NZTA air quality screening model v2.0 users' notes

June 2014

NZ TRANSPORT AGENCY
WAKA KOTAHI

New Zealand Government

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This document is available on the NZ Transport Agency's transport and air quality website at ***www.air.nzta.govt.nz***.

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Record of amendment

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1	Reference to NIWA NO_2 regression approach report updated	June 2014	S Sridhar

Foreword

The NZ Transport Agency (the Transport Agency) is a Crown agency responsible for, among other things, managing 10,894 kilometres of state highways. The state highway system accounts for about 12 per cent of New Zealand's roads and around half of the 40 billion vehicle kilometres New Zealanders travel each year[1]. Motor vehicles travelling on roads emit an array of air pollutants which can contribute to harmful effects on human health and smog formation.

In its *State highway environmental plan*[2], the Transport Agency is committed to being socially and environmentally responsible and improving the contribution of state highways to the environmental and social well-being of New Zealand. The Plan sets formal objectives regarding air quality from the state highway network including:

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 the national ambient air quality standards

The Transport Agency has developed a *Guide to assessing air quality effects for state highway asset improvement projects*[3] to help ensure that these objectives are met. To assist with implementation of the guide, the Transport Agency has developed a web based *Air quality screening model* which is available at ***www.air.nzta.govt.nz***.

This document provides supporting technical information for the *Air quality screening model*.

[1] MoT (2013). *The New Zealand vehicle fleet, annual fleet statistics 2012,* Ministry of Transport, February 2013 (updated in August 2013)

[2] Transit (2008). *State highway environmental plan, version 2*, Transit New Zealand, June 2008

[3] NZTA (2012). *Guide to assessing air quality effects for state highway asset improvement projects*, Draft version 0.6, NZ Transport Agency, September 2012

Contents

Executive summary

The NZ Transport Agency (hereafter referred to as the Transport Agency) assesses all potential environmental effects (including air quality) of roading projects in accordance with the *Z19 NZTA Environmental and Social Responsibility Standard*[4]. This utilises a stage-wise assessment process, as follows:

- Environmental and social responsibility (ESR) screen
- Preliminary technical assessment
- Technical assessment of environmental effects

The ESR screen[5] consists of a simple checklist of questions and is the first level of assessment undertaken in a project's life. The ESR screen is used in the preparation of the indicative business case for the project. As the project develops, the ESR screen is updated and may also be supplemented with results of an air quality screening model (for high risk projects) to form the preliminary technical assessment.

The updated ESR screen, or preliminary technical assessment where relevant, is used to scope the level of detail required in the full technical assessment of environmental effects (AEE). Depending on the air quality risk posed by the project, the AEE may be able to utilise the air quality screening model or require a fully detailed air quality assessment. The AEE is required in the project consenting and pre-implementation phase.

This document contains supporting technical information on the air quality screening model, which is available at *www.air.nzta.govt.nz*. The information includes:

- A description of the calculations and assumptions used within the screening model;
- A summary of work undertaken on behalf of the Transport Agency to validate the output of the screening model versus other assessment models; and
- A method for using the screening model to assess the effect of intersections or multiple roads.

The screening model has been designed to be easy to use and stand alone. Therefore users do not need to read this document in order to operate the model but they may find the additional technical information helpful, particularly in interpreting the results. The calculations and assumptions provided in this document, along with the results of the validation exercise, demonstrate that the screening model is conservative and fit for purpose for air quality screening assessments.

The Transport Agency released a draft *Guide to assessing air quality effects for state highway asset improvement projects*[6] in 2012. The guide describes the processes to be applied to the Transport Agency's projects in order to assess and reduce any adverse air quality effects resulting from the construction and operation of state highway asset improvement projects, including tunnels. This draft guide is currently (2014) being updated to give effect to the new ESR standard.

[4] NZTA (2014a). *Z19 NZTA Environmental and Social Responsibility Standard*, Draft version, February 2014

[5] NZTA (2014b). *Environmental and Social Responsibility (ESR) Screen*, Draft version 2.0, January 2014

[6] NZTA (2012). *Guide to assessing air quality effects for state highway asset improvement projects*, Draft version 0.6, September 2012

1. Introduction

1.1 Transport Agency assessment processes

Air quality is only one of many potential environmental impacts that need to be assessed for a road project. However, for a state highway asset improvement project, air quality can be a significant area of community concern.

The NZ Transport Agency (hereafter referred to as the Transport Agency) assesses all potential environmental effects (including air quality) of roading projects in accordance with the *Z19 NZTA Environmental and Social Responsibility Standard*[7]. This utilises a stage-wise assessment process, as follows:

- Environmental and social responsibility (ESR) screen
- Preliminary technical assessment
- Technical assessment of environmental effects

The ESR screen[8] consists of a simple checklist of questions and is the first level of assessment undertaken in a project's life. The ESR screen is used in the preparation of the indicative business case for the project.

As the project develops, the ESR screen is updated and may also be supplemented with results of an air quality screening model (for high risk projects) to form the preliminary technical assessment. The purpose of the preliminary technical assessment is to filter out those project options, or links within a project, where adverse effects on air quality will definitely **not** occur. The air quality screening model provides a conservative (worst case) assessment of likely air quality effects.

The updated ESR screen, or preliminary technical assessment where relevant, is then used to scope the level of detail required in the full technical assessment of environmental effects (AEE). Depending on the air quality risk posed by the project, the AEE may be able to utilise the air quality screening model or require a fully detailed air quality assessment. The AEE is required in the project consenting and pre-implementation phase.

This document contains supporting technical information on the air quality screening model, which is available at *www.air.nzta.govt.nz*. The information includes:

- A description of the calculations and assumptions used within the screening model;
- A summary of work undertaken on behalf of the Transport Agency to validate the output of the screening model versus other assessment models; and
- A method for using the screening model to assess the effect of intersections or multiple roads.

The screening model has been designed to be easy to use and stand alone. Therefore users do not need to read this document in order to operate the model but they may find the additional technical information helpful, particularly in interpreting the results.

[7] NZTA (2014a). *Z19 NZTA Environmental and Social Responsibility Standard*, Draft version, February 2014

[8] NZTA (2014b). *Environmental and Social Responsibility (ESR) Screen*, Draft version 2.0, January 2014

This document demonstrates that the screening model is conservative and fit for purpose for screening assessments.

1.2 Air quality assessment levels

The air quality impacts from roadways in New Zealand, including state highways, have traditionally been assessed using tiered approaches – where the level of detail in the assessment matches the level of air quality risk posed by the project.

