Northern Corridor Improvements

Assessment of Air Quality Effects

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Executive summary

Scope of the assessment

This air quality assessment has been prepared to inform the Assessment of Environmental Effects (AEE) for the Northern Corridor Improvement Project (the Project). The scope of the air quality assessment is:

- Evaluate the potential effects on air quality arising from road construction, including effects on residences from the construction area and indicative construction support areas;
- Recommend mitigation measures and monitoring for air quality effects associated with the Project construction works (if necessary); and
- Determine the potential effects on air quality and human health at sensitive receptor locations due to discharges from traffic associated with the improved roading alignment using predicted traffic data for the operational phase and recommend mitigation measures (if necessary).

Effects of the Project: Construction

The construction phase of the Project has a moderate to high potential for dust impacts to occur and these impacts are likely to be considered objectionable and/or offensive. Therefore, it is crucial to identify the key sources of dust and to:

- Have mitigation practices in place to minimise the amount of dust emitted;
- Have a monitoring programme in place to measure the effectiveness of the mitigation and facilitate a rapid response if and when additional dust mitigation is required;
- Develop a Dust Management Plan which will ensure the effective implementation of the dust mitigation measures and monitoring programme.

Effects of the Project: Operation

The assessment of effects of the operational phase of the Project was undertaken using a dispersion model which calculates ground level concentrations (GLCs) of pollutants that are discharged from the vehicles using the roads. The predicted GLCs were compared to the relevant ambient air quality standards to assess whether or not the vehicle emissions had a significant effect on air quality in the areas adjacent to the roadways. The assessment considered:

- Base case: 2015;
- Opening year: 2021 – (two scenarios: with and without the Project); and
- Opening year plus 10 years: 2031– (two scenarios: with and without the Project).

The analysis of the 2015 without Project scenario results show that none of the air quality standards were exceeded, although that for $PM_{2.5}$ (24-hour average) may have come close. For the particulate pollutants, the Project contribution to the cumulative concentration is relatively small at approximately 10 % of the total. The analysis of the 2021 with Project scenario results show that none of the air quality standards are likely to be exceeded.

A comparison of the GLC pollutants for 2021 without Project and with Project scenarios shows that with the Project being built the concentrations of pollutants at the residential receptors are likely to remain at similar levels (Unsworth Heights) or increase slightly (Oteha).

A comparison of the 2021 and 2031 results, for both the with and without Project scenarios, show that effects are likely to decrease over time as the positive effects of lower vehicle emissions outweigh the effect of increased vehicle numbers.

If the Project achieves the aim of increasing network capacity, traffic will flow more freely through the region, the total emissions will decline and on an airshed scale this is likely to result in a slight net benefit for regional air quality as compared to the air quality if the Project were not built.

The conclusions from the assessment of operational effects of the Project on air quality suggest that exceedances of the relevant air quality standards are unlikely to occur, so there is no need for a programme to mitigate these effects.

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Glossary of Terms and Abbreviations

Item	Description
AAAQS	Proposed Auckland Ambient Air Quality Standards
AADT	Annual average daily traffic flow in vehicles per day
AAQG	Ambient air quality guidelines (Ministry for the Environment)
AC	Auckland Council
AEE	Assessment of environmental effects
Airshed	An area designated by regional councils for the purposes of managing air quality and gazetted by the Minister for the Environment.
AQNES	Air Quality National Environmental Standards
ARP: ALW	Auckland Regional Plan: Air land, water
ART	Auckland Regional Transport
AUP	Auckland Unitary Plan Operative in Part (15 November 2016)
AWMA	Air and Waste Management Association
CEMP	Construction Environmental Management Plan
CERC	Cambridge Environmental Research Consultants
CliDB	National climate database
CO	Carbon monoxide
CO_2	Carbon dioxide
CSA	Construction support areas
Design year	10 to 20 years after the opening of the new or altered road.
DMP	Dust Management Plan
EPA SA	Environment Protection Authority of South Australia
FIDOL	Frequency, Intensity, Duration, Offensiveness and Location factors.
g/v.km	grams per vehicle kilometre
GLC	Ground level concentration
HDD	Heavy-Duty Diesel vehicles
HR	Haul road
MfE	Ministry for the Environment
NES	National Environmental Standard
NIWA	National Institute of Water and Atmospheric Research
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxides.
NZTA	New Zealand Transport Agency
O_3	Ozone
PM_{10}	Fine particulate matter less than 10 µm in diameter.
$PM_{2.5}$	Fine particulate matter less than 2.5 µm in diameter.
RWWTP	Rosedale Waste Water Treatment Plant

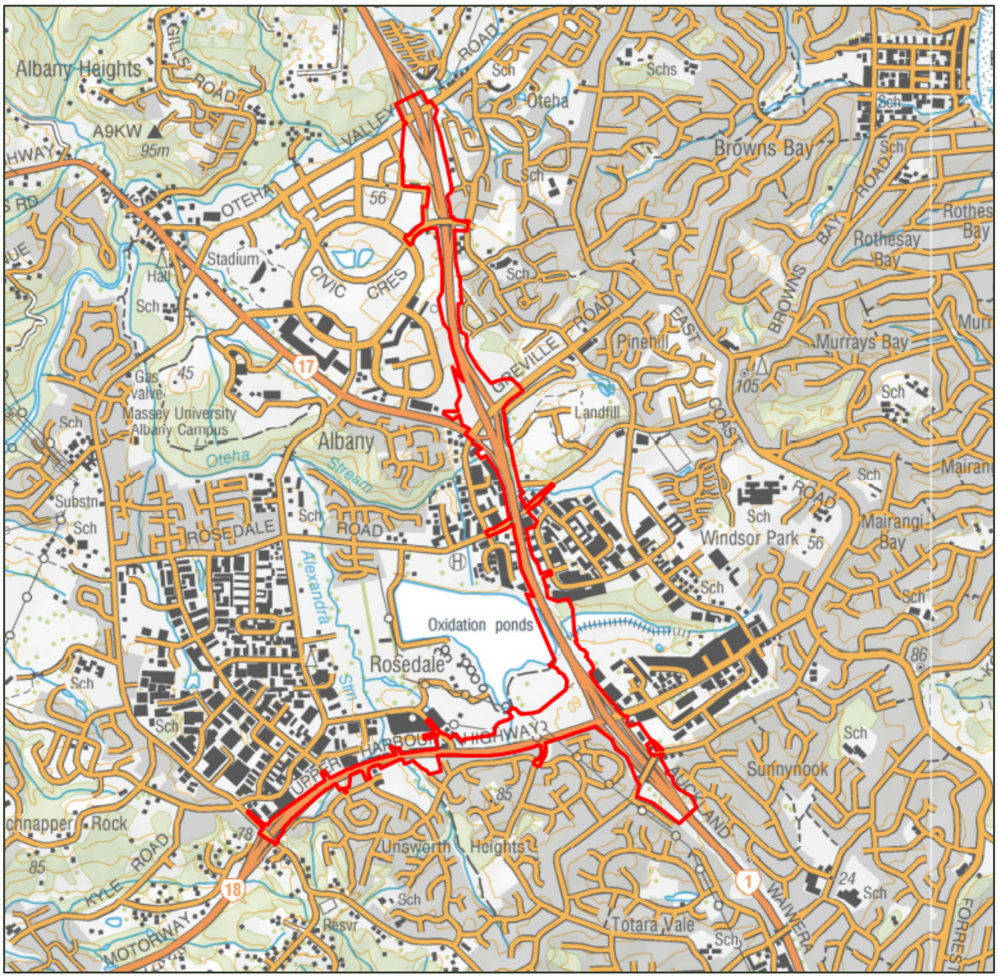
Item	Description
SH	State Highway
SUP	Shared Use Path
TSP	Total Suspended Particulate
VEPM	Vehicle Emissions Prediction Model
VOC	Volatile organic compounds

1 Description of the Project

1.1 Project background

The Northern Corridor Improvements Project (the Project) is an accelerated project. The Project area covers the area of SH18 between Albany Highway and Constellation Drive, and SH1 between Upper Harbour Highway (UHH) interchange and just beyond the Oteha Valley Road Interchange as indicated on **Figure 1** below and confirmed in the suite of plans provided in **Volume 5**.

Figure 1 Extent of Project area



Source: Base Map from LINZ

The Project proposes to upgrade the existing State highways within the Project area. In summary, the key elements of the Project are as follows:

- North and West Motorway Interchange connections – SH1/SH18;
- State highway capacity and safety improvements;
- Northern busway extension from Constellation Bus Station and connection to Albany Bus Station;
- Reconfiguration of Constellation Bus Station converting it from a terminus station to a dual direction station

- Shared Use Path (SUP) provision along existing SH1 and SH18 routes for the full extent of the Project corridor:
  - Constellation Station to Oteha Valley Road;
  - Constellation Drive to Albany Highway; and
  - Intermediate linkages to local network.

A full description of the Project, including its components and construction, is contained in section 5 of the Assessment of Environmental Effects (AEE).

1.2 Purpose of this Report

The NZ Transport Agency decided an assessment of air quality should be included within the AEE being prepared for the Project. The scope of the air quality assessment was defined as:

- Evaluate the potential effects on air quality arising from road construction, including effects on residences from the construction area and indicative construction support areas (CSA);
- Recommend mitigation measures and monitoring for air quality effects associated with the Project construction works (if necessary); and
- Determine the potential effects on air quality and human health at sensitive receptor locations due to discharges from traffic associated with the improved Project using predicted traffic data for the operational phase and recommend mitigation (if necessary).

