	8%	8%
Ngaio Road to Hadfield Road	AM Peak	10%	7%	11%	6%	11%	6%
	IP	13%	10%	15%	9%	15%	9%
	PM Peak	6%	4%	11%	4%	11%	3%
North of Hadfield Road	AM Peak	10%	8%	11%	7%	12%	7%
	IP	14%	10%	17%	10%	18%	10%
	PM Peak	6%	4%	11%	4%	11%	4%
Local Roads							
Kāpiti Road West of Arawhata Road	AM Peak	5%	6%	7%	6%	8%	6%
	IP	5%	5%	5%	5%	5%	5%
	PM Peak	3%	3%	8%	4%	8%	4%
Kāpiti Road East of Milne Crescent	AM Peak	6%	6%	7%	9%	8%	10%
	IP	5%	5%	5%	7%	5%	7%
	PM Peak	3%	3%	7%	6%	7%	6%
Kāpiti Road Milne Crescent to Te Roto Drive	AM Peak	6%	6%	7%	8%	8%	9%
	IP	5%	5%	5%	7%	6%	7%
	PM Peak	3%	3%	7%	5%	7%	6%
Milne Drive	AM Peak	2%	3%	3%	4%	3%	4%
	IP	2%	2%	2%	2%	2%	2%
	PM Peak	2%	2%	0%	3%	0%	3%
Te Moana Road west of Walton Road	AM Peak	4%	5%	4%	5%	4%	5%
	IP	6%	7%	6%	8%	6%	7%
	PM Peak	4%	4%			4%	5%

Table C3: Average speeds for each link used in assessment

Road Section	Period	2016		2026		2041	
		Do Min	With Project	Do Min	With Project	Do Min	With Project
Expressway							
South of Poplar Avenue	AM Peak	-	96	-	95	-	95
	IP	-	96	-	96	-	96
	PM Peak	-	94	-	94	-	94
Poplar Avenue to Kāpiti Road Interchange	AM Peak	-	99	-	99	-	99
	IP	-	99	-	99	-	99
	PM Peak	-	99	-	99	-	99
Kāpiti Road Interchange – Northbound Off-Ramp	AM Peak	-	38	-	38	-	38
	IP	-	38	-	38	-	38
	PM Peak	-	38	-	38	-	38
Kāpiti Road Interchange – Northbound On-Ramp	AM Peak	-	31	-	31	-	31
	IP	-	32	-	32	-	32
	PM Peak	-	32	-	32	-	32
Kāpiti Road Interchange – Southbound Off-Ramp	AM Peak	-	38	-	37	-	37
	IP	-	38	-	38	-	38
	PM Peak	-	38	-	38	-	38
Kāpiti Road Interchange – Southbound On-Ramp	AM Peak	-	32	-	31	-	31
	IP	-	31	-	31	-	31
	PM Peak	-	31	-	31	-	31
Kāpiti Road Interchange to Te Moana Interchange	AM Peak	-	96	-	95	-	95
	IP	-	95	-	96	-	96
	PM Peak	-	95	-	94	-	94
Te Moana Interchange to Peka Peka Road	AM Peak	-	95	-	94	-	94
	IP	-	95	-	95	-	95
	PM Peak	-	95	-	95	-	95

Road Section	Period	2016		2026		2041	
		Do Min	With Project	Do Min	With Project	Do Min	With Project
SH1							
South of Poplar Avenue	AM Peak	105	96	94	95	92	95
	IP	105	96	101	96	100	96
	PM Peak	105	94	62	94	56	94
Poplar Avenue to Raumati Road	AM Peak	76	86	71	84	70	84
	IP	85	88	83	88	82	88
	PM Peak	66	83	61	81	61	81
Ngaio Road to Hadfield Road	AM Peak	48	49	46	49	46	49
	IP	48	49	48	49	47	49
	PM Peak	47	48	46	48	46	48
North of Hadfield Road	AM Peak	41	42	37	42	36	42
	IP	46	43	44	42	44	42
	PM Peak	46	42	40	42	40	42
Local Roads							
Kāpiti Road West of Arawhata Road	AM Peak	42	44	31	31	31	31
	IP	44	45	30	32	29	31
	PM Peak	46	46	31	31	31	31
Kāpiti Road East of Milne Crescent	AM Peak	51	50	50	50	50	50
	IP	50	50	50	50	50	50
	PM Peak	51	51	50	50	50	49
Kāpiti Road Milne Crescent to Te Roto Drive	AM Peak	28	30	32	30	31	28
	IP	25	30	30	27	29	26
	PM Peak	29	31	25	27	25	25
Milne Drive	AM Peak	37	36	27	32	26	31
	IP	35	35	25	32	24	31
	PM Peak	35	34	36	31	36	30
Te Moana Road west of Walton Road	AM Peak	53	53	53	53	53	53
	IP	53	53	53	53	53	53
	PM Peak	53	53	53	53	53	53

Appendix 13.D

Significant Changes in Traffic Flows

The following table summarises the predicted increases in AADT and %HCV between the respective 'Do Minimum and 'With Project' scenarios for each road link in the Project area where the predicted 'With Project' AADT is greater than 7,000 vehicles per day. Uni-directional flows on each road link have been combined to a bi-directional flow for this purpose.

Link ID		Road	Section			Direction		2006-2010		2016						2026					
										DoMin		WP		Change		DoMin		WP		Change	
								%HCV	AADT	%HCV	AADT	%HCV	AADT	%HCV	AADT	%HCV	AADT	%HCV	AADT	%HCV	AADT
L1	L2	Old SH1	Sth	of	Poplar Interchange Ramps	N	S	12%	22273	14%	22500	14%	23089	-2%	3%	18%	25832	17%	26909	-4%	4%
L5	L6	Old SH1	Sth	of	Raumati Rd	N	S	12%	23057	13%	24276	13%	12991	-7%	-46%	17%	27497	17%	15303	-2%	-44%
L7	L8	Old SH1	Sth	of	Ihakara Rd	N	S	12%	23090	12%	25015	10%	14818	-19%	-41%	16%	27421	13%	16068	-20%	-41%
L9	L10	Old SH1	Nth	of	Ihakara Rd	N	S	12%	22652	12%	24800	10%	15420	-22%	-38%	15%	27964	10%	16728	-34%	-40%
L11	L12	Old SH1	Sth	of	Kāpiti Rd	N	S	11%	26942	11%	29022	8%	19583	-24%	-33%	14%	31777	9%	21157	-36%	-33%
L13	L14	Old SH1	Nth	of	Kāpiti Rd	N	S	12%	23132	13%	24760	11%	13381	-18%	-46%	14%	27923	10%	15061	-27%	-46%
L15	L16	Old SH1	Sth	of	Amohia St	N	S	12%	23132	13%	24760	11%	13381	-18%	-46%	14%	27923	10%	15061	-27%	-46%
L17	L18	Old SH1	Sth	of	Otaihanga Rd	N	S	12%	22380	13%	22605	12%	10658	-7%	-53%	14%	25520	11%	11729	-19%	-54%
L19	L20	Old SH1	Nth	of	Otaihanga Rd	N	S	11%	27038	12%	27533	10%	13344	-12%	-52%	14%	32123	10%	14932	-29%	-54%
L23	L24	Poplar Ave	Wst	of	Old SH1	E	W	8%	3214	7%	3474	11%	9519	51%	174%	8%	3532	14%	11105	74%	214%
L39	L40	Raumati Rd	Wst	of	Rimu Rd	E	W	4%	12947	5%	15101	5%	14280	-4%	-5%	8%	17710	7%	16299	-11%	-8%
L43	L44	Raumati Rd	Wst	of	Hillcrest Rd	E	W			10%	11143	9%	10662	-1%	-4%	14%	12407	13%	11412	-7%	-8%
L45	L46	Rimu Rd	Sth	of	Ihakara Rd	N	S	3%	10671	3%	11151	3%	10811	4%	-3%	3%	13897	3%	13613	4%	-2%
L47	L48	Rimu Rd	Nth	of	Ihakara Rd	N	S	3%	12987	5%	12435	5%	11232	0%	-10%	3%	11488	3%	11406	-3%	-1%
L49	L50	Ihakara Rd	Est	of	Rimu Rd	E	W	5%	6891	7%	7749	7%	6875	-3%	-11%	8%	10902	10%	10670	14%	-2%
L51	L52	Ihakara Rd	Wst	of	Rimu Rd	E	W	0%	18	1%	1115	1%	1065	-4%	-4%	8%	9483	9%	9502	10%	0%
L63	L64	Rimu Rd	Sth	of	Kāpiti Rd	N	S	4%	19627	5%	19444	5%	18750	-2%	-4%	4%	15480	4%	15408	-15%	0%
L67	L68	Arawhata Rd	Nth	of	Kāpiti Rd	N	S	3%	7787	4%	7768	4%	7431	25%	-4%	5%	6138	4%	6236	-16%	2%
L69	L70	Arawhata Rd	Nth	of	Tutanekai St	N	S	8%	5876	8%	5996	7%	7254	-11%	21%	8%	6312	7%	7908	-18%	25%