In 2008, the Ministry for the Environment (MfE) released a *Good practice guide for assessing discharges to air from land transport*[9]. This guide promotes a three-tiered assessment approach for considering the impacts on air quality from transport developments. In 2012, this approach was adopted by the Transport Agency and tailored to specifically managing operational effects associated with state highway projects in the draft *Guide to assessing air quality effects for state highway asset improvement projects*[10].

The Transport Agency draft guide provides direction on how to undertake air quality assessments for state highway projects within the framework of business processes that the Transport Agency follows. It covers how to assess and reduce any adverse air quality effects resulting from the construction and operation of state highway asset improvement projects (including tunnels). The aim is to achieve nationally consistent application of best air quality management practices.

The draft guide is currently (2014) being updated to give effect to the new ESR Standard[11]. As part of the update, some of the terminology in the draft guide will be changed. However the philosophy of assessing effects based on risk and the tools to undertake air quality assessments will remain unchanged.

The draft guide utilises the following terminology which is generally consistent with the ESR Standard as follows:

- Tier 1 risk assessment ≈ ESR screen
- Tier 2 screening assessment ≈ Preliminary technical assessment
- Tier 3 detailed assessment ≈ Technical assessment of environmental effects

The air quality screening model is utilised in the preliminary technical assessment as a tool to determine whether a project option is likely to exceed air quality criteria and to establish the level of likely detail required in the technical assessment of effects. Running the air quality screening model is intended to be a straightforward step that can be completed in no more than five to 10 minutes per option by a non-specialist.

For low to medium risk projects, the output of the air quality screening model may also be sufficient for the AEE without the need for a detailed air quality assessment. Detailed air quality assessments are typically only required for high risk projects in urban areas and require the input of suitably qualified air quality specialists as they involve comprehensive modelling and often dedicated ambient air quality monitoring campaigns. The typical requirements for a detailed assessment are in the draft guide.

[9] MfE (2008). *Good practice guide for assessing discharges to air from land transport*, Ministry for the Environment, May 2008

[10] NZTA (2012). *Guide to assessing air quality effects for state highway asset improvement projects*, Draft version 0.6, September 2012

[11] NZTA (2014a). *Z19 NZTA Environmental and Social Responsibility Standard*, Draft version, February 2014

1.3 Overview of the screening model

The screening model uses traffic data and information about the project location to estimate the air quality at the nearest highly sensitive receptor for each segment of road (hereafter referred to as a link) that is being assessed[12].

The screening model calculates the concentration of particulate matter less than 10 micrometres (PM_{10}) and nitrogen dioxide (NO_2) resulting from the road itself (the 'road contribution). These concentrations are then combined with estimates of background levels (ie existing without nearby roads) to yield cumulative concentrations (ie likely air quality) at the nearest highly sensitive receptor.

The predicted cumulative concentrations are then compared with relevant air quality guidelines and standards as shown in table 1.

Table 1: Relevant air quality guidelines and standards for assessing PM_{10} and NO_2

Pollutant	Limit	Averaging time	Reference
PM_{10}	50 $\mu g/m^3$	24-hour	National air quality standard[13]
NO_2	40 $\mu g/m^3$	Annual	Global air quality guideline[14]

1.4 Report layout

This report is structured as follows:

- Chapter 2 describes the calculations and assumptions used within the screening model to calculate air quality effects.
- Chapter 3 summarises the work undertaken to validate the screening model and to demonstrate that the screening model is conservative.
- Chapter 4 describes a method for using the screening model to assess the effect of intersections or multiple roads.

A full list of references, a glossary of terms and detailed tables of results from the validation are provided at the end of the report.

[12] It may not be necessary to assess every link affected by the project. For projects that affect multiple links or intersections, the worst case locations can be assessed to determine whether the significance criteria are exceeded. The worst case will be the location with the closest receptors and highest emissions.

[13] MfE (2011). *Resource Management (National Environmental Standards for Air Quality) Regulations 2004, including the 2011 amendments.* Ministry for the Environment, 2011

[14] WHO (2006). *Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide, Global update 2005*, World Health Organisation, 2006

2. Calculations and assumptions

Motor vehicle emissions contain a wide range of pollutants. However, most of the health effects arise from a few key air pollutants – particulate matter less than 10 micrometres (PM_{10}) and nitrogen dioxide (NO_2) – and these are appropriate to use for conducting a screen of the likely overall air quality risk. If the screening results for these two pollutants suggest a low air quality risk, further assessment is unlikely to be required. However, if the results suggest a higher level of risk, a more detailed assessment and/or an investigation of a broader range of air pollutants may be required.

The screening model predicts the cumulative ground level concentrations of PM_{10} and NO_2at the nearest highly sensitive receptor based on contribution of the road itself and the background air quality. This chapter describes the calculations and assumptions used in these predictions.

The model requires the user to define the variables described in table 2 for each link that is being assessed. Each link should be a section of the road where traffic conditions (flow, composition and average speed) are reasonably homogeneous.

Table 2: Variables to be defined in the screening model

Parameter	Commentary
Assessment year	Any calendar year between 2010 through to 2030 (enabling past, current and future predictions)
Annual average daily traffic[15] (AADT) count	Average number of vehicles per day (modelled or best estimate to the nearest 5000).
% of heavy vehicles (%HV)	Percentage of vehicles heavier than 3.5 tonnes in the traffic flow (modelled or best estimate of the worst case highest)
Average speed[16] of vehicles	Average speed of all vehicles between 10 km/h and 99 km/h (modelled or best estimate to nearest 10km/h)
The distance (d) to the nearest 'highly sensitive'[17] receptor	Distance from the road edge in metres (actual distance or best estimate of the closest to the nearest 5m)

[15] Traffic data on AADT and %HV for existing locations are available from http://www.nzta.govt.nz/resources/state-highway-traffic-volumes/index.html

[16] The speed should be representative of speed close to the receptor. For example, if the receptor is close to an intersection, the average speed over the whole link will likely be higher than the speed close to the intersection. In this case, the localised average speed should be used.

[17] A 'highly sensitive' receptor is a location where people or surroundings may be particularly sensitive to the effects of air pollution. Examples include 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 Ministry for the Environment's *Good practice guide for assessing discharges to air from land transport* (MfE, 2008).

2.1 Particulate matter, PM_{10}

The cumulative 24-hour average PM_{10} concentration at the nearest highly sensitive receptor is calculated from the road contribution and the background air quality according to the methodology outlined in the following subsections.

The predicted cumulative concentration is then compared against the relevant air quality assessment limit – in this case, the **national air quality standard**[18] **for 24-hour average PM_{10} concentrations of 50µg/m³**.