The NZ Transport Agency has produced a *Guide to Assessing Air Quality Impacts from State Highway Projects* (NZTA 2015) (the Guide). The Guide provides direction on how air quality risks and impacts from State highway improvement projects should be assessed. Based on the recommendations provided in the Guide, this 'comprehensive technical assessment' was prepared to assess the operational and construction air quality effects associated with the Project.

The purpose of a comprehensive technical assessment is to evaluate all air quality impacts (and opportunities) arising from the Project, feed this information back into the design process (to the extent possible) and inform the preparation of the AEE. The Guide determines that a comprehensive technical assessment has two main aspects relevant to the Project, namely:

- Assessing surface road air quality effects; and
- Assessing construction air quality effects.

This report presents the air quality assessment undertaken for the Project and is one of a suite of technical reports that has been prepared to inform the AEE for the Project.

The existing air quality of the Project area is described, the scale and significance of potential effects of the Project on air quality is assessed, and measures to minimise or mitigate adverse effects are identified where required.

This report does not cover air quality effects in respect to contaminated land or the landfill, which are covered in separate reports.

1.3 Construction phase

A preliminary construction programme (sequencing and timing) has been developed to inform the assessment of the environmental effects. It is anticipated that the Project will be progressed by way of eight indicative construction zones as shown in **Figure 2** which reflects the main components of the Project. The indicative planned start date, duration and end date for each construction zones is detailed in **Table 1.**

Table 1 **Project construction zones and indicative planned timelines**

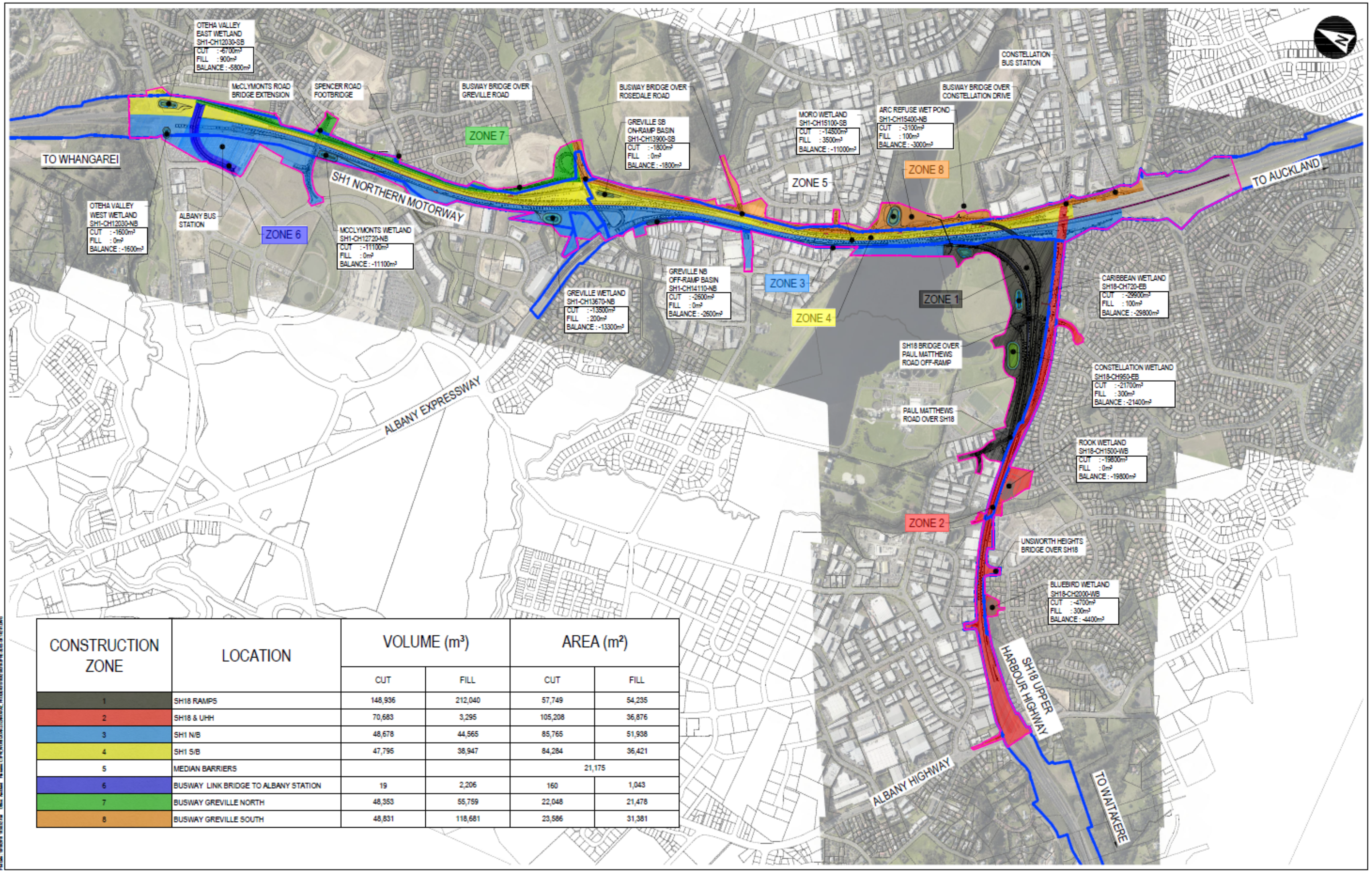
Zone number	Zone name	Indicative target start date	Duration (months)	Indicative target completion date
1	SH18 ramps	July 2018	31	December 2020
2	SH18 and Upper Harbour Highway	November 2019	23	September 2021
3	SH1 north bound widening	November 2019	14	December 2020
4	SH1 south bound widening	September 2018	14	October 2019
5	SH1 median works	April 2021	6	September 2021
6	Busway link busway to Albany Station	September 2018	28	December 2020
7	Busway north bound	June 2018	40	August 2021
8	Busway south bound	June 2018	40	August 2021

1.4 Operational phase

The Project would provide a direct motorway route between the Northern Motorway (SH1) and an upgraded Upper Harbour Highway (SH18). The Project is the final piece of Auckland's Western Ring Route, which runs between Manukau and the North Shore via West Auckland. The developments associated with the Project extend from Constellation Bus Station to just north of Oteha Valley Road. The Project's main components are described in section 1.1 above.

Figure 3 shows a schematic diagram of the Project area and the key elements. The eastern end section of SH18 which will be upgraded as part of the Project is approximately 1.2 km in length. The section of SH1 between SH18 and Oteha Valley Road and which will be upgraded is approximately 3.7 km in length.

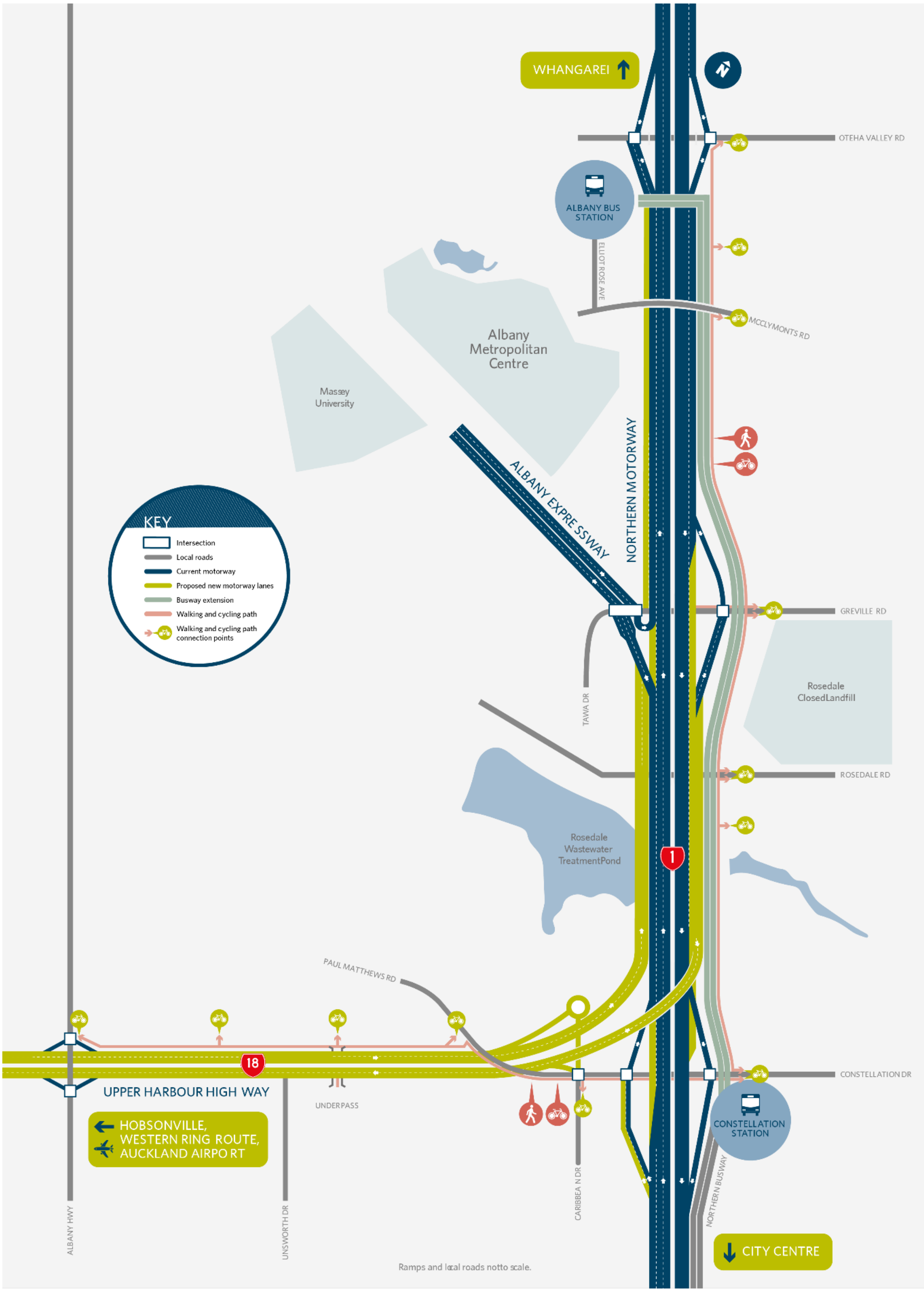
Figure 2 Indicative plan of the cut and fill values for construction zones 1 to 8