Link ID		Road	Section			Direction		2006- 2010		2016						2026					
										DoMin		WP		Change		DoMin		WP		Change	
								%HCV	AADT	%HCV	AADT	%HCV	AADT	%HCV	AADT	%HCV	AADT	%HCV	AADT	%HCV	AADT
L71	L72	Amohia St	Nth	of	Old SH1	N	S	13%	3673	11%	4986	9%	6932	-19%	39%	12%	5061	9%	8497	-26%	68%
L73	L74	Kāpiti Rd	Wst	of	Old SH1	E	W	7%	16030	7%	16062	6%	13496	-18%	-16%	10%	18104	6%	13635	-39%	-25%
L75	L76	Kāpiti Rd	Est	of	Rimu Rd	E	W	7%	17235	7%	17477	6%	14919	-16%	-15%	9%	19486	6%	15171	-39%	-22%
L77	L78	Kāpiti Rd	Wst	of	Rimu Rd	E	W	6%	28836	6%	28999	6%	27176	-5%	-6%	8%	24980	6%	22473	-30%	-10%
L79	L80	Kāpiti Rd	Est	of	Arawhata Rd	E	W	5%	28585	5%	29430	5%	28936	-1%	-2%	8%	25063	6%	25554	-26%	2%
L81	L82	Kāpiti Rd	Wst	of	Arawhata Rd	E	W	5%	24916	6%	27171	6%	27587	5%	2%	7%	28077	6%	29314	-12%	4%
L83	L84	Kāpiti Rd	Est	of	Sthbnd Ramps	E	W					6%	27587	N/A	N/A			6%	29314	N/A	N/A
L85	L86	Kāpiti Rd	Est	of	Nthbnd Ramps	E	W					6%	27704	N/A	N/A			7%	29968	N/A	N/A
L87	L88	Kāpiti Rd	Wst	of	Nthbnd Ramps	E	W					6%	13519	N/A	N/A			8%	15150	N/A	N/A
L95	L96	Te Roro Drv	Nth	of	Kāpiti Rd	N	S	9%	10260	9%	11621	9%	11196	7%	-4%	10%	12443	9%	12152	-7%	-2%
L97	L98	Kāpiti Rd	Wst	of	Milne Cres	E	W	6%	23601	6%	25949	7%	27385	9%	6%	7%	27902	8%	30227	14%	8%
L99	L100	Kāpiti Rd	Wst	of	Te Roro Drv	E	W	5%	15658	6%	17328	6%	19141	8%	10%	7%	20063	8%	22010	15%	10%
L101	L102	Kāpiti Rd	Est	of	Hurley Rd	E	W	6%	12805	6%	13529	6%	15202	8%	12%	7%	14384	8%	16044	19%	12%
L103	L104	Kāpiti Rd	Wst	of	Hurley Rd	E	W	6%	8648	6%	9888	7%	10773	16%	9%	7%	9232	7%	10198	11%	10%
L115	L116	Mazengarb Rd	Est	of	Ratanui Rd	E	W	8%	7357	8%	7696	7%	7709	-10%	0%	10%	8743	7%	8349	-27%	-5%
L117	L118	Mazengarb Rd	Est	of	Realm Rd	E	W	9%	5389	9%	5564	8%	6360	-11%	14%	9%	6081	7%	7551	-17%	24%
L123	L124	Old SH1	Sth	of	Te Moana Rd	N	S	10%	26909	11%	27475	9%	13278	-20%	-52%	13%	31932	8%	14816	-36%	-54%
L125	L126	Old SH1	Nth	of	Te Moana Rd	N	S	11%	22457	13%	22317	9%	12623	-28%	-43%	15%	25425	9%	13892	-43%	-45%
L127	L128	Old SH1	Nth	of	Elizabeth St	N	S	11%	20727	12%	22497	8%	12850	-34%	-43%	14%	26043	7%	14851	-50%	-43%
L129	L130	Old SH1	Nth	of	Ngaio Rd	N	S	13%	18257	14%	18911	10%	9161	-26%	-52%	17%	21823	9%	10742	-44%	-51%
L131	L132	Old SH1	Sth	of	Hadfield Rd	N	S	14%	15938	15%	16712	11%	7997	-26%	-52%	18%	19455	11%	8977	-43%	-54%
L135	L136	Te Moana Rd	Wst	of	Marae Ln	E	W	6%	11855	6%	11614	7%	7085	13%	-39%	6%	13608	7%	7773	16%	-43%
L139	L140	Elizabeth St	Est	of	Old SH1	E	W	6%	8106	6%	8482	6%	8630	-2%	2%	6%	9471	6%	9681	-9%	2%

Link ID		Road	Section			Direction		2006- 2010		2016						2026					
										DoMin		WP		Change		DoMin		WP		Change	
								%HCV	AADT	%HCV	AADT	%HCV	AADT	%HCV	AADT	%HCV	AADT	%HCV	AADT	%HCV	AADT
L141	L142	Ngaio Rd	Wst	of	Old SH1	E	W	7%	6539	7%	8006	6%	7508	-6%	-6%	7%	9070	6%	8392	-12%	-7%
L145	L146	Ngarara Rd	Nth	of	Park Ave	N	S	7%	4544	6%	6056	5%	6564	-10%	8%	5%	8258	4%	9371	-22%	13%
L149	L150	Park Ave	Est	of	Walton Rd	E	W	7%	3416	6%	4523	5%	5460	-15%	21%	6%	5941	4%	7538	-27%	27%
L159	L160	Te Moana Rd	Est	of	Te Moana Interchange SBD Ramps	E	W					7%	7401	N/A	N/A			6%	8902	N/A	N/A
L161	L162	Te Moana Rd	Est	of	Te Moana Interchange NBD Ramps	E	W					7%	8314	N/A	N/A			6%	9996	N/A	N/A
L163	L164	Te Moana Rd	Wst	of	Te Moana Interchange NBD Ramps	E	W					6%	8804	N/A	N/A			6%	10646	N/A	N/A
L181	L182	Old SH1	Nth	of	Sth Ōtaki Int.	N	S			17%	7063	17%	7206	-1%	2%	21%	7896	19%	8148	-9%	3%
L189	L190	Expressway	Sth	of	Poplar Int.	N	S					14%	23089	N/A	N/A			17%	26909	N/A	N/A
L191	L192	Expressway	Nth	of	Poplar Int.	N	S					14%	12061	N/A	N/A			16%	13911	N/A	N/A
L193	L194	Expressway	Nth	of	Kāpiti Int.	N	S					12%	16167	N/A	N/A			13%	20182	N/A	N/A
L195	L196	Expressway	Nth	of	Te Moana Int.	N	S					16%	10383	N/A	N/A			20%	12357	N/A	N/A
L197	L198	Expressway	Nth	of	Peka Peka Int.	N	S					15%	13521	N/A	N/A			18%	15909	N/A	N/A
L199	L200	Expressway	Nth	of	Sth Ōtaki Int.	N	S			13%	7815	12%	8032	-3%	3%	17%	9577	16%	9622	-6%	0%
L201	L202	Expressway	Nth	of	Nth Ōtaki Int.	N	S			14%	12212	14%	12439	-2%	2%	17%	14851	16%	14744	-4%	-1%

Appendix 13.E

Summary of Dispersion Modelling

AUSROADS dispersion model configurations

E1 Sector 1 Interchange Models

Figure E1 shows the line sources and discrete receptors incorporated in the AUSROADS 2016 and 2026 “With Project” and “Do Minimum” Sector 1 dispersion models. The start and end of each of the modelled line sources is indicated by circles. For ease of identification each line source has been assigned an identification number (i.e. 1 – 24) also shown in the figure. Line sources 20 to 24 corresponding to the existing SH1. Only these line sources were included in the “Do Minimum” dispersion models. These emission sources are shown as dashed lines in the figure.

The red crosses show the location of the discrete receptor points at the residential properties that are most likely to be affected by the Project. The lines of blue crosses have been used to assess pollutant levels with respect to distance from the road. Line sources and receptor points have been defined using a local coordinate system.

Figure E2 shows the location of discrete receptors with respect to nearby roads.