2.1.1 PM_{10} road contribution

The maximum 24-hour PM_{10} concentration resulting from the nearby roadway is calculated based on equation 1.

$$\mathbf{24\ hour\ PM_{10}\ (\mu g/m^3) = 0.325\exp(-0.3d^{0.5}) \times (\frac{AADT}{24}) \times EF \times 0.5} \qquad \textbf{Equation 1}$$

Where:

$d = distance\ from\ edge\ of\ traffic\ lane\ to\ the\ nearest\ highly\ sensitive\ receptor\ \ in\ metres$

$AADT = annual\ average\ daily\ traffic\ at\ the\ assessment\ year$

$EF = emission\ factor\ in\ g/km$

Equation 1 is based on equation A1.6 from the Ministry for the Environment's *Good practice guide for assessing discharges to air from land transport*[19]. This was derived from a **normalised dispersion curve** and is intended to represent worst case conditions for New Zealand (ie the highest likely concentration resulting from the worst likely dispersion conditions). The derivation of the normalised dispersion curves and their conservatism is discussed in detail in the good practice guide.

The PM_{10} **emission factors** used in the screening model are taken from the *Vehicle emissions prediction model Version 5.1*[20,21] (VEPM 5.1) using the default settings. Default fleet profiles have been used to calculate fleet weighted averages for light duty and heavy duty vehicles for:

- all years from 2010 to 2030
- all speeds between 10km/hour and 99km/hour

[18] MfE (2011). *Resource Management (National Environmental Standards for Air Quality) Regulations 2004, including the 2011 amendments*. Ministry for the Environment, 2011

[19] MfE (2008). *Good practice guide for assessing discharges to air from land transport,* Ministry for the Environment, May 2008

[20] EFRU *et al.* (2012). *Vehicle emissions prediction model version 5.1,* prepared by Energy and Fuels Research Unit and Emission Impossible Ltd for NZ Transport Agency, July 2012

[21] NZTA (2013a). *Vehicle emissions prediction model (VEPM 5.1) user guide,* Version 1.0, NZ Transport Agency, June 2013

The screening model calculates PM_{10} emission factors for **each link** based on the user defined **average speed** and percentage of **heavy vehicles** (%HV) for the **assessment year**. For a screening assessment, the assessment year is usually taken as the project opening year[22].

2.1.2 PM_{10} background values

Default background values for 24-hour PM_{10} concentrations have been developed for each census area unit in New Zealand and provide concentration estimates for locations **excluding the influence of nearby roads**. The values used in the screening model were derived from monitoring data and correlation analyses and were prepared by Emission Impossible Ltd[23] for the Transport Agency.

In the screening model, background 24-hour PM_{10} values can be accessed for every location in New Zealand either via an interactive map or by looking up a list provided.

2.2 Nitrogen dioxide, NO_2

The cumulative annual average NO_2 concentration at the nearest highly sensitive receptor is calculated from the road contribution and the background air quality according to the methodology outlined in the following subsections.

The predicted cumulative concentration is then compared against the relevant air quality assessment limit – in this case, the **global air quality guideline**[24] **for annual average NO_2 concentrations of 40μg/m³**.

2.2.1 NO_2 road contribution

The annual average NO_2 concentration is calculated based on equation 2.

$$\textit{Annual average } NO_2\ (\mu g/m^3) = 0.00077 \times AADT \times d^{-0.65} \qquad \text{Equation 2}$$

Where:

$$d = \textit{distance from edge of traffic lane to the nearest highly sensitive receptor in metres}$$

$$AADT = \textit{annual average daily traffic at the project assessment year}$$

Equation 2[25] is derived from an **NO_2 regression model** developed by NIWA for the Transport Agency[26]. The NIWA regression model is based on the shortest distance from the road centreline to the receptor.

[22] NZTA (2012). *Guide to assessing air quality effects for state highway asset improvement projects*, Draft version 0.6, NZ Transport Agency, September 2012

[23] EIL (2013). *Background air quality for NZ Transport Agency state highway assessments*, prepared by Emission Impossible Ltd for NZ Transport Agency, April 2013

[24] WHO (2006) *Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide, Global update 2005*, World Health Organisation, 2006

However, the screening model is based on distance from the road edge to the receptor. The NIWA equation has not been adjusted in any way to account for this difference, which will introduce additional conservatism.

The NIWA spatial regression model predicts annual mean concentrations of NO_2 at any given location as a function of local traffic density. The regression model is an empirical model based on the results of NO_2 passive monitoring data from 45 Transport Agency sites in Auckland. The **NO_2 regression model was not specifically developed for the screening assessment model and is therefore subject to certain limitations**, which are discussed further in the following subsection.

Limitations of the NO_2 regression model

The key limitations of using the NO_2 regression model in the screening assessment model are:

- The NO_2 regression model was **designed to produce realistic (not conservative) estimates** of annual average NO_2.
- The NO_2 regression model has **only been validated for the Auckland isthmus**.
- The NO_2 regression model will **under predict in highly localised hot-spots** (eg intersections and deep street canyons) **and where the percentage of heavy duty vehicles in the traffic flow is more than 5 per cent**.
- The NO_2 regression model was based on a single subset of passive monitoring results from January 2007 to February 2010 and is not dependent on assessment year. This means that the NO_2 concentrations predicted in the screening model (which use this regression model) **do not change based on the assessment year.**

Motor vehicle emissions are expected to gradually reduce due to improvements in emission control technology. Per vehicle emissions from light duty vehicles in New Zealand have reduced significantly since 2003 (when emissions standards legislation came into force) for most pollutants[27]. However, nitric oxide (NO) emissions from diesel vehicles, in particular, appear to have plateaued. Exhaust emissions standards regulate the levels of nitrogen oxides (NO_X)[28] in motor vehicle exhaust. The chemistry, however, is complicated as NO_X is a combination of NO (which is emitted directly) as well as NO_2 (which can be

[25] The equation is based on the shortest distance from the road centreline to the receptor. However, the screening model is based on distance from the road edge to the receptor. The equation has not been adjusted in any way to account for this difference, which will introduce some conservatism.

[26] NIWA (2014). *A regression approach to assessing urban NO_2 from passive monitoring – Application to the Waterview Connection*, NIWA client report AKL-2014-023 prepared for NZ Transport Agency, June 2014

[27] NZTA (2011). *Are the harmful emissions from New Zealand's light duty vehicle fleet improving?,* NZ Transport Agency research report 441, May 2011

[28] Nitrogen oxides result principally from fossil fuel combustion, when nitrogen in the air that is used to burn the fuel gets oxidised. The most common NO_X compounds are nitrogen dioxide (NO_2) and nitric oxide (NO). NO is the primary product emitted directly but this is eventually oxidised by other pollutants present in ambient air to form NO_2. Motor vehicles are a major source of NO_x emissions in most parts of New Zealand.

emitted directly but also results from NO oxidising to NO_2). Many urban environments here and overseas[29] show steady or even rising levels of ambient NO_2.