CONSTRUCTION ZONE	LOCATION	VOLUME (m³)		AREA (m²)	
		CUT	FILL	CUT	FILL
1	SH18 RAMPS	148,936	212,040	57,749	54,235
2	SH18 & UHH	70,683	3,295	105,208	36,876
3	SH1 N/B	48,678	44,565	85,765	51,938
4	SH1 S/B	47,795	38,947	84,284	36,421
5	MEDIAN BARRIERS			21,175	
6	BUSWAY LINK BRIDGE TO ALBANY STATION	19	2,206	160	1,043
7	BUSWAY GREVILLE NORTH	48,353	55,759	22,048	21,478
8	BUSWAY GREVILLE SOUTH	48,831	118,681	23,586	31,381

Source: Aurecon

Figure 3 Schematic diagram of the Project



Source: NZTA

2 Requirements for the Air Quality Assessment

2.1 Introduction

The requirements for the air quality assessment are defined within the guidance provided in the NZ Transport Agency Guide.

2.2 Key tasks for assessing air quality effects

The Guide defines there are two key tasks to be completed when undertaking a comprehensive air quality assessment. These are:

- Assessing the roadway construction air quality effects; and
- Assessing the roadway operational air quality effects.

2.2.1 Construction air quality effects

The Guide details the steps to be undertaken when assessing the construction air quality effects as:

1. Determine assessment criteria - presented in Section 2.3;
2. Identify highly sensitive receptors and other existing land uses - presented in Section 3.2;
3. Categorise areas by sensitivity - presented in Section 3;
4. Establish construction methodology and foot print – presented in Section 1.3;
5. Determine activities generating construction emissions – presented in Section 5.1;
6. Assess effects against criteria – presented in Section 5.2; and
7. Propose mitigation – presented in Section 6.

2.2.2 Roadway operational air quality effects

The Guide also details the steps to be undertaken when assessing the roadway operational air quality effects as:

1. Review existing ambient air quality and meteorological databases - presented in Section 3.3 and 3.4;
2. Decide on whether pre-project monitoring is required – not included in the scope of this report;
3. Identify highly sensitive receptors and other existing land uses - presented in Section 3.1 and 3.2;
4. Determine background and existing air quality - presented in Section 3.4;
5. Model traffic of opening and design years - presented in Section 7.2;
6. Calculate motor vehicle emissions - presented in Section 7.5;
7. Model dispersion of pollutants discharged from project links - presented in Section 8; and
8. Assess effects against criteria - presented in Section 8.

Proposed consent/designation conditions for both the construction and operational phases of the Project have been discussed with the Project team and proposed conditions will be included in the AEE.

2.3 Air quality assessment criteria

2.3.1 Roadway operational air quality effects

The Ministry for the Environment (MfE) has developed ambient (outdoor) Air Quality National Environmental Standards (AQNES) (MfE 2014) with the aim of protecting the quality of New Zealand's air. MfE's AQNES for the pollutants which are being assessed for the Project are detailed in **Table 2**.

Table 2 Air Quality National Environmental Standards relevant to the Project assessment

Pollutant	National Environmental Standard	Averaging Time
CO	10 mg/m^3	8-hour (rolling average)
NO_2	200 μg/m^3	1-hour
PM_{10}	50 μg/m^3	24-hour

In addition to the AQNES, the Auckland Council's (AC) Auckland Unitary Plan – Operative in Part (15 November 2016) (AUP) contains Auckland Ambient Air Quality Standards (AAAQS). The proposed AAAQS are detailed in **Table 3.**

Table 3 Auckland Council proposed Auckland Ambient Air Quality Standards and Targets

Pollutant	Proposed Auckland Ambient Air Quality Standards	ARP:ALW Air Quality Targets	Averaging Time
CO	10 mg/m^3	NA	8-hours (running mean)
	30 mg/m^3	30 mg/m^3	1-hour
NO_2	200 μg/m^3	NA	1-hour
	100 μg/m^3	100 μg/m^3	24-hour
	40 μg/m^3	NA	Annual
PM_{10}	50 μg/m^3	50 μg/m^3	24-hour
	20 μg/m^3	NA	Annual
$PM_{2.5}$	25 μg/m^3	25 μg/m^3	24-hour
	10 μg/m^3	NA	Annual

The key differences between the NES and the AAAQS is that that the latter includes additional standards for 1-hour CO concentrations, 24-hour and annual NO2 concentrations, and annual PM10 and 24-hour and annual PM2.5 concentrations.

Appeals have been lodged in respect AC's decision on the recommendations made by the Independent Hearing Panel to the AUP AAAQS. This means that in addition to the consideration of the AAAQS the relevant air quality guidelines and targets included in the Auckland Regional Plan:

Air, Land and Water (ARP:ALW) must be considered. The ARP:ALW air quality targets are listed in **Table 3.**

2.3.2 Construction air quality effects

Assessing the effects of dust can be done in either a quantitative or qualitative manner. When dust monitoring data is available dust emissions resulting from State highway construction activities are typically assessed against guidelines set by MfE (2001) as shown in **Table 4**.

Table 4 MfE recommended trigger levels for construction dust

Dust type	Protection	Criteria
Deposited particulate	All areas	4 g/m^2/30 days (above background concentrations)
Total suspended particulate (TSP)	Sensitive area	80 µg/m^3 (24-hour average)
	Moderately sensitive area	100 µg/m^3 (24-hour average)
	Insensitive area	120 µg/m^3 (24-hour average)

The MfE values in **Table 4** are typically used to assess the overall ability of a project to comply with the commonly used phrase 'no offensive or objectionable discharges of dust beyond the boundary of the project area'. The NZ Transport Agency has developed a range of short-term (1 hour) monitoring trigger values to assist project staff with maintaining effective dust control during the works. These trigger values are derived from the 24-hour values and are used for the following dust management purposes:

- Trigger value 1: This value is an investigation value. It indicates that dust concentrations are greater than would normally be expected and that, if they continue to increase, could result in a breach of the 24-hour value.
- Trigger value 2: This is a stop work value. It indicates that the 24-hour value will be exceeded if dust emissions are not reduced.

Examples of appropriate trigger values are presented in **Table 5**.

Table 5 Short-term (1-hour rolling average) trigger levels commonly used to manage construction dust

24-hour criteria	Trigger value 1 (1-hour)	Trigger value 2 (1-hour)
80 µg/m^3 (sensitive area)	100 µg/m^3	160 µg/m^3
100 µg/m^3 (moderately sensitive area)	140 µg/m^3	200 µg/m^3
120 µg/m^3 (insensitive area)	180 µg/m^3	240 µg/m^3

When dust monitoring data is not available or the assessment is for a green field site, dust assessments are commonly undertaken using qualitative assessment criteria. A key consideration in assessing adverse effects of dust emissions is whether impacts downwind are likely to result in an offensive or objectionable effect. The factors to be considered when determining the likelihood of dust impacts creating an offensive or objectionable adverse effect are referred to as the FIDOL factors. These factors are frequency (F), intensity (I), duration (D) of potential impacts at a sensitive location, offensiveness (O) or character of the discharge and the nature of the location (L) where the impact could occur.