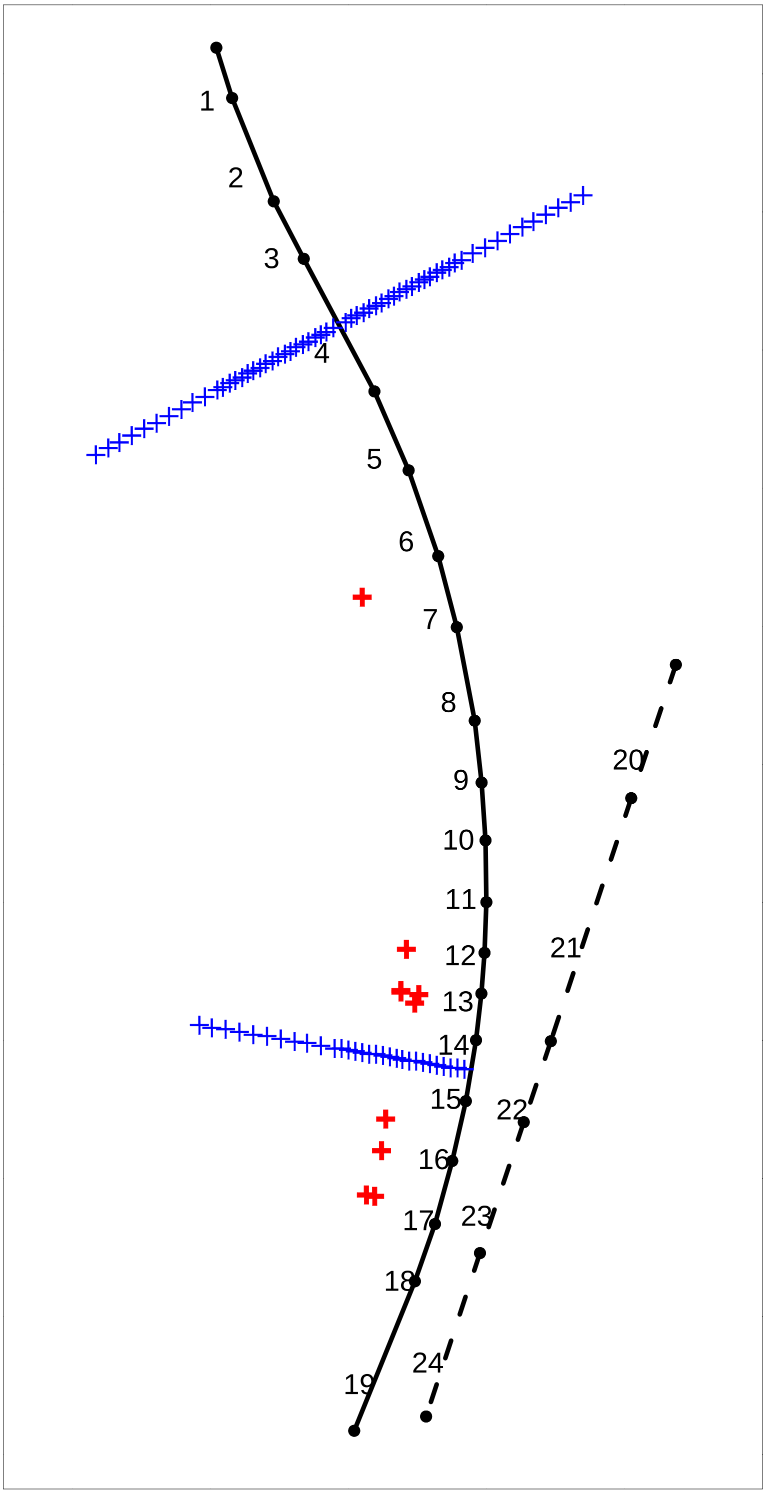

Figure E1: Sector 1 AUSROADS Model Configurations

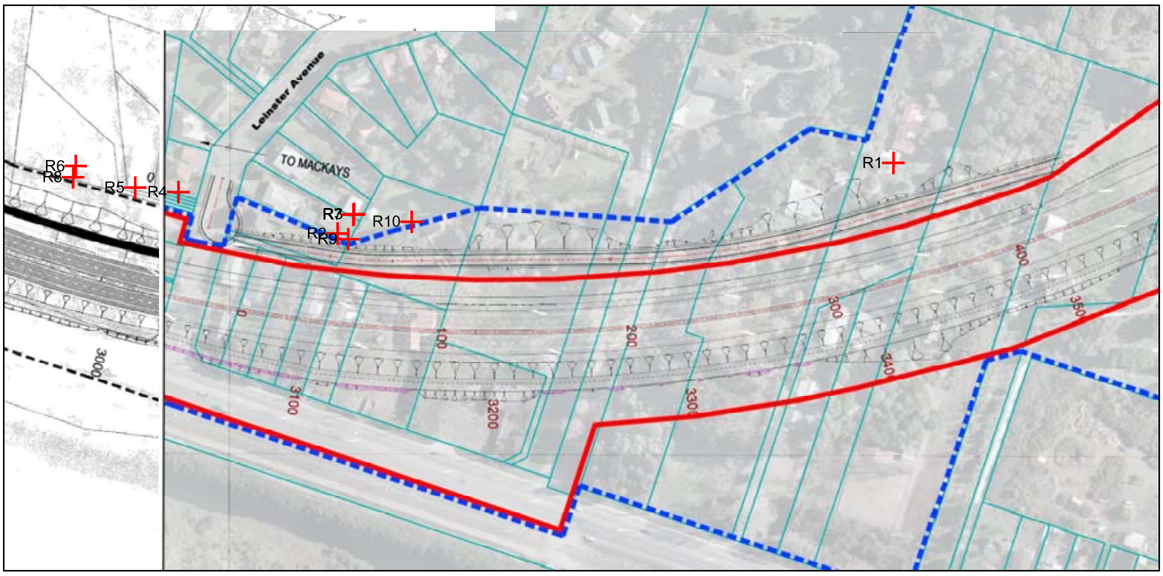

Figure E2: Locations of discrete receptors in the Sector 1 model

A summary of the modelled AM Peak, IP and PM Peak pollutant emissions rates (g/vehicle-km) for each of the line sources included in the 2016 and 2026 “With Project” and “Do Minimum” model configurations are presented in Tables C1 to C6. The link numbers in the table refer to the ID numbers shown in Figure E1.

The AM Peak and PM Peak vehicle emission rates were used to model vehicle emissions between 7am to 9am and 4pm to 6pm respectively. The IP Period emission rates were used to model vehicle emission rates for all other hours.

The tables also present the AM Peak, IP and PM Peak vehicle number (vehicles per hour) for each of the modelled links.

Table E1: Summary of 2016 "with Project" model emission parameters

Link Description	Link Nos	CO (g/vehicle- km)			VOC (g/vehicle- km)			NOX (g/vehicle- km)			PM_{10} (g/vehicle- km)			Traffic (Vehicles/hr)		
		AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM
Expressway	1-19	2.363	2.266	2.499	0.123	0.127	0.123	0.593	0.616	0.600	0.055	0.056	0.056	1125	727	1194
SH1	20-23	2.411	2.401	2.504	0.129	0.107	0.126	0.646	0.546	0.614	0.060	0.055	0.057	1113	766	1491
	24	2.161	2.134	2.269	0.152	0.132	0.136	0.667	0.570	0.593	0.057	0.051	0.052	1113	766	1491

Table E2: Summary of 2026 "with Project" model emission parameters

Link Description	Link Nos	CO (g/vehicle- km)			VOC (g/vehicle- km)			NOX (g/vehicle- km)			PM_{10} (g/vehicle- km)			Traffic (Vehicles/hr)		
		AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM
Expressway	1-19	0.828	0.794	0.861	0.074	0.080	0.073	0.391	0.412	0.390	0.047	0.047	0.048	1347	811	1433
SH1	20-23	0.822	0.783	0.845	0.083	0.059	0.075	0.440	0.340	0.389	0.049	0.047	0.047	1320	900	1690
	24	0.803	0.765	0.818	0.105	0.083	0.089	0.475	0.384	0.399	0.045	0.042	0.042	1320	900	1690

Table E4: Summary of 2016 "do minimum" model emission parameters

Link Description	Link Nos	CO (g/vehicle- km)			VOC (g/vehicle- km)			NOX (g/vehicle- km)			PM_{10} (g/vehicle- km)			Traffic (Vehicles/hr)		
		AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM
SH1	20-22	2.216	2.281	2.013	0.134	0.128	0.155	0.605	0.625	0.518	0.055	0.057	0.046	2195	1481	2403
	23	2.277	2.121	2.615	0.160	0.146	0.193	0.606	0.584	0.543	0.058	0.055	0.058	2160	1428	2295
	24	2.158	2.226	1.948	0.151	0.153	0.156	0.665	0.724	0.508	0.056	0.061	0.045	2160	1428	2295

Table E5: Summary of 2026 "do minimum" model emission parameters

Link Description	Link No	CO (g/vehicle- km)			VOC (g/vehicle- km)			NOX (g/vehicle- km)			PM_{10} (g/vehicle- km)			Traffic (Vehicles/hr)		
		AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM
SH1	20-22	0.782	0.775	0.782	0.093	0.083	0.093	0.404	0.422	0.404	0.044	0.046	0.044	2530	1684	2530
	23	0.929	0.786	0.929	0.126	0.102	0.126	0.461	0.415	0.461	0.050	0.045	0.050	2522	1622	2522
	24	0.790	0.801	0.790	0.108	0.110	0.108	0.459	0.520	0.459	0.044	0.048	0.044	2522	1622	2522

E2 Sector 2 – Kāpiti Road Interchange Models

Figure E3 shows the line sources and discrete receptors incorporated in the AUSROADS 2016 and 2026 “With Project” Kāpiti Interchange dispersion models. The 45 line sources used to simulate the interchange are shown as black lines. The start and end of each line source is indicated by circles. For ease of identification each line source has been assigned an identification number (i.e. 1 – 45) also shown in the figure. The red crosses show the location of the discrete receptor points at the commercial and residential properties that are most likely to be affected by the Project. The line of blue crosses which transects the proposed Expressway has been used to assess pollutant levels with respect to distance from the road. Line sources and receptors have been defined using a local coordinate system.

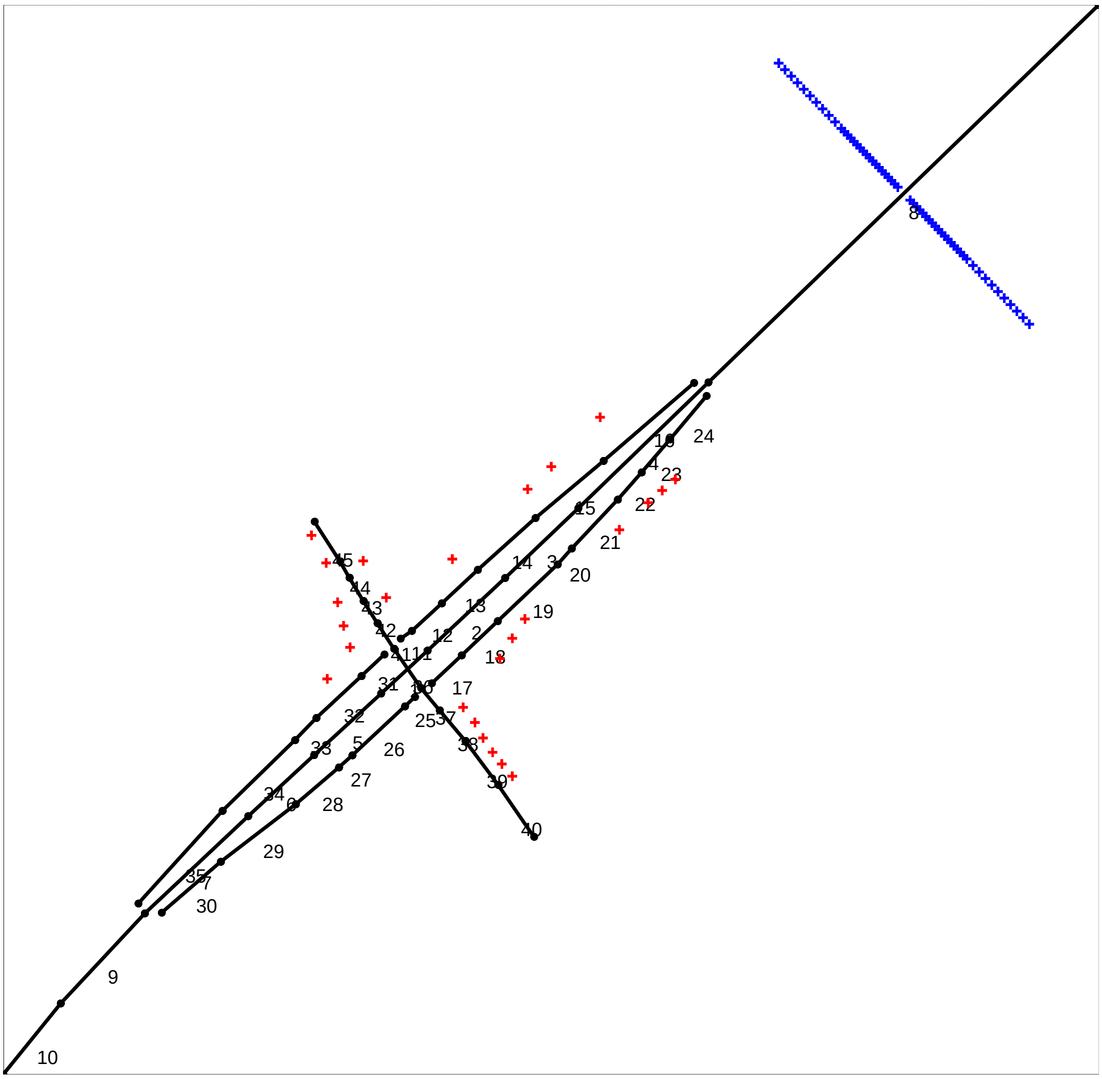

Figure C3: Kāpiti Interchange “With Project” AUSROADS Model Configuration

Figure E4 shows the line sources incorporated in the AUSROADS Kāpiti Road Interchange 2016 and 2026 “Do Minimum” dispersion models. The alignment of Kāpiti Road in the “Do Minimum” models varies slightly from the “With Project” models. The same discrete receptors used in the “With Project” dispersion model assessment have also been used in the “Do Minimum” dispersion model configuration.