Given the considerable uncertainty in the rate of reduction in exhaust emissions of NO_X and their consequential impact on ambient NO_2 levels, **the fact that the current regression model is independent of assessment year is probably appropriate at this stage and likely introduces an element of conservatism**. The Transport Agency has an on-going programme of NO_2 passive monitoring[30] and the results will provide the basis for regular updates of the NO_2 regression model.

On balance, **the NO_2 regression model is expected to be reasonably conservative**, with the possible exception of the Auckland CBD where there are deep street canyons. This conclusion is supported by validation of the screening model (described in chapter 3), which indicates that the results are indeed conservative.

2.2.2 NO_2 background values

Default background values for annual-NO_2 concentrations have been developed for each census area unit in New Zealand and provide concentration estimates for locations **excluding the influence of nearby roads**. The values used in the screening model were derived from monitoring data and correlation analyses and were prepared by Emission Impossible Ltd[31] for the Transport Agency.

In the screening model, background annual NO_2 values can be accessed for every location in New Zealand either via an interactive map or by looking up a list provided.

[29] Carslaw *et al.* (2011). *Trends in NOx and NO_2 emissions and ambient measurements in the UK*, prepared by D Carslaw, S Beevers, E Westmoreland, M Williams and J Tate for Department of Environment, Food and Rural Affairs, March 2011

[30] NZTA (2013b). *Ambient air quality (nitrogen dioxide) monitoring network – Annual report 2007 to 2012*, NZ Transport Agency, October 2013

[31] EIL (2013). *Background air quality for NZ Transport Agency state highway assessments*, prepared by Emission Impossible Ltd for NZ Transport Agency, April 2013

3. Validation

The air quality screening model is intended to provide a conservative (worst case) assessment of air quality risk from a single road.

In order to confirm that the screening model did indeed provide a conservative assessment of likely air quality effects, the Transport Agency commissioned NIWA and Beca to undertake a series of validation exercises. Results were taken from detailed air quality assessments that had been previously conducted for a selection of major roading projects across New Zealand. The screening model was then run, utilising the same key input parameters, and the outputs compared to establish whether the screening model was more or less conservative than the detailed models used.

The methodology followed is outlined in section 3.1, with the results discussed in section 3.2. Further information is available in appendix 1, which presents the detailed tables for all comparisons undertaken.

3.1 Methodology

The validation exercises were undertaken in 2011 using a preliminary version of the screening model. This early version used emission factors from VEPM 3.0[32], so the results were directly comparable with the results from available detailed assessments also based on VEPM 3.0. The early screening model version also included predictions for particulate matter less than 2.5 micrometres ($PM_{2.5}$) and utilised a different calculation method for NO_2 predictions.

Both NIWA and Beca were engaged by the Transport Agency to undertake validation exercises. For each project, a range of scenarios was considered. For each scenario, the maximum predicted concentrations of PM_{10} (24-hour), $PM_{2.5}$ (24-hour)[33] and NO_2 (annual average) from the detailed assessment were compared with predicted concentrations from the screening model. The comparisons were made for the **predicted road contributions to air quality only** – not the cumulative values which include background air quality. Both validation reports included a comparison of detailed predictions with the NIWA regression model used in the current version of the screening model as well as with the original NO_2 algorithm used in the preliminary version of the screening model. This users' note discusses the results from the NIWA regression model only.

The validation comparisons undertaken by NIWA[34] included the following roading projects[35]:

Transmission Gully – Wellington

[32] The screening model has since been updated to use VEPM 5.1 emission factors.

[33] $PM_{2.5}$ was included in the earlier version of the screening model but is not included in the current version.

[34] NIWA (2012). *Evaluation of an air quality screening assessment tool*, NIWA client report AKL2012-030 prepared by NIWA for NZ Transport Agency, July 2012

[35] The NIWA validation report also includes the Manukau Harbour Crossing. However the detailed assessment was undertaken using New Zealand Traffic Emission Rates (NZTER) emission factors, which means its results are not comparable with the screening model results. Therefore Manukau Harbour Crossing results are not discussed here.

- Detailed air quality assessment originally prepared by Beca in 2010
- Assessment undertaken using the AUSROADS dispersion model[36] and vehicle emission factors from VEPM 3.0

Northern Arterial and Queen Elizabeth Drive project – Christchurch

- Detailed air quality assessment originally prepared by NIWA in 2011
- Assessment undertaken using the AUSROADS dispersion model and vehicle emission factors from VEPM 3.0

Waikato Expressway – Cambridge section

- Detailed air quality assessment originally prepared by SKM in 2010
- Assessment undertaken using the BREEZE ROADS dispersion model37 and vehicle emission factors from VEPM 3.0

A more detailed validation was undertaken by Beca[38] in Auckland for:

SH16 Huruhuru Road Bridge to Hobsonville – Auckland

- Detailed air quality assessment originally prepared by Beca in 2010
- Assessment undertaken using the AUSROADS dispersion model and a one year meteorological data set developed by NIWA based on the outputs of a fine scale CALMET meteorological model. Vehicle emission factors were from VEPM 3.0.

For the validation comparisons, the ratios of the screening model road contribution results to the detailed modelling road contribution results were calculated. If the ratio was greater than 1.0 then the screening assessment was more conservative (ie predicted higher concentrations at the receptor) than the detailed assessment.

3.2 Results

The results of the comparison are summarised in appendix 1. The results show that, for all pollutants and all scenarios considered, the screening model results are **at least as conservative** as the detailed assessment results. The scenarios cover a range of locations, traffic conditions and distances from the roadside.

[36] AUSROADS is a Gaussian dispersion model developed by the Environment Protection Authority of Victoria (Australia) and is used for predicting ground level concentrations of pollutants from roads. See http://www.epa.vic.gov.au/

[37] BREEZE ROADS is an air dispersion model that predicts air quality impacts of pollutant concentrations from moving and idling motor vehicles at or alongside roadways and roadway intersections.
See http://www.breeze-software.com/roads/

[38] Beca (2011). *NZTA Tier 2 screening toolkit validation,* report prepared by Beca Infrastructure Ltd for NZ Transport Agency, October 2011

The relative conservatism of the detailed assessments to actual monitoring results was not evaluated for this exercise. However, in general, the maximum concentration predicted by a detailed assessment should be conservative relative to what would actually be measured or experienced at that location.