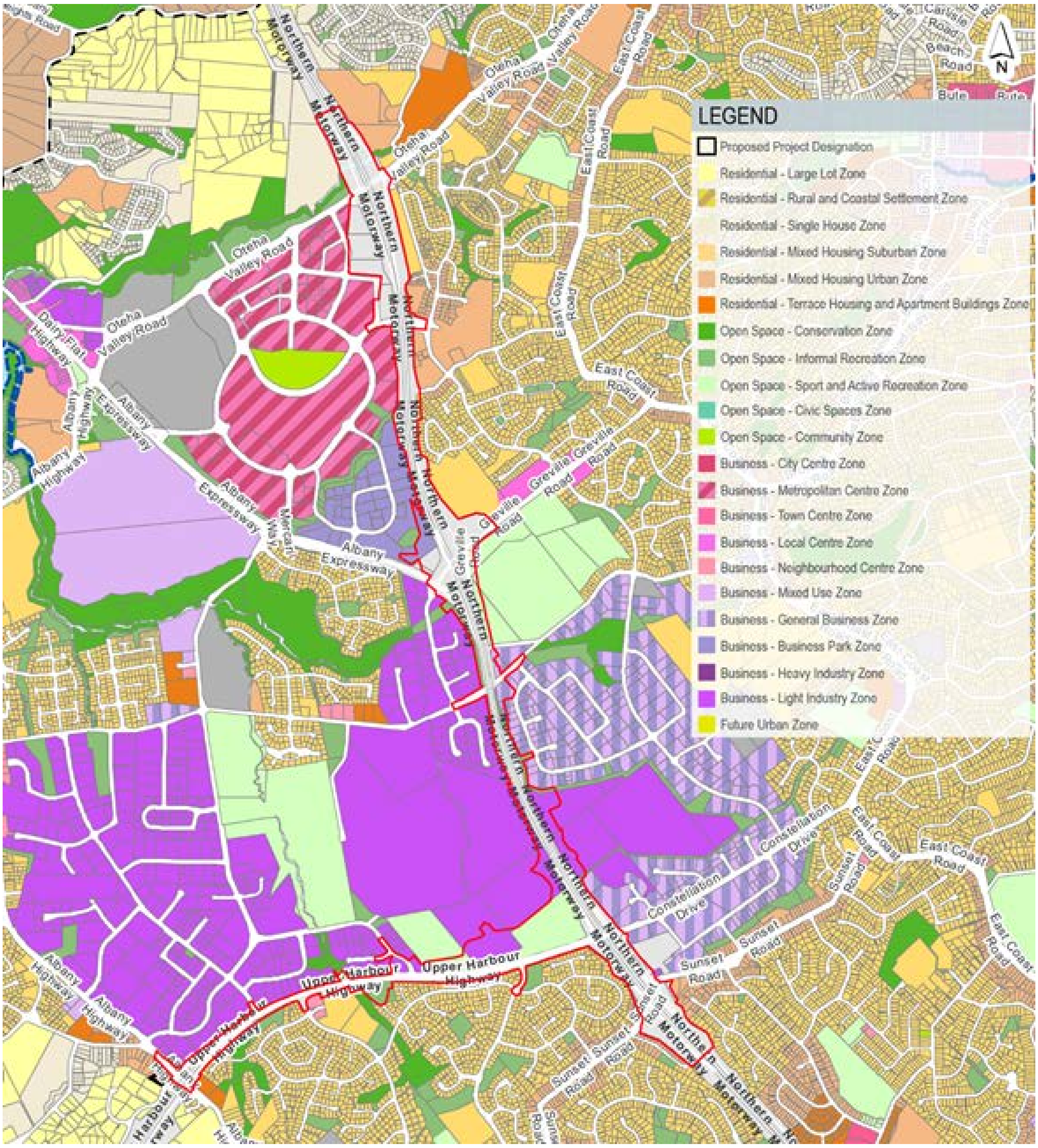
The FIDOL factors used in the assessment account for the frequency and duration of repeated events impacting at a sensitive location. They also require consideration of the sensitivity of the receiving environment location (for instance, residential locations will be more sensitive to dust than industrial locations) and the offensiveness of the dust being generated. For dust impacts, FIDOL factors are usually considered for long term exposure/repeat events. However single events at a receptor should still be considered (for acute effects) but in more simple terms of duration, intensity and character.

3 Existing Environment

3.1 Land use and topography

Figure 4 shows the land use zones around the Project area. The AUP identifies a number of land use zonings in the Project area including Light Industrial, General Business and Recreation.

Figure 4 Land use zones around the Project area



Source. https://unitaryplanmaps.aucklandcouncil.govt.nz/upviewer/

The land use zones around the Project corridor shown in **Figure 4** are colour coded as follows:

- Purple: Business/Industrial;
- Blue/purple: Business mixed use zone;
- Yellow: Residential;
- Pink stripes: Business/Metropolitan Centre;
- Green: Parks and Open Space;
- Grey: Institutional/Educational; and
- Orange: Residential – Terrace housing and apartment building zones.

Figure 4 shows that the land around the Project corridor is zoned for a number of different purposes. To the south of SH18 the land is predominantly zoned residential and to the north of SH18 the land is zoned either industrial or open space. On both the eastern and western sides of SH1 between SH18 and the Albany Expressway/Greville Road interchange the land use is predominantly zoned industrial. On the eastern side of SH1 between the Albany Expressway/Greville Road interchange and Oteha Valley Road the land use is predominantly zoned residential. While, on the western side of SH1 between the Albany Expressway/Greville Road interchange and Oteha Valley Road the land use is zoned either industrial or Business/Metropolitan Centre.

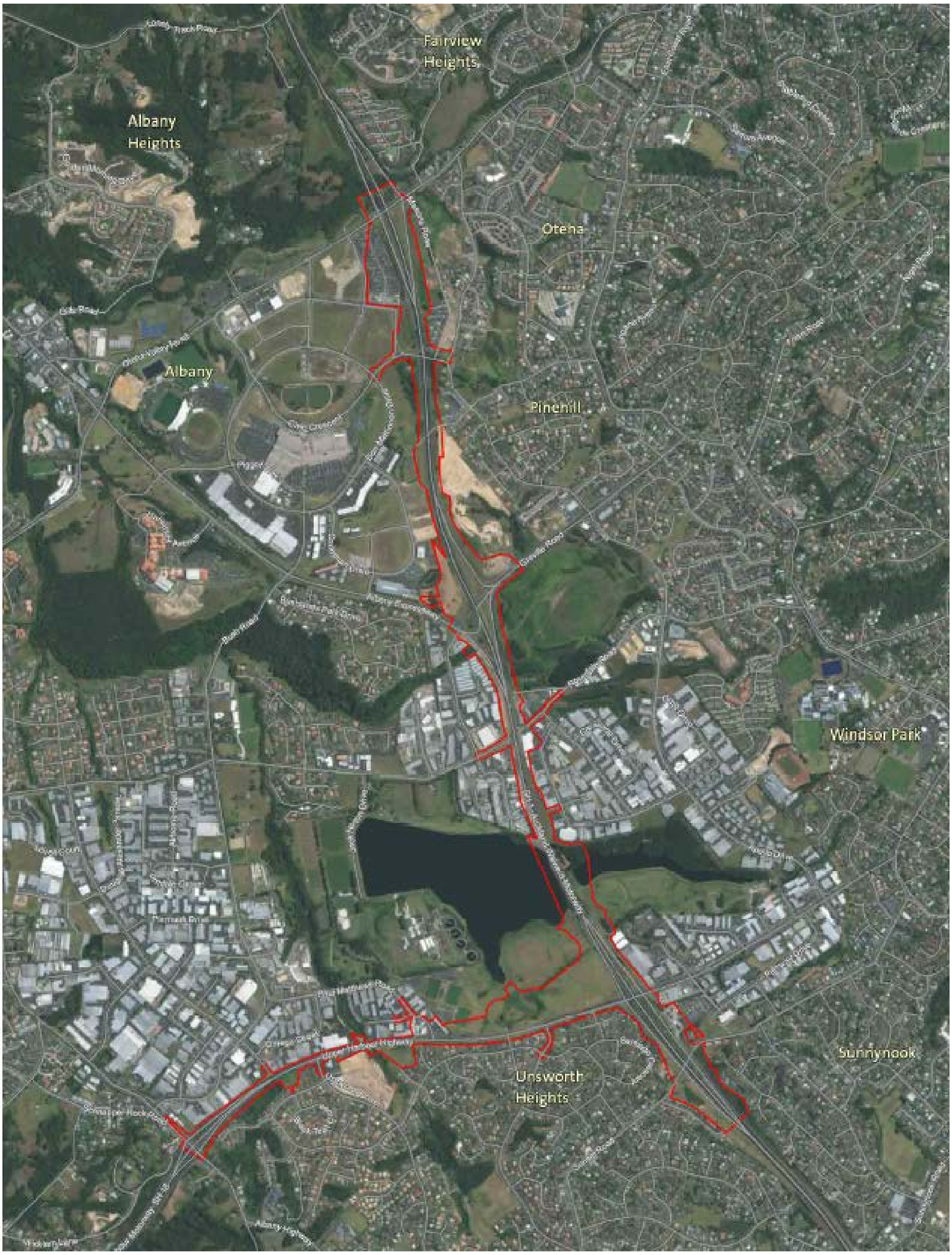
While the zoning envisages this land use, aerial photos (**Figure 5**) show the current land use is still relatively non-built up around the Project and this makes the environment around the Project less sensitive at least for the near future in terms of operation and for the construction period.

In summary, the residential zones that are closest to the Project and downwind during prevalent south-westerlies will be highly sensitive to the discharge of dust from roadway construction and pollutants discharged from vehicles using the roadways. The industrial and business/metropolitan centre zones will be less sensitive to the pollutants discharged from vehicles using the roadways, but moderately sensitive to the dust discharged from roadway construction.

Figure 6 shows the topography of the land around the Project area and an overlay of the Project roadway links. The topography of the Project area is a series of gently sloping valleys and hills. The SH18 section runs east/west reasonably level at an elevation of approximately 45 m above sea level. The section of SH1 that runs north of the intersection with SH18 to Rosedale Road has a gentle decline of between 2 and 4 %. At Rosedale Road the elevation of SH1 is approximately 15 m above sea level. From Rosedale Road heading north SH1 climbs to a peak of approximately 85 m above sea approximately 500 m north of the Greville Road on and off ramps. From that high point on this section of SH1, the motorway declines as it goes north to Oteha Valley Road to reach an elevation of approximately 15 m above sea level.