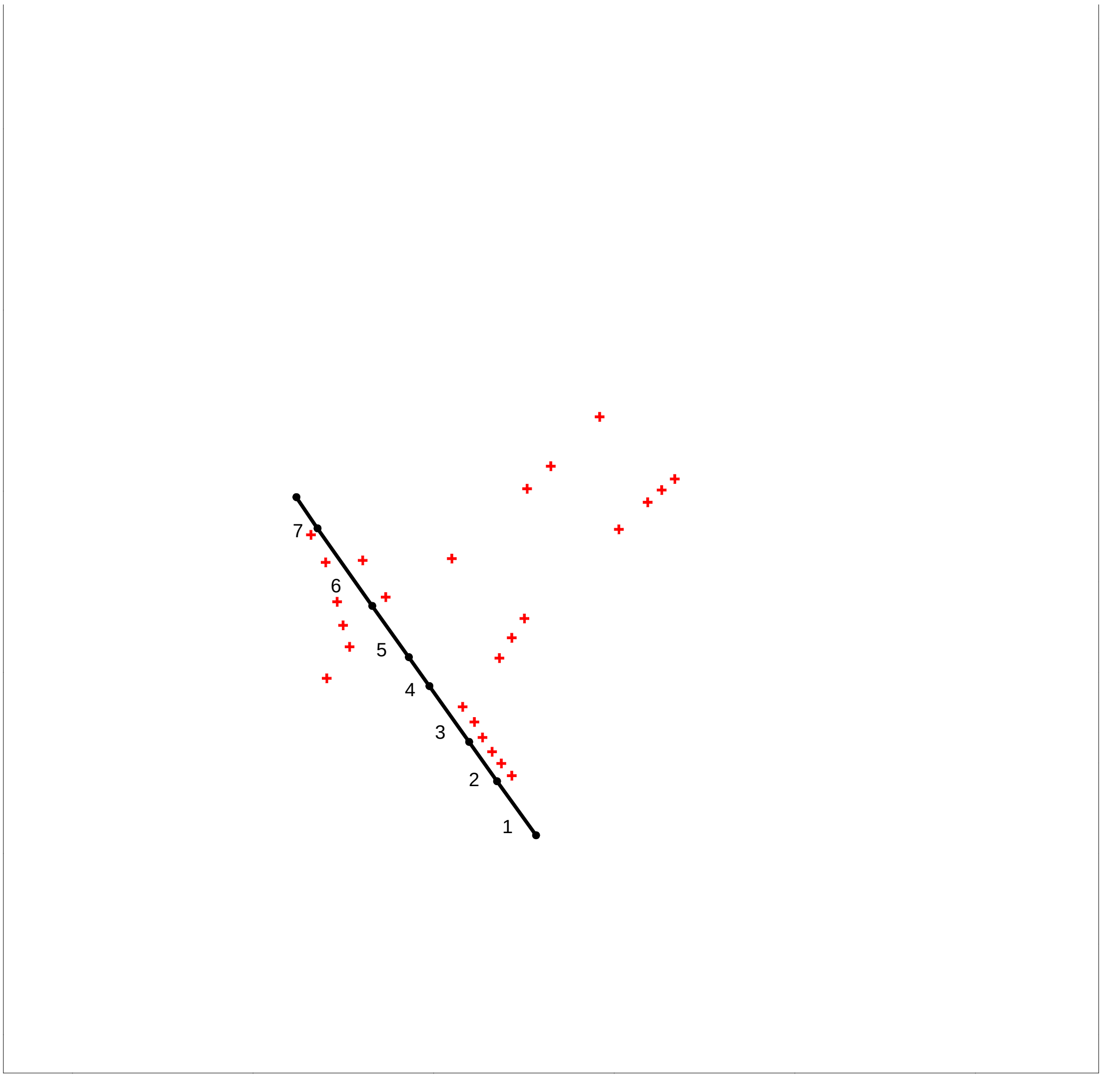

Figure E4: Kāpiti Interchange “Do Minimum” AUSROADS Model Configuration

The location of the discrete receptor points with respect to the road sources is shown in Figure E5.

Figure E3: Location of Discrete Receptors in the Kāpiti Road Interchange Model

A summary of the modelled AM peak, IP and PM peak pollutant emissions rates (g/vehicle-km) for each of the line sources included in the 2016 and 2026 "With Project" model configurations are presented in Tables E7 to E9. The link numbers in the table refer to the ID numbers shown in Figure E3.

AM peak, IP and PM peak pollutant emissions rates (g/vehicle-km) for each of the line sources included in the 2016 and 2026 "do minimum" model configurations are presented in Tables E10 to E12. The link numbers in the tables refer to the ID numbers shown in Figure E4.

The AM Peak and PM Peak vehicle emission rates were used to model vehicle emissions between 7am to 9am and 4pm to 6pm respectively. The IP Period emission rates were used to model vehicle emission rates for all other hours.

The tables also present the AM Peak, IP and PM Peak vehicle number (vehicles per hour) for each of the modelled links.

Table E7: Summary of 2016 "With Project" Model Emission Parameters

Link Description	Link Nos	CO (g/vehicle- km)			VOC (g/vehicle- km)			NOX (g/vehicle- km)			PM_{10} (g/vehicle- km)			Traffic (Vehicles/hr)		
		AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM
Expressway intersection	1-7	2.353	2.251	2.460	0.143	0.154	0.132	0.685	0.735	0.632	0.060	0.062	0.057	698	526	748
Expressway north	8	2.401	2.330	2.486	0.112	0.108	0.116	0.548	0.532	0.567	0.053	0.052	0.055	1372	1056	1353
Expressway south	9	2.288	2.172	2.308	0.131	0.130	0.127	0.599	0.593	0.561	0.054	0.054	0.051	1125	727	1194
	10	2.376	2.250	2.509	0.111	0.105	0.117	0.542	0.514	0.573	0.053	0.051	0.055	1125	727	1194
NB on Ramp	11	1.946	1.956	1.973	0.153	0.151	0.147	0.534	0.526	0.512	0.046	0.046	0.045	224	287	370
	12-16	1.937	1.946	1.961	0.170	0.167	0.163	0.514	0.505	0.490	0.046	0.045	0.044	224	287	370
SB off ramp	17	6.795	6.782	6.763	0.556	0.560	0.567	0.747	0.760	0.777	0.087	0.088	0.090	451	243	235
	18-24	1.964	1.960	1.955	0.149	0.150	0.151	0.519	0.523	0.527	0.045	0.045	0.046	451	243	235
SB on ramp	25	1.972	1.922	1.974	0.148	0.157	0.147	0.513	0.553	0.511	0.045	0.048	0.044	291	99	95
	26-30	1.961	1.915	1.962	0.164	0.175	0.163	0.490	0.536	0.489	0.044	0.048	0.044	291	99	95
NB off ramp	31	6.509	6.632	6.915	0.655	0.612	0.514	1.014	0.900	0.635	0.111	0.101	0.077	136	101	351
	32-35	1.880	1.916	1.999	0.165	0.158	0.142	0.587	0.558	0.491	0.050	0.048	0.043	136	101	351
Kāpiti Rd intersection	36	5.132	4.437	5.194	0.443	0.379	0.408	0.690	0.621	0.595	0.080	0.072	0.071	1741	2047	1884
Kāpiti Rd east	37	4.059	4.618	4.718	0.346	0.375	0.363	0.618	0.613	0.569	0.065	0.067	0.063	1652	2061	1845
	38-40	2.041	2.052	2.069	0.182	0.178	0.173	0.502	0.489	0.470	0.047	0.046	0.044	1652	2061	1845
Kāpiti Rd west	41	4.627	4.294	4.128	0.387	0.357	0.325	0.642	0.612	0.554	0.069	0.065	0.060	1868	2057	2076
	42-45	2.037	2.047	2.072	0.183	0.180	0.173	0.506	0.495	0.467	0.047	0.046	0.044	1868	2057	2076