The results of the validation exercises (discussed in more detail in the following subsections) show that the screening model is conservative and fit for purpose as a **screening** assessment.

3.2.1 PM_{10} and $PM_{2.5}$ results

For particulate matter (PM_{10} and $PM_{2.5}$), the predictions for the screening model were **at least as (if not considerably more) conservative** than those from the detailed assessment. The ratios of screening model results to the detailed assessment results ranged from 1.0 to 7.1.

Note: $PM_{2.5}$ was included in the preliminary version of the screening model but is not included in the current version.

For the Waikato Expressway project, the screening model predictions **were equal** to the detailed predictions for PM_{10}. This is likely to be due to the effect of side roads, which were included in the detailed assessment, whereas the screening assessment was based on emissions from the main road only. The detailed assessment report did not include traffic data for the side roads so this was not able to be investigated further. However, use of the screening model for assessment of intersections and multiple roads was investigated for another example, as discussed in chapter 4.

3.2.2 NO_2 results

For nitrogen dioxide (NO_2), the predictions using the NIWA regression model were **at least as (if not more) conservative** than those from the detailed assessment. The ratios of NIWA regression model results to the detailed assessment results ranged from 1.0 to 4.4. The ratio is close to one for 2006 assessments. This is expected, and confirms that the NIWA regression model provides a reasonably realistic estimate of annual average NO_2 for assessment of existing air quality. For assessments based on future years, the regression model results were much more conservative than the results of the detailed assessments. This is expected, as discussed in section 2.2.1.

Note: The preliminary version of the screening model utilised a different NO_2 algorithm. Based on the validation work, the NO_2 calculation method in the screening model was updated to the NIWA regression model which yielded better results.

4. Intersections and multiple roads

The air quality screening model is designed to assess air quality risk from a single road on a link by link basis. However, the screening model can be used to assess the effects of more than one road at a given receptor location.

To assess the influence of multiple links on a single receptor, the screening model outputs for the road contribution from each link can simply be added together with the background air quality estimate. This will give a very conservative assessment of the cumulative impact of multiple links at a receptor.

This section provides some examples of how to select appropriate traffic and distances for assessment of intersections and multiple roads. A case study is also provided.

4.1 Method

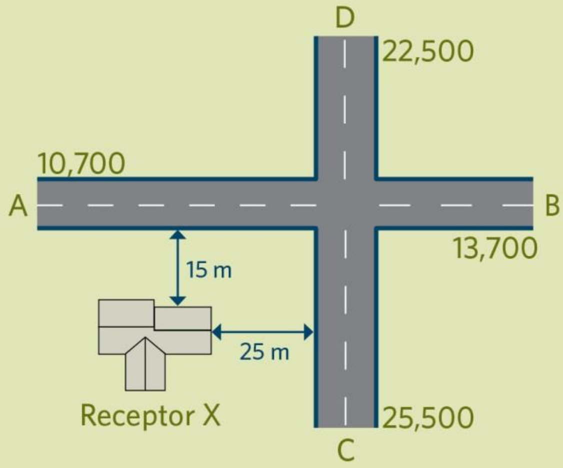
The method to estimate worst case effects of an intersection at the nearest highly sensitive receptor using the screening model is as follows:

1. Data for individual links should be defined based on the examples provided in the following section.
2. The road contribution for each link should be estimated separately using the screening model.
3. The sum of the predicted road contributions for the links together with the estimate of background air quality for the location will provide an estimate of cumulative effect at the nearest highly sensitive receptor.

4.2 Examples

Detailed guidance on how to define distance to receptors and traffic data for intersections is provided in the UK *Design manual for roads and bridges*[39]. The following examples have been adapted from the UK design manual.

[39] DfT (2007). *Design manual for roads and bridges*, *Volume 11, Section 3, Part 1, Air Quality*, Highways Agency Advice Note HA207/07, UK Department for Transport, May 2007

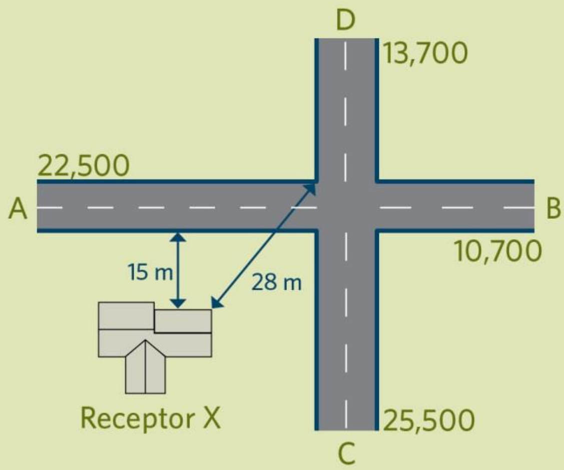


This simple intersection should be assessed as two roads, AB and CD. The traffic flows (and other input data) should be those on the links closest to the receptor (X).

Table 3: Screening model inputs for example 1

Link name	Nearest highly sensitive receptor	AADT
AB	15 m	10,700 vpd
CD	25 m	25,500 vpd

Figure 1: Example 1 to estimate the effect of an intersection at a receptor

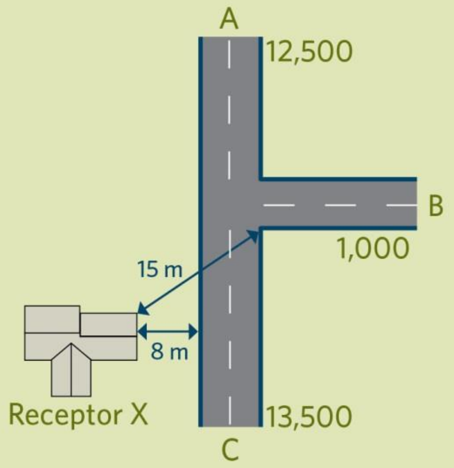


This is the same network as for example 1, but now the major flow of traffic takes the route AC. Links should be defined for the screening assessment based on homogeneous traffic rather than geometry (so in this case the two links are AC and BD). The distance should be measured from the closest road edge on link BD to the receptor.

Table 4: Screening model inputs for example 2

Link name	Nearest highly sensitive receptor	AADT
AC	15 m	22,500 vpd
BD	28 m	13,700 vpd

Figure 2: Example 2 to estimate the effect of an intersection at a receptor

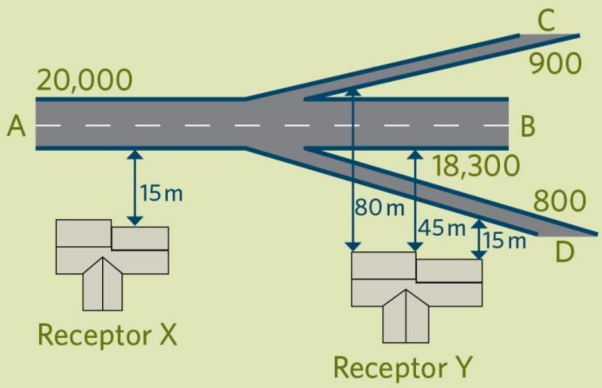


This T intersection should be assessed as two links. On the basis of the traffic flows, arms A and C are most similar.