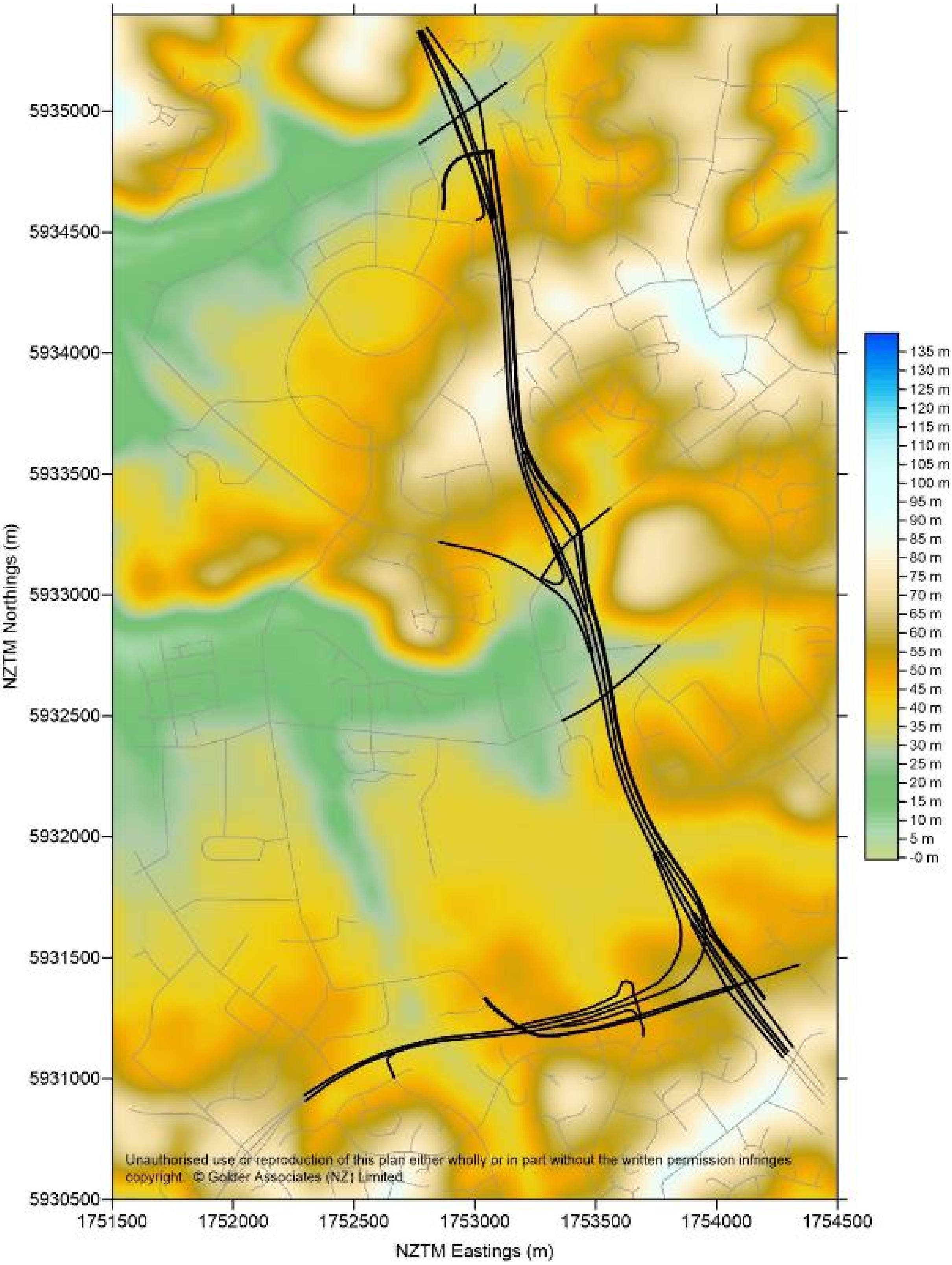
None of the local terrain features appear steep enough to significantly slow or divert regional wind patterns, although some local channelling is likely to happen especially during lower wind speeds. Due to the relatively sheltered location of SH1 at Rosedale Road and Oteha Valley Road the dispersion of pollutants discharged from vehicles at these points is likely to be reduced slightly compared to more exposed sites of Unsworth Heights and Oteha.

Figure 5 Aerial photo showing the current land uses around the Project area



Source: Aerial base, AC GIS

Figure 6 Topography of the land around the Project area



Source: Golder

3.2 Highly sensitive receptors

The Guide defines highly sensitive receptors as: "*Receptors in locations 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*."

For the Project a number of highly sensitive receptors have been identified as being within 200 m from the edge of affected roadway links, which include, but are not limited to, the following:

- Unsworth Heights residential area;
- Oteha residential area;
- North Harbour Hockey Stadium;
- Pinehill School, Pinehill;
- Northshore Language school, 75 Corinthian Drive, Albany;
- Fairview Care Hospital, 21 Fairview Ave Albany;
- Meadowood Community House, 55 Meadowood Drive, Unsworth Heights;
- Windsor Medical Centre, B3/51 Corinthian Dr Albany;
- Albany Basin Accident and Medical Centre, 110 Unsworth Drive;
- Childcare facilities, 15 Saturn Place & 29-31 Omega Place; and
- Meadowood Reserve.

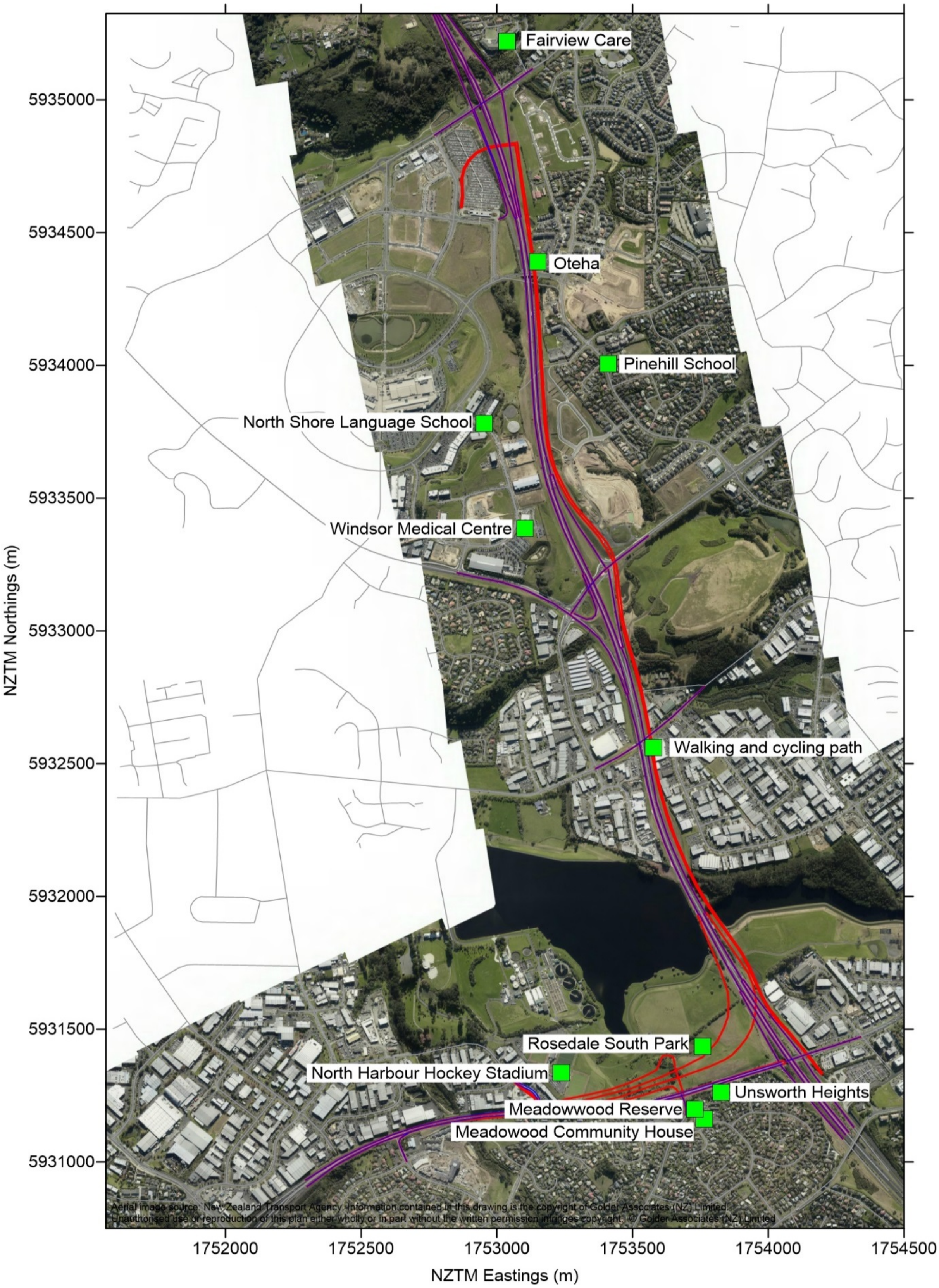
As part of the Project a dedicated SUP on the eastern side of the Northern Motorway (SH1) is to be built alongside the new Busway extension and alongside Upper Harbour Highway (SH18) all the way to Albany Highway. As there will be people walking or cycling along the SUP, this means it will be a highly sensitive receptor (albeit a long receptor rather than a single point). For the purposes of the air quality assessment, a relatively high impact area on the proposed SUP has been chosen to provide a likely worst case scenario for person exposure. A SUP receptor is only relevant to the 'with Project' scenario.