Table E8: Summary of 2026 "With Project" Model Emission Parameters

Link Description	Link Nos	CO (g/vehicle- km)			VOC (g/vehicle- km)			NOX (g/vehicle- km)			PM_{10} (g/vehicle- km)			Traffic (Vehicles/hr)		
		AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM
Expressway intersection	1-7	0.856	0.828	0.870	0.089	0.102	0.080	0.452	0.508	0.413	0.049	0.049	0.048	870	587	876
Expressway north	8	0.827	0.790	0.849	0.064	0.061	0.066	0.354	0.338	0.364	0.047	0.045	0.047	1849	1284	1693
Expressway south	9	0.822	0.776	0.827	0.081	0.083	0.078	0.400	0.399	0.373	0.046	0.044	0.043	1347	811	1433
	10	0.814	0.759	0.854	0.063	0.059	0.066	0.349	0.325	0.366	0.046	0.044	0.048	1347	811	1433
NB on Ramp	11	0.780	0.784	0.787	0.103	0.099	0.096	0.387	0.374	0.363	0.038	0.038	0.037	286	367	521
	12-16	0.816	0.820	0.823	0.115	0.111	0.108	0.382	0.367	0.354	0.038	0.037	0.037	286	367	521
SB off ramp	17	2.937	2.901	2.913	0.377	0.415	0.403	0.585	0.681	0.650	0.064	0.069	0.067	693	330	296
	18-24	0.789	0.781	0.784	0.095	0.102	0.100	0.357	0.383	0.375	0.037	0.038	0.038	693	330	296
SB on ramp	25	0.789	0.769	0.784	0.095	0.112	0.099	0.356	0.421	0.372	0.037	0.039	0.038	307	102	142
	26-30	0.824	0.807	0.820	0.106	0.126	0.111	0.347	0.421	0.365	0.036	0.039	0.037	307	102	142
NB off ramp	31	2.796	2.857	2.934	0.525	0.461	0.381	0.961	0.799	0.595	0.084	0.075	0.065	169	123	414
	32-35	0.757	0.771	0.788	0.122	0.110	0.096	0.460	0.416	0.360	0.041	0.039	0.037	169	123	414
Kāpiti Rd intersection	36	2.300	2.272	2.489	0.297	0.279	0.288	0.523	0.492	0.467	0.058	0.057	0.056	1835	2202	2112
Kāpiti Rd east	37	1.768	1.951	2.018	0.225	0.237	0.231	0.441	0.437	0.407	0.048	0.049	0.048	1703	2180	2045
	38-40	0.883	0.884	0.888	0.113	0.111	0.106	0.344	0.336	0.319	0.037	0.037	0.036	1703	2180	2045
Kāpiti Rd west	41	1.887	1.889	1.824	0.252	0.242	0.224	0.489	0.461	0.428	0.052	0.050	0.048	2036	2238	2354
	42-45	0.877	0.881	0.885	0.120	0.115	0.111	0.369	0.349	0.334	0.038	0.037	0.037	2036	2238	2354

Table E10: Summary of 2016 "Do Minimum" Model Emission Parameters

Link Description	Link Nos	CO (g/vehicle- km)			VOC (g/vehicle- km)			NOX (g/vehicle- km)			PM_{10} (g/vehicle- km)			Traffic (Vehicles/hr)		
		AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM
Kāpiti Rd	1	2.411	2.282	2.245	0.225	0.205	0.190	0.528	0.501	0.468	0.054	0.050	0.047	1660	2024	1826
	2-7	2.049	2.085	2.094	0.183	0.182	0.174	0.504	0.491	0.464	0.047	0.046	0.044	1660	2024	1826

Table E11: Summary of 2026 "Do Minimum" Model Emission Parameters

Link Description	Link Nos	CO (g/vehicle- km)			VOC (g/vehicle- km)			NOX (g/vehicle- km)			PM_{10} (g/vehicle- km)			Traffic (Vehicles/hr)		
		AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM
Kāpiti Rd	1	1.945	1.842	1.816	0.258	0.230	0.214	0.490	0.440	0.401	0.052	0.049	0.047	1741	2147	2197
	2-7	0.886	0.913	0.927	0.120	0.116	0.112	0.362	0.342	0.322	0.038	0.038	0.037	1741	2147	2197

Appendix 13.F

Detailed Modelling Results

Detailed results of Dispersion Modelling

The following table presents the highest ground level concentrations of PM_{10} (maximum 24-hour average) and NO_2 (99.9% of 1-hour and maximum 24-hour averages) at each of the selected discrete receptors in the vicinity of Leinster Avenue and the Kāpiti Road intersection. NO_2 concentrations in this table are calculated by multiplying the maximum predicted NO_x concentration by 0.1 (refer Appendix 13.G).

These discrete receptors were selected as representative of those locations likely to be most impacted by the proposed Expressway; the inclusion or omission of any specific receptor does not imply any indication of the sensitivity or otherwise of that receptor to the effects of motor vehicle exhaust emissions.

Address	PM_{10} 24- hour Average ($\mu g/m^3$)				NO_2 1- hour Average ($\mu g/m^3$)				NO_2 24- hour Average ($\mu g/m^3$)			
	2016		2026		2016		2026		2016		2026	
	Do Min	With Project	Do Min	With Project	Do Min	With Project	Do Min	With Project	Do Min	With Project	Do Min	With Project
Sector 1												
105 Leinster Ave	0.56	0.96	0.51	0.92	2.72	4.87	2.23	3.63	0.60	1.02	0.48	0.77
106B Leinster Ave	0.65	1.05	0.60	1.02	3.22	5.72	2.61	4.24	0.70	1.12	0.57	0.85
107 Leinster Ave	0.62	1.13	0.57	1.09	2.98	5.88	2.46	4.44	0.68	1.21	0.53	0.91
108 Leinster Ave	0.67	1.10	0.62	1.07	3.38	5.99	2.68	4.43	0.73	1.18	0.60	0.89
112 Leinster Ave	0.66	1.07	0.62	1.04	3.36	5.96	2.76	4.41	0.72	1.15	0.59	0.87
238 Main Road South (east of Expressway)	0.35	0.94	0.32	0.91	2.66	6.13	2.10	4.62	0.27	0.78	0.20	0.59
238 Main Road South (west of Expressway)	0.24	0.73	0.22	0.70	1.57	4.08	1.17	3.06	0.39	1.01	0.30	0.76
240 Main Road South	0.57	0.93	0.53	0.90	3.32	5.72	2.62	4.27	0.63	1.00	0.49	0.76
246 Main Road South	0.77	0.97	0.71	0.94	4.07	5.45	3.22	4.02	0.84	1.04	0.65	0.78
252 Main Road South	1.05	1.05	0.97	1.02	5.19	5.53	4.13	4.03	0.84	1.04	0.65	0.78
264 Main Road South	0.53	0.95	0.48	0.92	2.60	4.83	2.12	3.60	0.58	1.02	0.45	0.77
Sector 2												
90 Kāpiti Road	2.76	3.27	2.42	2.81	10.00	11.90	8.57	8.94	2.93	3.49	2.20	2.58
92 Kāpiti Road	2.57	2.74	2.51	2.36	9.09	10.90	8.42	7.99	2.56	3.29	1.92	2.46

Address	PM10 24- hour Average (µg/m³)				NO2 1- hour Average (µg/m³)				NO2 24- hour Average (µg/m³)			
	2016		2026		2016		2026		2016		2026	
	Do Min	With Project	Do Min	With Project	Do Min	With Project	Do Min	With Project	Do Min	With Project	Do Min	With Project
94 Kāpiti Road	2.73	3.11	2.47	2.68	9.79	11.70	8.99	8.58	2.67	3.48	2.00	2.64
88 Kāpiti Road	2.84	3.23	2.50	2.78	10.30	12.10	9.16	8.91	3.01	3.46	2.27	2.55
86 Kāpiti Road	2.41	3.12	2.12	2.68	8.67	10.50	7.15	8.24	2.89	3.33	2.23	2.45
84 Kāpiti Road	2.51	3.42	2.20	2.90	9.27	10.90	7.65	8.70	2.66	2.94	2.25	2.16
15 Greenwood Place	2.28	3.32	2.00	2.93	9.19	11.30	7.21	9.70	0.71	1.59	0.53	1.32
17 Greenwood Place	2.06	2.77	1.83	2.48	8.08	11.00	6.37	9.13	0.56	1.56	0.42	1.30
18 Greenwood Place	0.52	1.50	0.46	1.38	2.16	5.98	1.68	4.95	0.46	1.61	0.34	1.35
10 Elder Grove	0.67	1.56	0.58	1.41	2.55	5.95	2.09	5.06	0.21	1.27	0.15	1.05
9 Elder Grove	0.53	1.49	0.46	1.37	2.12	6.13	1.65	5.15	0.17	1.20	0.13	0.99
8A Elder Grove	0.43	1.50	0.37	1.41	1.79	6.55	1.31	5.62	0.16	1.16	0.12	0.96
28B Cypress Grove	0.15	1.03	0.13	0.98	0.82	5.80	0.64	4.74	0.15	1.12	0.11	0.92
11A Sheffield Street	0.16	1.06	0.14	1.02	0.87	5.96	0.67	4.89	0.21	1.33	0.16	1.10
12 Manchester Street	0.20	1.13	0.17	1.08	1.00	6.12	0.76	5.10	0.16	1.23	0.12	1.01
13 Sheffield Street	0.14	0.99	0.12	0.95	0.78	5.66	0.60	4.59	0.25	1.36	0.19	1.12
102 Kāpiti Road	0.20	1.21	0.17	1.16	1.08	5.21	0.78	4.32	2.43	3.35	1.82	2.72
108 Kāpiti Road	0.24	1.24	0.21	1.19	1.21	5.29	0.88	4.38	2.19	2.93	1.66	2.32
104 Kāpiti Road	0.15	1.12	0.13	1.09	0.89	4.93	0.64	4.10	0.55	1.58	0.42	1.30
27 Milne Drive	3.69	4.33	3.28	3.85	16.90	19.90	13.80	16.20	1.14	2.50	0.85	2.06
23 Milne Drive	2.80	3.79	2.49	3.36	11.60	17.10	9.35	14.00	1.32	2.48	0.99	2.00
11 Milne Drive	1.60	2.71	1.40	2.45	6.44	11.40	4.87	9.51	1.70	2.85	1.27	2.28
5 Milne Drive	1.24	2.39	1.09	2.15	5.24	8.85	3.89	7.24	2.98	3.96	2.26	3.12
1 Milne Drive	1.07	2.50	0.94	2.22	4.49	9.83	3.28	7.86	3.92	4.58	2.97	3.59
29 Milne Drive	0.63	1.66	0.55	1.50	2.70	7.80	2.01	6.31	0.67	1.70	0.50	1.41

Appendix 13.G

Assessment of Nitrogen Dioxide

Assessment of Nitrogen Dioxide

Nitrogen oxides (NO_x) are emitted mainly in the form of nitric oxide (NO) but, once released into the atmosphere, variable proportions are oxidised to the more harmful nitrogen dioxide (NO_2), predominantly by ozone (O_3). Typically only about 10% or less of the total nitrogen oxides released from a combustion source are in the form of NO_2. Air quality standards and guidelines are defined only for NO_2. Therefore, when assessing the potential impact of NO_x emissions from the Project it is important to consider the chemical processes that occur in the atmosphere.