Table 5: Screening tool inputs for example 3

Link name	Nearest highly sensitive receptor	AADT
AC	8 m	13,500 vpd
B	15 m	1,000 vpd

Figure 3: Example 3 to estimate the effect of a T junction at a receptor



This example represents a motorway with an on-ramp and off-ramp for a receptor located away from the ramps (in this case, Receptor X) only the flow on the main link (A) needs to be considered. For a receptor in the vicinity of the ramps (Receptor Y to the east) all three links would need to be considered as shown.

Table 6: *Receptor Y* screening tool inputs for example 4

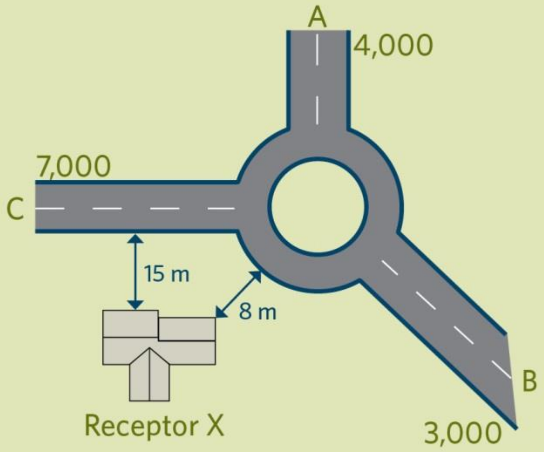
Link name	Nearest highly sensitive receptor	AADT
B	45 m	18,300 vpd
C	80 m	900 vpd
D	15 m	800 vpd

Table 7: *Receptor X* screening tool inputs for example 4

Link name	Nearest highly sensitive receptor	AADT
A	15 m	20,000 vpd

Figure 4: Example 4 to estimate the effect of a motorway at two receptors

Even though this example includes a roundabout, it is similar to the T intersection in example 3. The two arms with the most similar traffic conditions are considered as one link and the remaining arm is the second link. On the basis of the traffic flows, arms A and B are most similar.



However, the roundabout has the effect of bringing some of the traffic nearer to the receptor, so in this case the distance to link AB is measured to a point on the roundabout. The flow for AB is taken to be the average of that on arms A and B.

Table 8: Screening tool inputs for example 5

Link name	Nearest highly sensitive receptor	AADT
AB	8 m	3,500 vpd
C	15 m	7,000 vpd

Figure 5: Example 5 to estimate the effect of a roundabout at a receptor

4.3 Case study

The Beca validation report[40] includes a comparison of the screening model results with the results of a detailed assessment at an interchange.

To estimate worst case effects at each receptor, the effect of each road was estimated separately using the screening model. An estimate of cumulative effects at each receptor was calculated as the sum of the predicted result for each of the roads.

The Beca report notes that this approach is expected to be conservative as it takes no account of the geometrical relationship of the receptors and road sources to each other, and whether the receptor will be potentially downwind of one of both of the sources during worst case dispersion conditions.

Figure 6 illustrates the location of the roads and the receptors that were included in the comparison.

[40] Beca (2011). *NZTA Tier 2 screening toolkit validation,* report prepared by Beca Infrastructure Ltd for NZ Transport Agency, October 2011

Figure 6: Location of roads and receptors in the interchange case study (Beca, 2011)

The traffic parameters used in this assessment are shown in table 9.

Table 9: Traffic parameters used in the interchange case study

Scenario	Link	AADT	% HV	Speed
2006	SH 16	42,500	8	96
	Royal Rd (west of Makora Rd)	7,800	4	29
	Royal Rd (east of Makora Rd)	11,500	7	16
	Makora Rd	16,700	7	16
2026 With Project	SH 16	75,300	11	96
	Royal Rd (west of Makora Rd)	12,400	6	27
	Royal Rd (east of Makora Rd)	21,500	7	28
	Makora Rd	14,600	8	14
2026 Do Minimum	SH 16	68,800	12	96
	Royal Rd (west of Makora Rd)	11,000	6	27
	Royal Rd (east of Makora Rd)	19,400	8	32
	Makora Rd	13,400	8	15

An example of the screening assessment for the 2006 interchange area scenario is shown in table 10 below. The Beca report notes that the assessment at receptor RRP1 (see figure 6) does not include any consideration of traffic on Makora Road.

Table 10: Screening assessment results for the 2006 interchange area scenario

Scenario	Receptor	Source	Distance to receptor	Screening model outputs		
			(m)	PM_{10}	$PM_{2.5}$	NO_2
2006 Interchange Area	H1 (see figure 6)	SH16	24	4.6	4.4	3.8
		Royal Rd (east)	11	3.3	3	1.6
		Sum		**7.9**	**7.4**	**5.4**
	H2 (see figure 6)	SH16	40	3.0	2.9	2.8
		Royal Rd (east)	16	2.6	2.4	1.3
		Sum		**5.6**	**5.3**	**4.1**
	RRP1 (see figure 6)	SH16	98	1.0	1.0	1.6
		Royal Rd (west)	28	0.9	0.8	0.6
		Sum		**1.9**	**1.8**	**2.3**

The full results of the comparison with the detailed assessment for the interchange area are summarised in appendix 1, table 12.

The ratio of screening model results to the detailed assessment results ranges from 1.7 to 6.5. The results of the case study show that the screening model can be used to provide a conservative assessment of air quality effects at intersections.