For the construction phase of the Project, where a qualitative assessment method is used (Section 4), the sensitive receptors listed above were grouped together into one of five assessment areas depending on their location in relation to the construction zones, construction yards or haul roads.

For the operational assessment, where a quantitative assessment method is used (Section 8), the results from key locations (Oteha and Unsworth residential areas and the SUP) are provided as indicators of effects on highly sensitive receptors. Clearly, there are many more sensitive receptors than these three indicator locations, and these are included within the dispersion modelling by way of gridded receptors (Section 7.8.5). However, the locations of the three key indicator receptors, mean that peak concentrations occur here and the concentrations experienced at the other sensitive receptors will be similar or lower. Therefore, these three indicator locations provide sufficiently detailed information for the purposes of this assessment.

Figure 7 shows the locations of a number of the highly sensitive receptors identified within 200 m of the Project corridor.

Figure 7 Locations of some highly sensitive receptors within 200m of the Project corridor



Source: Golder

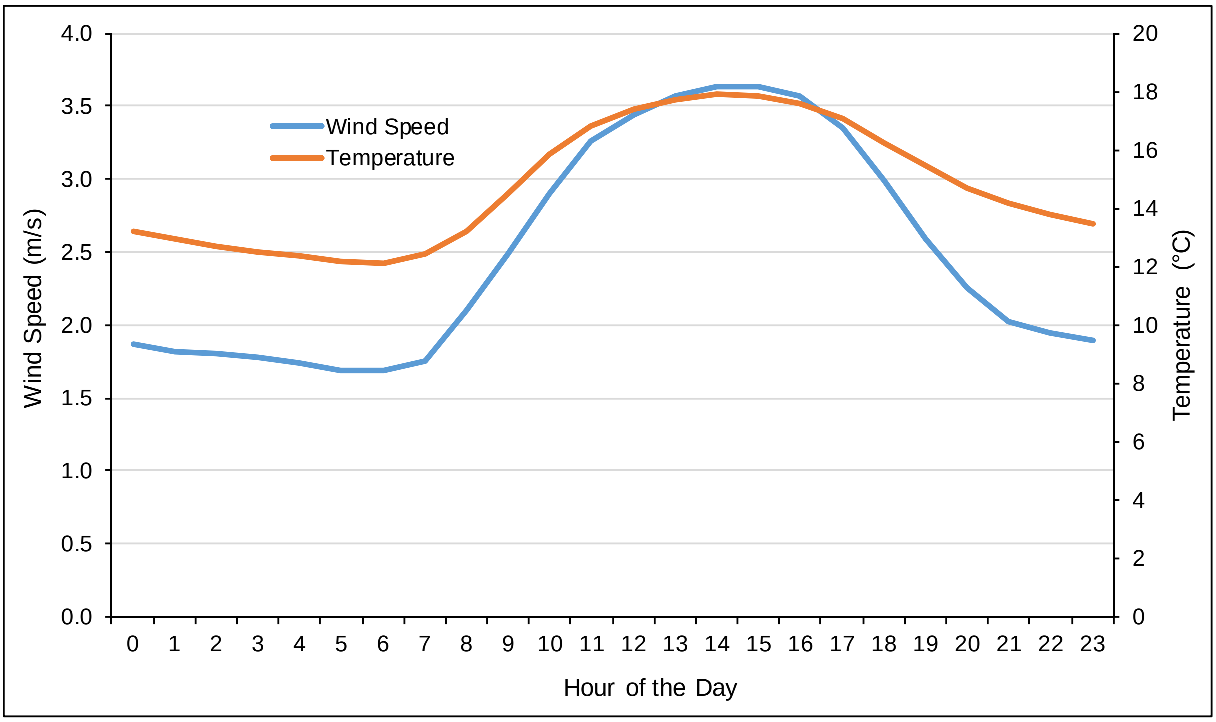
3.3 Meteorology

Understanding the meteorology of the Project area is important as it is one of the primary factors which determine the air quality experienced in the area. For example, wind direction determines which areas are impacted by pollutants, wind speeds determine how quickly pollutants are diluted and rain will reduce or eliminate emissions of dust.

The meteorology of the Project area was investigated by undertaking an analysis of data collected over the years 2014 and 2015 from the meteorological monitoring site located at the Rosedale Waste Water Treatment Plant (RWWTP) (site agent number 37852). This meteorological monitoring site is run by NIWA[1] and the data is publicly available through the national climate database (CliDB). The RWWTP is sited at the southern end of the Project area, and is in a well exposed area which will provide a good indicator of the meteorological conditions experienced across the Project area.

Figure 8 shows the diurnal pattern of average 1-hour average wind speed and temperature for the period 1 January 2014 to 31 December 2015. **Figure 9** shows the wind rose and **Figure 10** shows the monthly average rainfall for this site over the same period.

Figure 8 Diurnal patterns of wind speed and temperature



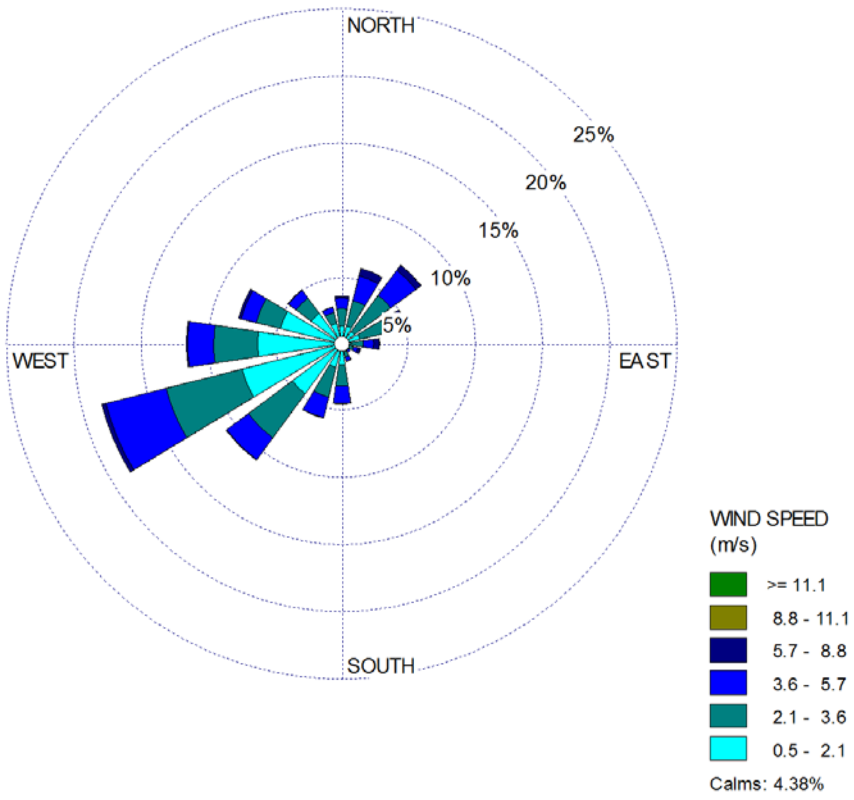
Source: Golder

Figure 8 shows that the average wind speed for each hour of the day varied between approximately 1.5 and 3.5 m/s. It notes that there is a general increase in average wind speed over the hours 07:00 to 15:00 when the highest average wind speed (3.5 m/s) is reached. From 16:00 to 20:00 the wind speed steadily decreases until the night time average wind speed (1.5 m/s) is reached at around 00:00. The night time hourly average wind speed is relatively consistent a little above 1.5 m/s between the hours of 23:00 to 07:00.

[1] The National Institute of Water and Atmospheric Research

It also shows that the average temperature for each hour of the day varied between 12 and 18 degrees Celsius (°C) with the hourly average temperature decreasing slightly between the hours of 01:00 and 07:00 (from 13°C to 12°C). The hourly average temperature then steadily increases between the hours of 07:00 and 15:00 to reach the highest hourly average value of approximately 18°C. Between the hours of 16:00 and 07:00 there is a steady decrease in hourly average temperature to reach 12°C at 0700.