The most important short-term transformation is the reaction of NO in the emission plume with ambient ozone to form NO_2:

$$NO + O_3 \rightarrow NO_2 + O_2$$

Since the reaction is a 1-to-1 molecular transformation, the maximum possible concentration of NO_2 that can occur in the emission plume is directly related to the maximum ambient concentration of ozone. During the daytime, the main competing reaction in the short term is the photo-dissociation of NO_2 to form NO, which can decrease the concentrations of NO_2 to some degree.

$$3\ NO_2 + hv \rightarrow 3NO + O3$$

Near an emission source, the formation of NO_2 is in general limited by the availability of NO in the emission plume to react with ambient ozone (reactant limited), or alternatively the availability of ambient ozone to react with NO (oxidant limited). At the highest recorded background ozone concentrations of 37 ppb (Gomez, 1996), up to 37 ppb of nitrogen dioxide (equivalent to 72 $\mu g/m^3$) could be formed in the emission plume by the oxidation of NO, if sufficient NO is present, in addition to the NO_2 in the plume originally released in the emissions. Therefore, there is effectively a limit to the maximum concentration of NO_2 that could actually occur near an emission source.

Elevated levels of ozone can, on occasion, occur from photochemical smog formation processes. These episodes require significant emissions of both NO_x and reactive organic compounds, usually from large city areas, under conditions where the dispersion of the polluted air mass is limited for periods of several hours combined with warm air temperatures and sunlight. However, Wellington is well ventilated so it is unlikely these events would to occur in the region.

Figures G1 and G2 shows the relationship of 1-hour average NO_2 and NO_x concentration recorded at the Tawa and Raumati Road monitoring sites. Pollutant levels recorded at the site are indicative of concentrations near a main road within the region. The limiting effect of ambient ozone on NO_2 concentrations is clearly evident in these figures when NO_x concentrations exceed approximately 80-100 $\mu g/m^3$. For NO_x concentrations above 100 $\mu g/m^3$, NO_2 concentrations are shown to increase only gradually. This increase in NO_2 with NO_x concentrations above 80 $\mu g/m^3$ is primarily associated with NO_2 directly emitted from vehicle tail pipes; the slope of this increase correlates to the percentage of NO_x emitted as NO_2.

The figures show that 1-hour average NO_2 concentrations recorded at either Tawa or Raumati South rarely exceed 50 µg/m³, even though 1-hour average NO_x concentrations on occasion exceed 400 µg/m³.

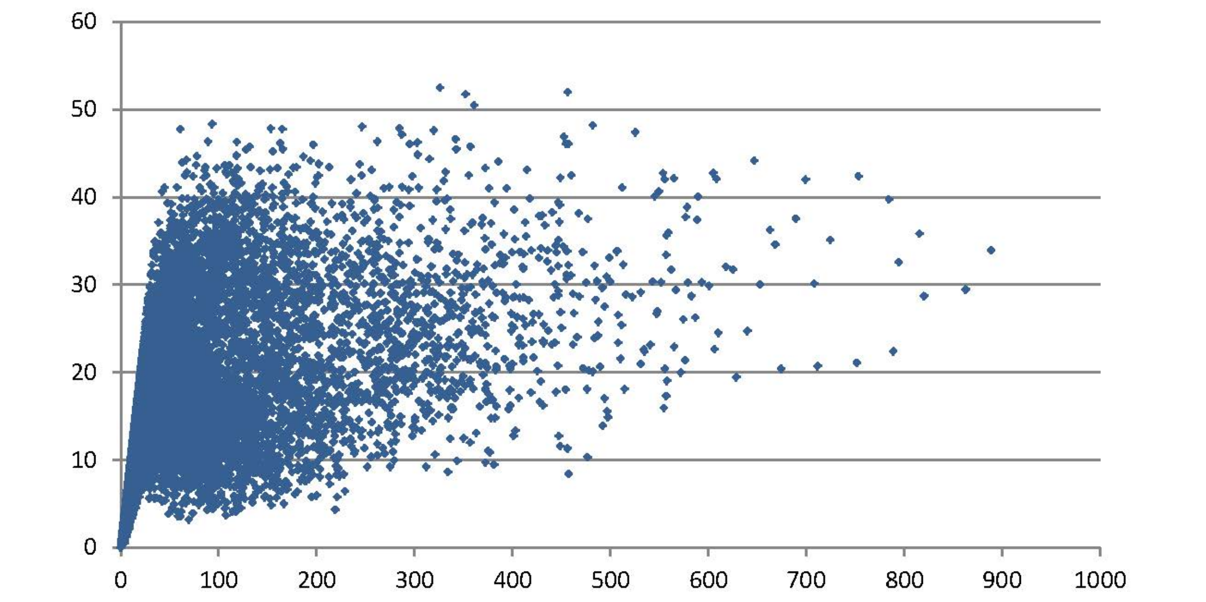

Figure G1: Relationship between 1-hour average NO_2 and NO_x concentrations recorded at the Tawa monitoring site in 2008-2009

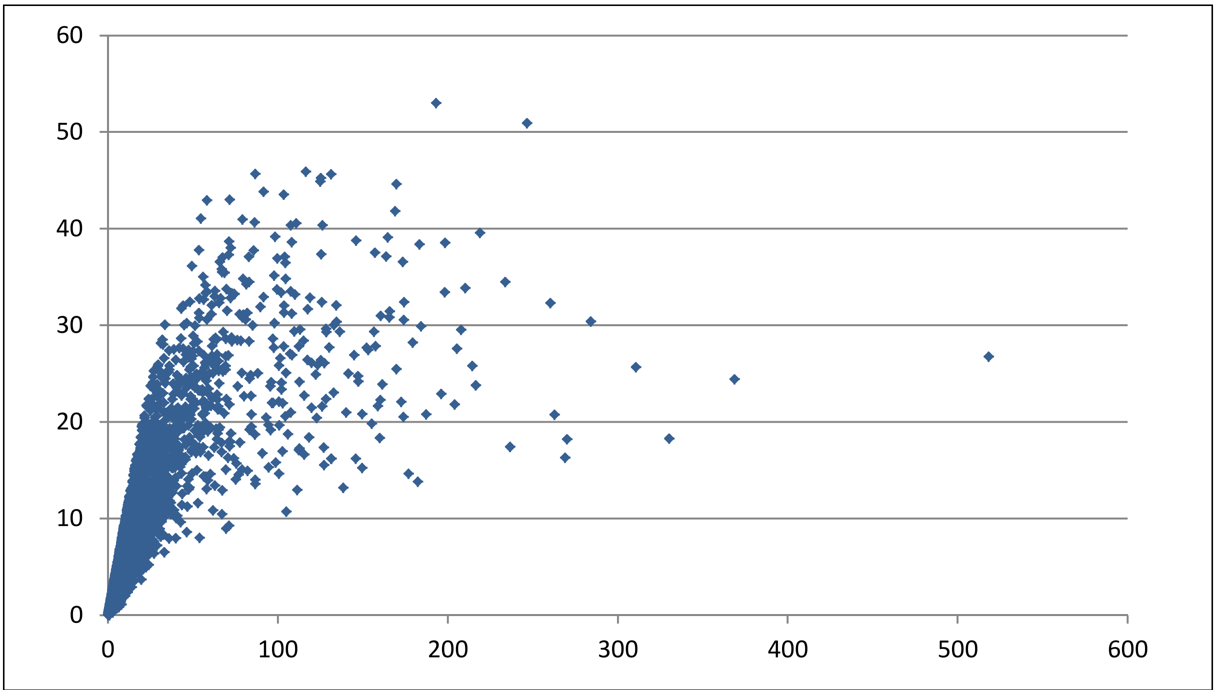

Figure G2: Relationship between 1-hour average NO_2 and NO_x concentrations recorded at the Raumati Road monitoring site in 2011

Minoura & Ito (2009) estimated 7.3% of NO_x vehicle emissions were emitted as NO_2, based on studies of Japanese roads. A UK study of ambient air quality estimated the percentage as varying between 8-14% (Abbott, 2005). From the average NO_2 to NO_x slope observed in Figure 3.1 when NO_x concentrations exceed 100 µg/m³, the percentage of NO_2 emitted as

Figure 3.1 when NO_x concentrations exceed 100 µg/m^3, the percentage of NO_2 emitted as NO_x can be estimated to be less than 5%, which is lower but comparable to these reported emission ratios. The lower ratio may be due to the older vehicle fleet and lower proportion of diesel vehicles in the New Zealand fleet compared to Japan and UK.

In the analysis, cumulative NO_2 levels have been estimated by assuming a worse case background NO_2 concentrations equal to the maximum 1-hour average NO_2 recorded at the Raumati Road monitoring site of 53 µg/m^3 occurs during the same hour as the maximum ground level concentrations associated with the modelled road source also occurs. During these periods the formation of NO_2 is expected to be ozone limited, as indicated in Figure G1 by the flattening of the NO_2 - NO_x curve. During these conditions additional NO_2 is expected to be associated with NO_2 emitted at the point of discharge. Therefore, the contribution from the modelled road sources to ambient pollutant levels has been calculated by multiplying the predicted incremental maximum 1-hour average NO_x concentration by the percentage of NO_x assumed to be emitted as NO_2. In this instance it has been assumed that 10% of NO_x is emitted as NO_2. The expression used to calculate cumulative maximum 1-hour average NO_2 concentrations is shown below:

$$[NO_2]_{cumulative} \text{ 1-hour average} = 0.10 * [NO_X]_{predicted} \text{ 1-hour average} + 53$$

A similar method can been used to estimate maximum 24-hour average NO_2 concentrations. However, NO_x and ambient ozone concentrations can vary significantly throughout any 24-hour period. Therefore during any 24-hour period, the formation of NO_2 may be both NO limited and ozone limited. Figures G3 and G4 show the relationship between recorded 24-hour average NO_2 and NO_x concentrations at the Tawa and Raumati Road monitoring sites.

The figures show comparatively linear relationships between 24-hour average NO_2 and NO_x concentrations when 24-hour NO_x concentrations are higher than 50µg/m^3. At these concentrations, 24-hour average NO_2 concentrations increase only slowly with respect to increases in 24-hour average NO_x concentrations. The results suggest that at these concentrations, increases are predominantly associated with increases in NO_2 tail pipe emission rates.