5. Glossary of terms and abbreviations

AADT	Annual average daily traffic.
AEE	Assessment of environmental effects.
AQNES	Air quality national environmental standards.
Concentration	The amount of a substance in a mixture. The concentration is usually proportional to the observable intensity of effects. For air pollution, concentration is reported as either a volumetric measure (eg parts per million ppm) or as a mass measure (eg milligrams per cubic metre mg/m^3 or micrograms per cubic metre $\mu g/m^3$).
EF	Emission factor, in grams per kilometre g/km.
Emission	The release of a substance (eg an air pollutant) from a source, (eg transport, industry or domestic fires). Emissions are often expressed in units per activity (eg grams per kilometre driven g/km or grams per kilogram fuel burnt g/kg).
ESR	Environmental and social responsibility.
ESR screen	The first level of assessment required in a project's life. It is undertaken early in a proposed project's life to highlight potential air quality risk factors associated with the option under consideration. All roading projects are expected to undergo a tier 1 assessment. An ESR screen consists of completing a simple checklist of basic questions. It is quick and can be easily undertaken by non-specialists It is generally equivalent to the old Tier 1 risk assessment in the Transport Agency's draft *Guide to assessing air quality effects for state highway asset improvement projects* which is currently (2014) being updated.
Exceedance	An occasion when the concentration of an air pollutant exceeds a standard or permissible measurement.
Exposure	The concentration of air pollution experienced by a person for a set duration, usually expressed as a time averaged concentration (e.g. 1-hour average or annual average). Air quality guidelines and standards are usually set for two extremes of exposure – a short-term or acute exposure level and a long-term or chronic exposure level.
Highly sensitive receptor	A location where people or surroundings may be particularly sensitive to the effects of air pollution. Examples include residential houses, hospitals, schools, early childhood education centres, childcare facilities, rest homes, marae, other cultural facilities, and sensitive ecosystems.
%HV	Proportion of heavy duty vehicles (eg vehicles with a gross vehicle mass of over 3.5 tonnes).
Link	In a road network, a portion of a road between two intersections, junctions, interchanges or nodes. Its basic characteristics are length, vehicle speeds, travel times and number of lanes.

MfE	Ministry for the Environment
MoT	Ministry of Transport
NO	Nitric oxide
NO_2	Nitrogen dioxide is produced from the combustion of fossil fuels used in transport. NO_2 can cause health effects such as retarded lung development in children and increased susceptibility to lung infections.
NO_X	Oxides of nitrogen, which includes both NO and NO_2.
NZTA	The NZ Transport Agency is the agency responsible for the building and operation of New Zealand's state highway network, amongst other duties, since July 2008. Previously, this was managed by Transit New Zealand.
Opening year	The year in which the state highway improvement is completed and opened for use.
PM_{10}	Fine particulate matter less than 10 μm in diameter, an air pollutant produced from the combustion of fossil fuels, primarily diesel, used in transport. PM_{10} can cause serious health effects such as increased cardio-respiratory illness and premature death. Although $PM_{2.5}$ is of increasing concern, because its emissions relate more directly to observed health effects, PM_{10} is commonly used in air quality assessments as it covered by an AQNES and more comprehensive monitoring records exist.
$PM_{2.5}$	Fine particulate matter less than 2.5 μm in diameter, an air pollutant produced from the combustion of fossil fuels, primarily diesel, used in transport.
Preliminary technical assessment	The second level of assessment required in a project's life. It is undertaken to indicate whether an air quality guideline or standard is likely to be exceeded by the preferred option/s under consideration. It is also used to scope the requirements for the full technical assessment. A preliminary technical assessment may involve an updated ESR screen (for lower risk projects) or utilise the air quality screening model (for higher risk projects). It is slightly more involved than a tier 1 assessment but can still be quickly and easily undertaken by non-specialists. It is generally equivalent to the old Tier 2 screening assessment in the Transport Agency's draft *Guide to assessing air quality effects for state highway asset improvement projects* which is currently (2014) being updated.
Technical assessment of effects	The third level of assessment required in a project's life to provide a comprehensive assessment of the likely air quality impacts associated with the final design of the project. A technical assessment may be able to utilise results from the air quality screening model (for lower risk projects) or may require a detailed air quality assessment (for higher risk projects such as large scale urban developments). A detailed assessment utilises modelling of traffic, emissions and dispersion patterns to predict the air quality impacts from the proposed project. A dedicated air quality monitoring campaign may also be required in order to confirm existing background air quality. It is

	a complex exercise and should only be undertaken by air quality technical specialists. It is generally equivalent to the old Tier 3 detailed assessment in the Transport Agency's draft *Guide to assessing air quality effects for state highway asset improvement projects* which is currently (2014) being updated.
Tier 1 risk assessment	See ESR screen.
Tier 2 screening assessment	See Preliminary technical assessment.
Tier 3 detailed assessment	See Technical assessment of effects.
$\mu g/m^3$	Microgram per cubic metre, a measure of the concentration of a pollutant in ambient air.
μm	Micrometre or a millionth of a metre, a measure of the diameter of particulate matter.
VEPM	Vehicle emissions prediction model.
vpd	Vehicles per day.

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Appendix 1: Detailed validation results

This appendix presents results of the validation studies as follows:

- Table 11 is a comparison of road contribution concentrations predicted by the screening model with those from detailed assessments for a range of projects.
- Table 12 is a comparison of road contribution concentrations predicted by the screening model with those from detailed assessments for an interchange area.

These results are summarised from the screening model validation reports prepared by Beca[41] and NIWA[42] for the Transport Agency.

[41] Beca (2011). *NZTA Tier 2 screening toolkit validation,* report prepared by Beca Infrastructure Ltd for NZ Transport Agency, October 2011

[42] NIWA (2012). *Evaluation of an air quality screening assessment tool*, NIWA client report AKL2012-030 prepared by NIWA for NZ Transport Agency, July 2012

Table 11: Comparison of screening model results with the results of detailed assessments

Scenario	%HV	AADT	Average speed	Distance to highly sensitive receptor (m)	Screening model outputs		Regression model results*	Detailed results			Ratio of screening model to detailed model results		
					PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2
Transmission Gully, Wellington													
2006 SH1	7.2	43900	80	10	6.9	5.7	–	3.8	2.3	–	1.8	2.5	–
2031 with project	7.2	65600	80	10	5.4	3.7	–	2.8	1.7	–	1.9	2.2	–
Northern Arterial and Queen Elizabeth Drive, Christchurch													
2006 QE2	8.0	28600	80	50	1.2	1.0	1.5	0.3	0.3	1.5	4.4	4.0	1.0
2006 Main North Road	8.0	34200	60	10	2.9	2.4	3.8	0.4	0.4	2.1	7.1	6.5	1.8
2016 Northern Arterial	8.0	34100	80	15	2.3	1.8	3.2	0.4	0.4	1.6	5.9	5.1	2.0
Waikato Expressway – Cambridge Section													
2016 SH1 without project	9.3	23900	45	20[1]	2.1	–	2.3	2.1	–	0.9	**1.0**	–	2.6
2016 expressway	9.3	16400	80	15[2]	1.6	–	1.8	1.6	–	1.5	**1.0**	–	1.2

*The NIWA regression model is the NO_2 calculation method used in the current version of the screening model (see section 2.2.1 for details).

[1] A distance of 20m is assumed based on the detailed assessment distance of 25m from the centreline.