Figure 9 Wind rose 2014-2015

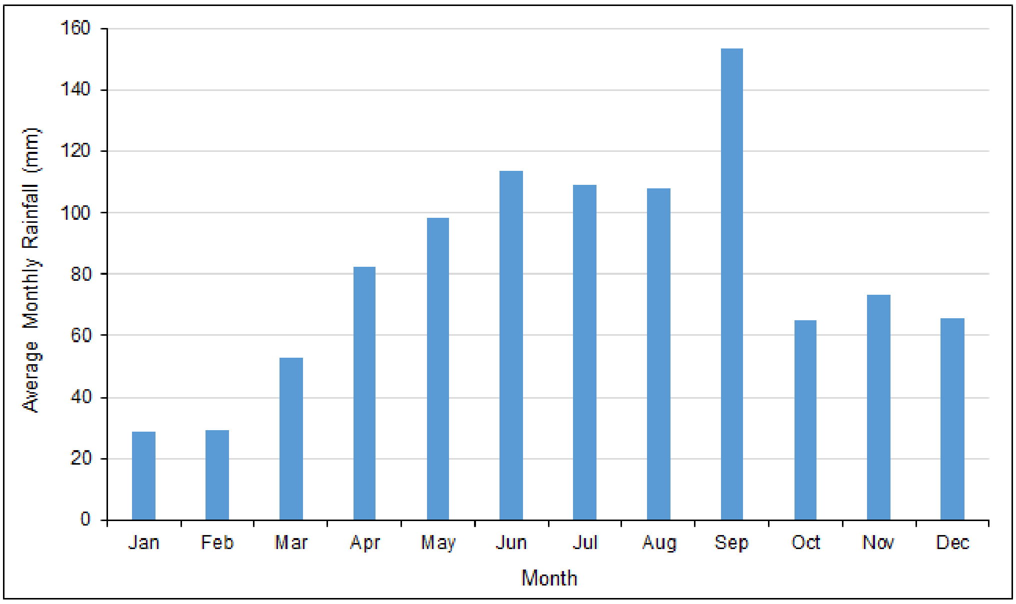


Source: Golder

Figure 9 confirms that the predominant wind direction during the monitoring period was from the southwest through to the northwest with winds from these directions occurring for approximately 55 % of the time. The next most frequent wind direction was from the north-easterly direction, for approximately 17 % of the time. Calms, when wind speeds are below 0.5 m/s, occurred for approximately 4 % of the time. There is a seasonal variation in wind conditions experienced at the site. Wind roses for the seasons of spring (September, October and November), summer (December, January and February), autumn (March, April and May) and winter (June, July and August) are shown in **Appendix A** – Wind roses. The key seasonal differences are that:

- South-westerly winds are more frequent in summer and spring;
- North-easterly winds occur relatively infrequently in spring; and
- The frequency of calms is greater in autumn and winter.

Figure 10 Average monthly rainfall 2014-2015



Source: Golder

Figure 10 shows that rainfall is relatively high over the cooler months of the year (April to September)[2]. **Figure 10** shows relatively low rainfall during the warmer months of the year (October through to March).

3.4 Background ambient air quality

AC has produced a guidance document "*Use of background air quality data in resource consent applications"* (Metcalfe, Wickham and Sridhar 2014). **Table 6** depicts the AC recommended background air quality concentrations. These values have been adopted for use in the Project's air quality assessment. A comparison of these values with data from the AC Takapuna air quality monitoring site (**Appendix B** – Air Quality Data – AC Northern Motorway (SH1) Takapuna site) suggest the AC recommended values are likely to be conservative (higher background levels than experienced in reality). However, to be consistent with the guidance provided by AC for resource consent applications, the recommended background air quality concentrations have been used for this assessment.

Table 6 Auckland Council recommended background air quality concentrations

Pollutant	Averaging Time	AC urban recommended background concentration - Pine hill	AC urban recommended background concentration - Unsworth Heights
CO*	1-hour	7 mg/m^3	7 mg/m^3
	8-hour (running mean)	4.5 mg/m^3	4.5 mg/m^3
NO_2**	1-hour	75 µg/m^3	75 µg/m^3
	24-hour	39 µg/m^3	39 µg/m^3
	Annual	13 µg/m^3	13 µg/m^3

[2] The rainfall for September is unexpectedly high, which is likely a result of non-typical high rainfall events occurring in either or both of September 2014 and September 2015.

Pollutant	Averaging Time	AC urban recommended background concentration - Pine hill	AC urban recommended background concentration - Unsworth Heights
PM_{10}	24-hour	33 $\mu g/m^3$	32 $\mu g/m^3$
	Annual	14 $\mu g/m^3$	13 $\mu g/m^3$
$PM_{2.5}$	24-hour	20 $\mu g/m^3$	19 $\mu g/m^3$
	Annual	7 $\mu g/m^3$	6 $\mu g/m^3$

*Auckland urban roadside locations

**Auckland urban locations

4 Method to Assess Construction Effects

4.1 Introduction

Three approaches are used to assess potential nuisance effects of the discharge of dust during construction of the Project:

1) Buffer distances;
2) FIDOL factors; and
3) Assessment of dust erosion conditions.

4.2 Buffer distances

The distance between sensitive neighbours and discharge-generating activities is an important consideration in assessing the likely intensity of impacts of an activity. A suitably defined buffer distance can help to mitigate nuisance effects on occasions when standard mitigation measures may not be entirely effective (for example, on occasions when strong, dry winds occur). By having a suitable buffer distance, emissions can be dispersed, diluted and deposited to such an extent that the intensity of effects at sensitive locations should be minimised to an acceptable level. Buffer distances are used as a gateway assessment tool to decide whether or not a more detailed assessment is required.

In the absence of any New Zealand specific guidance on buffer distances it is accepted good practice to consider guidelines developed in Australia. With respect to dust discharges the Environment Protection Authority of South Australia (EPA SA) (EPA SA 2016) published *Evaluation distances for effective air quality and noise management*. Within these guidelines bulk storage activities are defined as including the bulk handling of rock and consider the likely impacts of dust from products being stockpiled, moved on to and from the site and traffic movements on site. These activities are similar to those which will be carried out during the construction of the Project.

For bulk storage activities the EPA SA recommends a separation distance of 300 m. The EPA SA separation distances are intended to ensure an adequate separation for unintended emissions to dissipate without adverse impacts on sensitive land uses. Given the application of standard dust mitigation measures (Section 6.1) in association with the Project construction activities, Golders experience suggests that in reality areas beyond 200 m from the site are unlikely to experience incremental dust exposure that has potential to cause any significant nuisance. Therefore sensitive receptors located at distances greater than 200 m from the Project construction dust sources are not considered in the assessment.

Sensitive receptors within 200 m of the Project construction dust sources may experience incremental dust exposure that has potential to cause significant nuisance. The FIDOL factors (discussed in Section 4.3) are examined to establish the potential for dust effects.

4.3 FIDOL factors

A key consideration in assessing adverse effects of dust emissions is whether impacts downwind are likely to result in an offensive or objectionable effect.

The FIDOL factors used in the assessment account for the frequency and duration of repeated events impacting a sensitive location, and do not rely on a single event in time. They also require consideration of the sensitivity of the receiving environment location (for instance, residential locations will be more sensitive to dust than industrial locations) and the offensiveness of the dust being generated (for instance, dust from construction activities is likely to be considered as having less impact than coal dust). The topography and meteorology of the area also influence the risk of exposure to construction dust emissions.

When assessing the potential effects of construction dust impacts it is important to consider the sensitivity of the location to dust impacts, in particular the prevalent land uses, the meteorology and topography of the area that influences the risk of expose to construction dust emissions. These matters have been discussed in Sections 3.1 and 3.3.

For the assessment of dust impacts, locations that would be sensitive to discharges from the construction of the Project are identified. For these locations the local meteorological conditions are assessed to determine the frequency and duration of potential construction dust generation that would disperse towards that location. Information on the frequency and duration of potential dust exposure is then combined with an analysis of the proximity of the sensitive receptors (which determines the intensity of any potential impacts).

The identification of potentially sensitive receptors is described in Section 3.2. The method for determining the meteorological conditions that could transport dust towards sensitive receptor locations is described further in Section 5.2.

The combination of information on dust exposure risk and proximity to the construction site was used to establish locations that have a high, medium and low risk of potential impacts, assuming no mitigation was in place to control emissions from the site. This risk information is then used to inform an evaluation of mitigation measures needed to control impacts to an acceptable level.

4.4 Dust erosion conditions

Dust erosion requires wind speeds of sufficient energy to entrain dust into the air from exposed surfaces and result in off-site dust impacts. It is important to consider how often such conditions occur (which generally require mitigation measures to be ramped up), as well as how often more extreme wind conditions occur.

Extreme conditions are those where there can be some loss of dust control due to especially dry and strong wind speed conditions for prolonged periods. These are conditions where standard dust suppression via watering methods can become ineffective. It is useful to assess the likelihood of such conditions as well as other additional measures that can be employed.

According to the Air and Waste Management Association, the entrainment of significant dust from exposed surfaces can start to occur when wind speeds are between 5 m/s and 10 m/s (AWMA 2000). For this assessment, a conservative wind speed threshold of 5 m/s has been used to estimate when significant dust erosion could occur. This wind speed threshold has been selected as it is at the lower end of the range of wind speeds that can entrain significant dust.

Extreme wind conditions generally occur at 10 m/s or higher and unless they are associated with rainfall or follow a heavy fall period, these can generate a significant dust impact event. The mitigation of such events can require less conventional measures including the use of dust suppressing chemicals, sprayed on surface covers, as well as re-vegetation.

5 Assessment of Effects: Construction Phase of the Project

5.1 Potential sources of dust during construction

5.1.1 Overview

The main discharge into air arising from the proposed construction activities is particulate matter (dust). The most common concerns relating to dust discharges are generally nuisance impacts and health effects from the respirable particulate fraction less than ten microns in diameter (PM_{10}). Dust nuisance effects include impacts on amenity, visibility and impacts on structures, such as soiling and abrasion. Effects of dust deposition on plant life can also occur where there are significantly high dust deposition loadings and sensitive vegetation, but are typically only a concern where sensitive vegetation is located in very close proximity to a source.

Impaired visibility effects can occur when there are significant dust effects. However, these are usually only a concern in the immediate vicinity of the source and when there are very high dust levels.

The main factors that influence dust emissions associated with construction activities are:

- Disturbances of potentially dusty material, by vehicle movements, excavation, loading and unloading of materials;
- The moisture content of the surface or materials being handled;
- The area of exposed surface – including stockpiles;
- Wind speed across exposed surfaces; and
- The percentage of fine particles contained in the surface material.