Therefore cumulative NO_2 levels can be estimated by assuming a worst case background NO_2 concentrations equal to the average of the maximum 24-hour average NO_2 concentration recorded at the Raumati Road monitoring site of 27 µg/m^3. The contribution from the modelled motorway sources to ambient pollutant levels can be calculated by multiplying the predicted maximum incremental 24-hour average NO_x concentration by 10%. The expression used to calculate cumulative 24-hour average NO_2 concentrations is shown below:

$$[NO_2]_{cumulative} \text{ 24-hour average} = 0.10 * [NO_X]_{predicted} \text{ 24-hour average} + 27$$

A highly conservative approach has been used for estimating annual average NO_2 concentrations, which assumes that, in the longer timeframe, all NO_x discharged in vehicle exhaust emissions is converted to NO_2. Cumulative concentrations of NO_2 are calculated by adding the annual average NO_x concentration predicted by dispersion to the annual average background NO_2 concentration (14 µg/m^3).

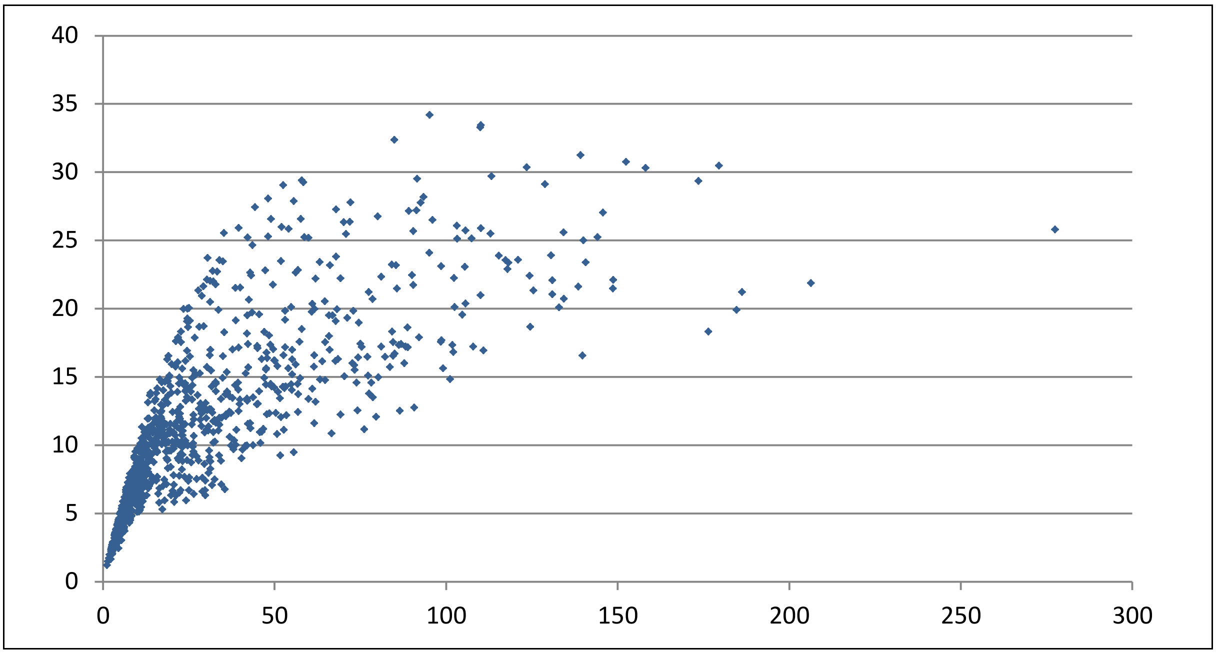

Figure G3: Relationship between 24- hour average NO_2 and NO_x concentrations recorded at the Tawa monitoring site in 2008- 2009

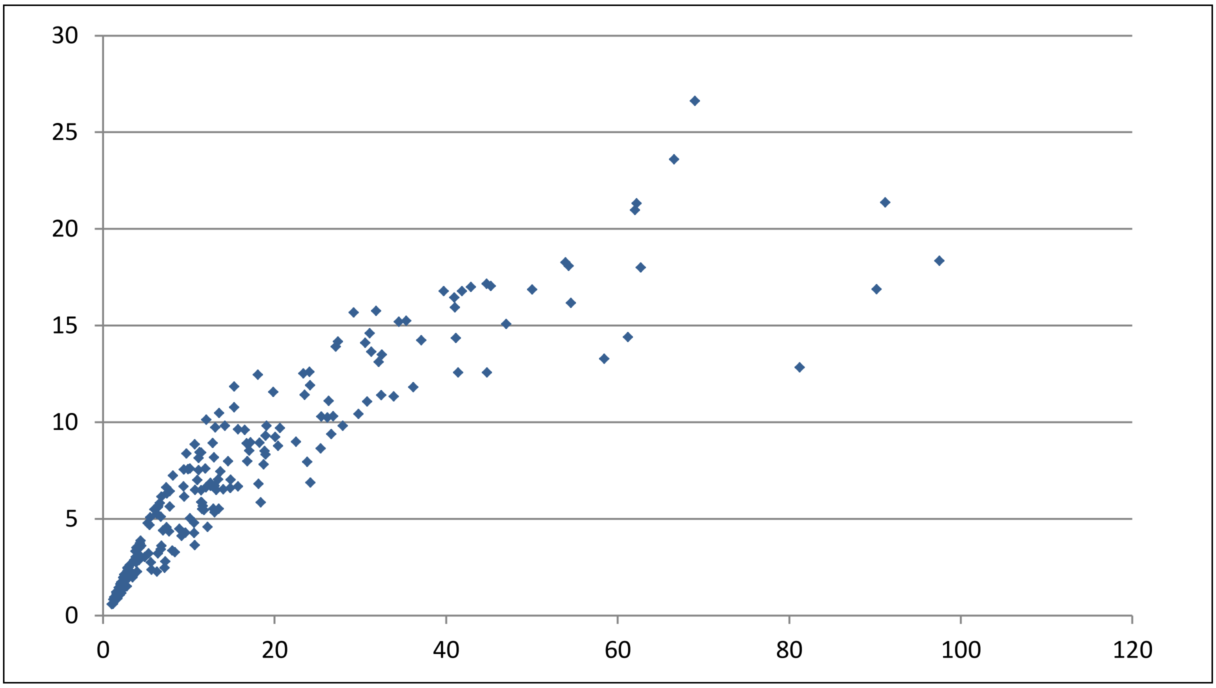

Figure G4: Relationship between 24- hour average NO_2 and NO_x concentrations recorded at the Raumati Road monitoring site in 2011

Appendix 13.H

Health Effects of Vehicle Emissions

Health Effects of Vehicle Emissions

There is a wide range of substances present in motor vehicle exhaust, which are summarised in Table H1.

Table H1: Substances present in motor vehicle emissions

Acetaldehyde	Cobalt and compounds	Oxides of nitrogen
Acetone	Copper and compounds	Particulate matter (PM_{10} and $PM_{2.5}$)
Benzene	Cyclohexane	Polycyclic aromatic hydrocarbons (PAH)
1,3-butadiene	Ethylbenzene	Sulphur dioxide
Cadmium and compounds	Formaldehyde	Styrene
Carbon dioxide	n-hexane	Toluene
Carbon monoxide	Lead and compounds	Volatile organic compounds (VOCs)
Chromium (III) compounds	Manganese and compounds	Xylenes
Chromium (VI) compounds	Nickel and compounds	Zinc and compounds

Carbon Monoxide

Vehicle traffic is the single largest source of CO in most urban areas. CO disperses rapidly from the discharge source, with the highest potential exposure levels being immediately adjacent to roads. Historically, CO concentrations measured near New Zealand roads approached, or exceeded, guideline levels; however this is no longer the case. CO remains a key indicator for assessing local effects from vehicles.

CO is an odourless gas formed as a result of incomplete combustion of carbon-containing fuels, including petrol and diesel. CO is readily absorbed from the lungs into the bloodstream, which then reacts with haemoglobin molecules in the blood to form carboxyhaemoglobin. This reduces the oxygen-carrying capacity of blood, which, in turn impairs oxygen release into tissue and adversely affects sensitive organs such as the brain and heart. Motor vehicles are the predominant sources of CO in most urban areas.

Long-standing international (and New Zealand) air quality guidelines/standards for CO are based on keeping the carboxyhaemoglobin concentration in blood below a level of 2.5%, in order to protect people from an increased risk due to heart attacks. This has led to little variation in the guidelines/standards, being typically 10mg/m^3, eight-hour average, and 30mg/m^3, one-hour average.

Oxides of Nitrogen (NOX)

As with CO, vehicle traffic is the largest source of oxides of nitrogen in urban areas. Most is emitted as nitric oxide (NO) but is subsequently oxidised in air to NO_2. Emission rate characteristics are different to those for CO, and local dispersion of NO_2 is often slower due to oxidation of NO to NO_2. Concentrations of NO_2 measured near busy roads in Auckland have shown levels approaching, and exceeding, guidelines.

Nitrogen oxides (primarily NO and lesser quantities of NO_2) are gases formed by oxidation of nitrogen in air at high combustion temperatures. NO is oxidised to NO_2 in ambient air, which has a major role in atmospheric reactions that are associated with the formation of photochemical oxidants (such as O_3) and particles (such as nitrates). NO_2 is also a serious air pollutant in its own right. It contributes both to morbidity and mortality, especially in susceptible groups such as young children, asthmatics and those with chronic bronchitis and related conditions.

NO_2 appears to exert its effects directly on the lung, leading to an inflammatory reaction on the surfaces of the lung. Air quality guidelines/standards for NO_2 are set to minimise the occurrence of changes in lung function in susceptible groups. The lowest observed effect level in asthmatics for short-term exposures to nitrogen dioxide is about 400µg/m^3. Although fewer data are available, there is increasing evidence that longer-term exposure to about 80µg/m^3 during early and middle childhood can lead to the development of recurrent upper and lower respiratory tract symptoms. A safety factor of two is usually applied to these lowest-observed effect levels, giving air quality guidelines/standards for NO_2 of 200µg/m^3, one-hour average, and either 40 µg/m^3 annual average, or 100µg/m^3 24-hour average (these two longer-term exposure concentrations being roughly equivalent).