[2] A distance of 15m is assumed based on the detailed assessment distance of 20m from the centreline.

Scenario	%HV	AADT	Average speed	Distance to highly sensitive receptor (m)	Screening model outputs		Regression model results*	Detailed results			Ratio of screening model to detailed model results		
					PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2
SH16 Huruhuru Road Bridge to Hobsonville, Auckland													
2006 South Residential Area	8.0	61000	96	21	7.2	7.0	5.1	3.7	2.8	4.1	1.9	2.5	1.3
				41	4.2	4.1	3.7	2.4	1.8	2.7	1.8	2.3	1.4
				66	2.5	2.4	2.8	1.7	1.3	1.9	1.5	1.9	1.5
				91	1.6	1.6	2.4	1.4	1.1	1.5	1.1	1.5	1.6
2026 South Residential Area with project	11.0	96200	96	17	7.8	5.9	8.1	3.4	2.6	2.8	2.3	2.3	3.0
				37	4.3	3.3	5.8	2.1	1.6	1.7	2.0	2.1	3.3
				62	2.5	1.9	4.5	1.5	1.1	1.2	1.7	1.7	3.7
				87	1.6	1.2	3.7	1.2	0.9	0.9	1.3	1.3	3.9
2026 South Residential Area do minimum	12.0	86500	94	17	7.0	5.3	7.3	2.6	2.0	2.1	2.7	2.7	3.4
				37	3.9	2.9	5.2	1.7	1.3	1.4	2.3	2.3	3.8
				62	2.3	1.7	4.0	1.2	0.9	1.0	1.9	1.9	4.1
				87	1.5	1.1	3.3	0.9	0.7	0.8	1.7	1.6	4.4

*The NIWA regression model is the NO_2 calculation method used in the current version of the screening model (see section 2.2.1 for details).

Scenario	%HV	AADT	Average speed	Distance to highly sensitive receptor (m)	Screening model outputs		Regression model outputs*	Detailed results			Ratio of screening model to detailed model results		
					PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2
SH16 Huruhuru Road Bridge to Hobsonville, Auckland													
2006 North Residential Area	8.0	42500	96	15	6.2	6.1	4.0	3.2	2.4	3.3	1.9	2.5	1.2
				20	5.2	5.1	3.6	2.8	2.1	2.9	1.9	2.4	1.2
				40	3.0	2.9	2.6	1.9	1.4	1.9	1.6	2.0	1.4
				65	1.8	1.7	2.0	1.3	1.0	1.4	1.4	1.7	1.5
				90	1.1	1.1	1.6	1.0	0.8	1.1	1.1	1.5	1.5
2026 North Residential Area with project	11.0	75300	96	12	7.4	5.6	7.2	3.3	2.5	2.5	2.2	2.2	2.9
				17	6.1	4.6	6.4	2.9	2.2	2.2	2.1	2.1	2.9
				37	3.4	2.6	4.6	1.8	1.4	1.4	1.9	1.9	3.3
				62	2.0	1.5	3.5	1.3	0.9	1.0	1.6	1.6	3.6
				87	1.3	1.0	2.9	0.9	0.7	0.7	1.4	1.4	3.9
2026 North Residential Area do minimum	12.0	68800	96	12	6.8	5.1	6.5	3.1	2.3	2.3	2.2	2.2	2.8
				17	5.6	4.2	5.8	2.7	2.0	2.0	2.1	2.1	2.9
				37	3.1	2.3	4.2	1.7	1.3	1.3	1.8	1.8	3.2
				62	1.8	1.4	3.2	1.2	0.9	0.9	1.5	1.6	3.5
				87	1.2	0.9	2.7	0.9	0.7	0.7	1.4	1.4	3.8

*The NIWA regression model is the NO_2 calculation method used in the current version of the screening model (see section 2.2.1 for details).

Table 12: Comparison of screening model results with the results of a detailed assessment at an interchange

Scenario	Receptor	Source	Distance to receptor (m)	Screening model outputs		Regression model outputs*	Detailed results			Ratio of screening model to detailed model results		
				PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2
2006 Interchange Area	H1	SH16	24	4.6	4.4	3.8	3.1	2.3	3.1			
		Royal Rd (east)	11	3.3	3	1.6						
		Sum		7.9	7.4	5.4				2.6	3.2	1.7
	H2	SH16	40	3.0	2.9	2.8	1.9	1.4	1.8			
		Royal Rd (east)	16	2.6	2.4	1.3						
		Sum		**5.6**	**5.3**	**4.1**				3.0	3.8	2.3
	RRP1	SH16	98	1.0	1.0	1.6	1.1	0.8	0.9			
		Royal Rd (west)	28	0.9	0.8	0.6						
		Sum		**1.9**	**1.8**	**2.3**				1.8	2.3	2.5
2026 Interchange Area With Project	H1	SH16	23	5.0	3.8	6.6	2.9	2.2	2.3			
		Royal Rd (east)	11	1.9	1.8	2.9						
		Sum		**6.9**	**5.6**	**9.5**				2.4	2.6	4.2
	H2	SH16	37	3.4	2.6	5.1	1.7	1.2	1.3			
		Royal Rd (east)	16	1.6	1.5	2.4						
		Sum		**5.0**	**4.1**	**7.5**				3.0	3.3	5.9
	RRP1	SH16	95	1.1	0.9	2.9	0.9	0.6	0.6			
		Royal Rd (west)	28	0.6	0.6	1.0						
		Sum		**1.7**	**1.5**	**3.9**				2.0	2.3	6.3

*The NIWA regression model is the NO_2 calculation method used in the current version of the screening model (see section 2.2.1 for details).

Scenario	Receptor	Source	Distance to receptor (m)	Screening model outputs		Regression model outputs*	Detailed results			Ratio of screening model to detailed model results		
				PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2
2026 Interchange Area Do Minimum	H1	SH16	24	4.4	3.3	6.1	2.4	1.8	1.8			
		Royal Rd (east)	11	1.7	1.7	2.6						
		Sum		**6.1**	**5**	**8.8**				2.6	2.8	4.7
	H2	SH16	40	2.9	2.2	4.6	1.4	1.0	1.1			
		Royal Rd (east)	16	1.4	1.4	2.2						
		Sum		**4.3**	**3.6**	**6.7**				3.1	3.5	6.2
	RRP1	SH16	95	1.0	0.7	2.6	0.7	0.5	0.5			
		Royal Rd (west)	28	0.5	0.5	0.9						
		Sum		**1.5**	**1.2**	**3.5**				2.1	2.2	6.5

*The NIWA regression model is the NO_2 calculation method used in the current version of the screening model (see section 2.2.1 for details).