Particulate Matter

Sources of particulate matter (PM_{10} and $PM_{2.5}$) include exhaust emissions, re-suspension of road surface dust, tyre wear, and brake and road surface wear. Diesel exhausts contain much higher particulate concentrations than petrol exhausts, and the contribution of transport to urban discharges of particulate matter (PM_{10} and $PM_{2.5}$) may be growing with increasing numbers of heavy diesel vehicles. Diesel particulate is especially concerning because it has been identified as a potential carcinogen, although at present all particulate matter is assessed in the same way regardless of its source. In many parts of New Zealand (including Auckland), existing concentrations of particulate are high, due to discharges principally from domestic sources. This means it may sometimes be difficult to identify the particulate contribution from a road as distinct from other sources.

Fine particles such as sulphates cause increased morbidity and mortality, and there are no apparent threshold concentrations for those health effects. Despite this, most countries (including New Zealand) have taken a pragmatic approach and have set guidelines (typically 50µg/m^3 for PM_{10}, 24-hour average) aimed at minimising the occurrence of health effects. Recent preliminary research is showing that it is probably the finer particles causing greater effects ($PM_{2.5}$), and particles from diesel emissions possibly having greater effects than those from other sources.

Ozone

Ozone (O_3) and other secondary pollutants are primarily associated with regional effects because the rate of formation is such that they result from long-range dispersion. Their formation also depends on the mix of chemicals within the urban airshed.

Ozone is a natural substance found in the atmosphere. At lower levels (in the troposphere up to about 10km altitude), it occurs through natural reaction with oxygen and is present in concentrations between about 30 and 60 µg/m^3 depending on the latitude and season. At higher levels (in the stratosphere above 10km altitude) it forms an important barrier to dangerous ultraviolet light from the sun, and its loss, in the so-called 'ozone-hole' is detrimental to life on earth. There is very little relationship between tropospheric and stratospheric ozone.

Ozone is also a secondary, urban air pollutant formed by reactions of nitrogen oxides and volatile organic compounds in the presence of sunlight. These primary emissions arise mainly from motor vehicles. Ozone is only one of a group of chemicals called photochemical oxidants (commonly called photochemical smog), but it is the predominant one. Also present in photochemical smog are formaldehyde, aldehydes and peroxyacetyl nitrate.

Ozone is another air pollutant that has respiratory tract impacts. Its toxicity occurs in a continuum in which higher concentrations, longer exposure and greater activity levels during exposure cause greater effects. It contributes both to morbidity and mortality, especially in susceptible groups such as those with asthma and chronic lung disease, healthy young adults undertaking active outdoor exercise over extended periods, and the elderly, especially those with cardiovascular disease. Substantial acute effects occur during exercise with one-hour exposures to ozone concentrations of 500µg/m^3 or higher. Ozone, like particulate matter, is an air pollutant for which there is no indication of a threshold concentration for health effects. More than any other air pollutant, there is considerable variation in air quality guidelines/standards for ozone, because of complexities involved in reducing ambient concentrations of it. In New Zealand a relatively "pure" approach has been taken, and air quality guidelines for ozone of 150 µg/m^3, one-hour average, and 100 µg/m^3, eight-hour average, have been established.

Volatile Organic Compounds (VOCs)

VOCs are a range of hydrocarbons, the most important of which are benzene, toluene, xylene, 1,3-butadiene, polycyclic aromatic hydrocarbons (PAHs), formaldehyde and acetaldehyde. The potential health impacts of these include carcinogenic and non-carcinogenic effects. According to the WHO, benzene and PAHs are definitely carcinogenic, 1,3-butadiene and formaldehyde are probably carcinogenic, and acetaldehyde is possibly carcinogenic. Non-carcinogenic effects of toluene and xylene include damage to the central nervous system and skin irritation. Heavier VOCs are also responsible for much of the odour associated with diesel exhaust emissions.

Motor vehicles are the predominant sources of VOCs in urban areas. Benzene, toluene, xylene, and 1,3-butadiene are all largely associated with petrol vehicle emissions. The first three of these result from the benzene and aromatics contents of petrol, and 1,3-butadiene results from the olefins content. Evaporative emissions, as well as exhaust emissions, can also be significant, especially for benzene.

Motor vehicles are collectively a major source of formaldehyde and acetaldehyde. These carbonyls are very reactive and are important in atmospheric reactions, being products of most photochemical reactions. PAHs arise from the incomplete combustion of fuels, including diesel.

Of the VOCs, the most important in the New Zealand context is benzene. The benzene content of petrol is high, often exceeding four percent by volume, especially for the "premium" grade, whereas many overseas countries restrict the benzene content to less than one percent by volume. Health effects data and guidelines/standards for hazardous air pollutants include a recommended air quality guideline for benzene of 3.6µg/m^3 as an annual average concentration. The implied cancer risks (leukaemia) corresponding to concentration is 16 to 27 per million population, based on WHO unit risk factors for benzene.

Significant sources of VOCs include home heating and industry, as well as motor vehicles. For this reason, and due to the cost and difficulty associated with analysing all of the wide range of contaminants that may be present (in addition to the specific assessment for benzene) this assessment has focussed on CO, PM_{10}, $PM_{2.5}$ and NO_x as good indicators of the likely effects.

Other Contaminants

Sulphur dioxide

Sulphur oxides (primarily SO_2 and lesser quantities of sulphur trioxide, SO_3) are gases formed by the oxidation of sulphur contaminants in fuel on combustion. SO_2 is a potent respiratory irritant, and has been associated with increased hospital admissions for respiratory and cardiovascular disease, as well as mortality. Asthmatics are a particularly susceptible group. There appears to be a threshold concentration for adverse effects in asthmatics from short-term exposures to SO_2 at a concentration of 570 µg/m^3, for 15 minutes. Ambient air guidelines/standards are based on this figure; for example, the guidelines for New Zealand are 350µg/m^3 as a one-hour average, and 120 µg/m^3 as a 24-hour average. However, in its 2005 review of air quality guidelines (WHO, 2005), the WHO has significantly reduced its annual average air quality guideline for SO_2 to 20 µg/m^3.

Sulphur oxides from fuel combustion are further oxidised to solid sulphates, to a certain extent within the engine and completely in the atmosphere. The former inhibits the performance of exhaust emission control equipment for nitrogen oxides and particles, and this is a major reason why the sulphur content of petrol and diesel are being reduced internationally. Many countries are moving to "sulphur-free" petrol and diesel (less than 10ppm). It is an unfortunate reality that unless the sulphur content of diesel is less than about 120 ppm, vehicles with advanced emission control systems are actually net producers of additional fine particles because of oxidation of the sulphur oxides to sulphates.

SO_2 concentrations in New Zealand are relatively low, and motor vehicles are minor contributors to ambient SO_2. Until recently, New Zealand had a high-sulphur-content diesel (up to about 3,000 ppm). This was reduced in 2006 to 50ppm and further reduced to 10 ppm in 2009. The sulphur content of petrol was reduced to 50ppm in 2008. Given these reductions in the sulphur content of fuels, the effects of discharges of SO_2 from vehicles have not been assessed in this report.

Others

As noted above, vehicles and other transport-related sources can emit a wide range of air pollutants. However, the MfE Transport GPG indicates that, if the above indicators pass the relevant assessment criteria, then so will all the other types of emissions

Appendix 13.I

NZTA Tier 1 Screening Assessment Checklist

1. Project information

Item	Value
What is the project name?	**MacKays to Peka Peka**
Which NZTA region[1] is the project is in?	**Wellington**
What is the State highway number?	**State Highway 1**

2. Key questions

Existing air quality	Value	Risk
Is the project in an airshed where the PM_{10} NES[2] is exceeded? **NOTE : 9 weeks monitoring data collected at Raumati South (Glen Rd) in Winter 2010. 3 exceedances recorded**	X☐ Yes ☐ No	
Does the existing annual NO_2 average[3] exceed 30µg/m[3] in the vicinity of the project?	☐ Yes X ☐ No	
Existing air quality risk: Both 'No'=Low, Any 'Yes'=High		**High**
Exposure	**Value**	**Risk**
How many 'highly sensitive' receptors[4] are within 200 metres of any part of the road proposed by the project?	**> 50**	
Exposure risk: <10=Low, 10-50=Medium, >50=High		**High**
Emissions	**Value**	**Risk**
What is the likely AADT[5] for the project at opening year?	**20,000**	
Emissions Risk: <10,000=Low, 10,000-50,000=Medium, >50,000=High		**Medium**

3. Risk assessment

Overall Tier 1 Risk Assessment	Low	Medium	High	Value
Number of individual risk factors		1	2	
Overall risk: 2 or more High=High, 2 or more Low=Low, all other combinations=Medium				High

4. Tunnels

Tunnel	Value	Risk
Does the project include any links with tunnels longer than 150m?	☐ Yes X ☐ No	
Tunnel Risk: it is likely that a detailed tier 3 assessment will be required for any tunnel especially if the overall air quality risk is high.		

Notes:

1. A detailed map indicating the project area and the location of highly sensitive receptors should also be included in the basic project information (see next page).
2. For information on the local airshed status regarding the PM_{10} NES, please either visit the MfE website at http://www.mfe.govt.nz/environmental-reporting/air/air-quality/pm10/nes/index.html, phone the local regional council, or contact the NZTA Environment and Urban Design team for advice.
3. For information on annual NO_2 levels, please visit NZTA's Spatial Viewer at https://spatialviewer.nzta.govt.nz. In order to access it you will need a user name and password, which can be obtained from the NZTA Geospatial team. Either select the maximum NO_2 annual average recorded at the site or the maximum NO_2 annual average recorded at an adjacent site on the same state highway within 10km of the project. If in doubt, contact the NZTA Environment and Urban Design team for advice.
4. A 'highly sensitive' receptor is a location where people or surroundings may be particularly sensitive to the effects of air pollution, e.g. residential houses, hospitals, schools, early childhood education centres, childcare facilities, rest homes, marae, other cultural facilities, and sensitive ecosystems as outlined in Table 6.2 of the MfE Good Practice Guide for Assessing Discharges to Air from Transport available at http://www.mfe.govt.nz/publications/air/assessing-discharges-land-transport-jun08/.
5. AADT is the annual average daily traffic count. Traffic data is available from http://www.nzta.govt.nz/network/operating/counting-traffic/traffic-statistics.html

Map