Dust emissions resulting from the excavation and handling of inert spoil materials are likely to be dominated by coarse particles, typically greater than 20 microns in diameter. Fine particles less than 10 microns are likely to constitute only a small fraction of dust emissions, with the exception of dust entrained by vehicle movements which will have elevated levels of PM_{10} due to the action of vehicle wheels which can grind larger particles into smaller ones. More importantly, the fraction of dust generated by spoil excavation that has a particle size of less than 2.5 microns is likely to be small.

Given the above, the effects of dust emissions associated with the construction activities are likely to be limited to amenity and nuisance. Furthermore, PM_{10} and $PM_{2.5}$ emissions will be minimised to low levels provided dust mitigation measures are implemented and are effective at controlling dust to an acceptable level (i.e., one that is not offensive or objectionable beyond the site boundary).

The following sections describe the key sources of dust emissions from the site, and comment on their relative significance.

5.1.2 Construction support areas

The locations of the Project construction support areas (CSA) are shown on **Figure 11** as:

- CSA1: Paul Matthews Road;
- CSA2: North facing Ramps;
- CSA3: Rosedale Road;

- CSA4: Greville Road east;
- CSA5: Greville Road west; and
- CSA6: McClymonts Road.

The construction support areas will house staff facilities such as offices, lunchrooms, toilets and vehicle parking. Shipping containers may be placed on the CSAs to store small machines. Large vehicles and machines will be stored and weigh bridges installed within the CSAs. Structure compounds including laydown for bridge/s and retaining wall construction materials will be stored on the CSAs.

The surfaces of CSAs will be compacted hard fill, except for the impervious areas that already exist in the Rosedale Road and Paul Matthews Road construction areas. All the construction areas will be used for stockpiling of earthworks. A rock crusher may be installed and operated on the Greville Road west CSAs. The construction plans for the Project do not include a concrete batching plant as there are a number of concrete suppliers within a practical distance from the site.

The key sources of dust from the CSAs will be:

- Non-sealed or sealed road or area surfaces;
- Vehicle movements on non-sealed surfaces or sealed surfaces covered with dust;
- The building and removing of stockpiles;
- Stockpile surfaces; and
- Process dust emissions (rock crusher).

Depending on the scale and duration of each of these activities, the dust emissions from the CSAs could be significant. Therefore, the CSAs will need to be carefully considered within a dust management plan.

5.1.3 Haul roads

The indicative locations of the Project haul roads (HR) are shown on **Figure 11** as blue lines and include:

- CSA1 to CSA2;
- Tait Place to Rosedale Road;
- Rosedale Road to Greville Road West;
- Greville Road overpass to SH1; and
- CSA5 to CSA6.

Figure 11 Locations of Project construction support area and haul roads

Source: Aurecon

Most site haul roads are likely to be unsealed. Unsealed haul roads can be significant potential sources of dust if they are not mitigated. This is because on dry days the surface of the haul road can dry out and the action of vehicle wheels can act to pulverise the road surface material and subsequently suspend fine material in the air as the vehicle passes over it. The amount of dust generated from an uncontrolled, unsealed haul road depends on the volume of traffic, speed and weight of the vehicle and the condition of the road surface (presence of a high silt content as well as corrugations and pot-holes in the road surface). Because the dust from haul roads is generated by mechanical means (vehicle movements) rather than being driven by meteorological conditions (particularly higher wind speeds), haul roads require careful and constant dust management which is independent of and not triggered by wind speed conditions. Therefore, haul roads will need to be carefully considered within the planned mitigation methods and a dust management plan.

5.1.4 Excavation and spoil removal

Excavation and spoil removal is likely to be a key activity with significant potential for generating dust emissions. This activity will occur for both the formation of the roadway foundations and the drilling and digging required for forming bridge and retaining wall foundations. The three key mechanisms that can generate dust associated with the excavation and spoil removal activities are:

1) Suspended dust from the action of wheels and tracks associated with vehicle movements (trucks, loaders and excavators) moving along the length of the exposed roadway foundation;
2) The disturbance of materials as they are excavated or drilled from the ground and dumped on trucks for removal; and
3) Wind erosion of material from exposed surfaces within the roadway foundation.

The potential for dust being generated from excavation and spoil removal will be particularly high if the base material is dry and during dry weather and periods with strong winds. Therefore excavation and spoil removal activities will need to be carefully considered within the planned mitigation methods and a dust management plan.

5.1.5 Backfilling and road construction

The formation of the road sub-surfaces will involve transporting fill material into the roadway foundation and depositing and compacting the fill material in layers until the road surface is reached. This process is essentially the reverse of that which occurs during the excavation stage. However, it is possible that the back fill and road construction materials would be dryer than the material that was excavated and therefore potentially dustier. As with the excavation stage, dust emissions could occur from either the action of vehicles travelling along unpaved surfaces and/or from wind erosion of exposed surfaces. For these reasons backfilling and road construction has some potential to generate dust emissions and mitigation measures will need to be carefully considered within the planned mitigation methods and a dust management plan.

5.1.6 Vehicle exhaust emissions

Combustion emissions from construction vehicle and machinery engine exhausts will occur. Additionally, the disruptions to existing vehicle traffic patterns in the vicinity of the construction sites may result in increased traffic and congestion in the surrounding area and therefore elevated vehicle related emissions. The main emissions of interest associated with combustion processes are fine particulate matter (PM_{10} and $PM_{2.5}$), oxides of nitrogen and carbon monoxide.

The discharges to air from vehicle and mobile machinery emissions are permitted activities under the AUP (Discharge of contaminants into air from mobile sources and tunnels - Rule number A114). Given the comparatively small number of construction vehicles, and the temporary nature of the construction, effects are not expected to be significant.

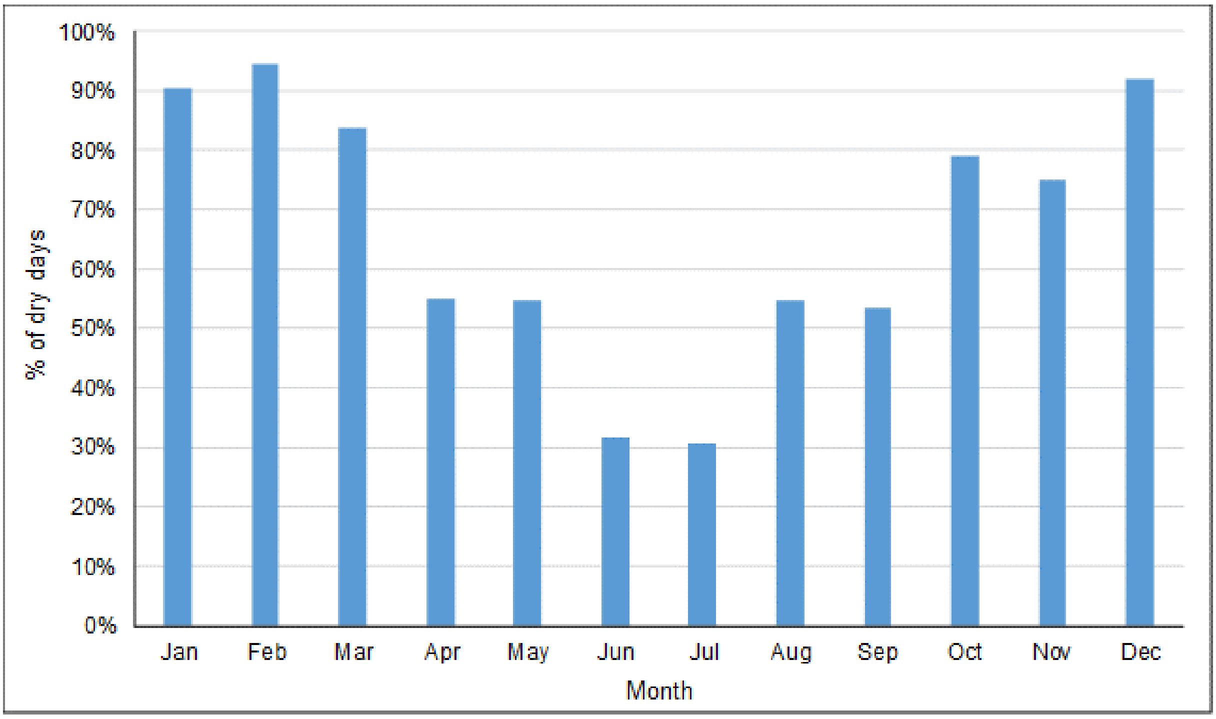
5.2 Dust erosion assessment

The dust erosion assessment will consider each of the FIDOL factors.

5.2.1 Frequency

The frequency of dust events is primarily determined by dry and windy meteorological conditions. For this assessment windy conditions are defined as hourly wind speeds of 5 m/s and dry days as when evaporation exceeds daily rainfall by more than 1 mm. **Figure 12** shows the percentage of dry days per month measured in Albany, North Shore (2014-2015 inclusive). **Figure 12** shows that over the cooler months of the year (April to September) dry days occur at a frequency of 50 % or less. For the warmer months of the year (October to March) dry days occur more than 75% of the time.

Figure 12 Percentage of dry days per month at the Albany, North Shore (2014-2015 inclusive).



Source: Golder.

For the purposes of the dust erosion assessment the highly sensitive receptors identified in Section 3.2 have been grouped together in areas which are likely to be exposed to the effects of dust discharged from construction activities including construction zones, construction support areas and haul roads. The key receptors are identified as

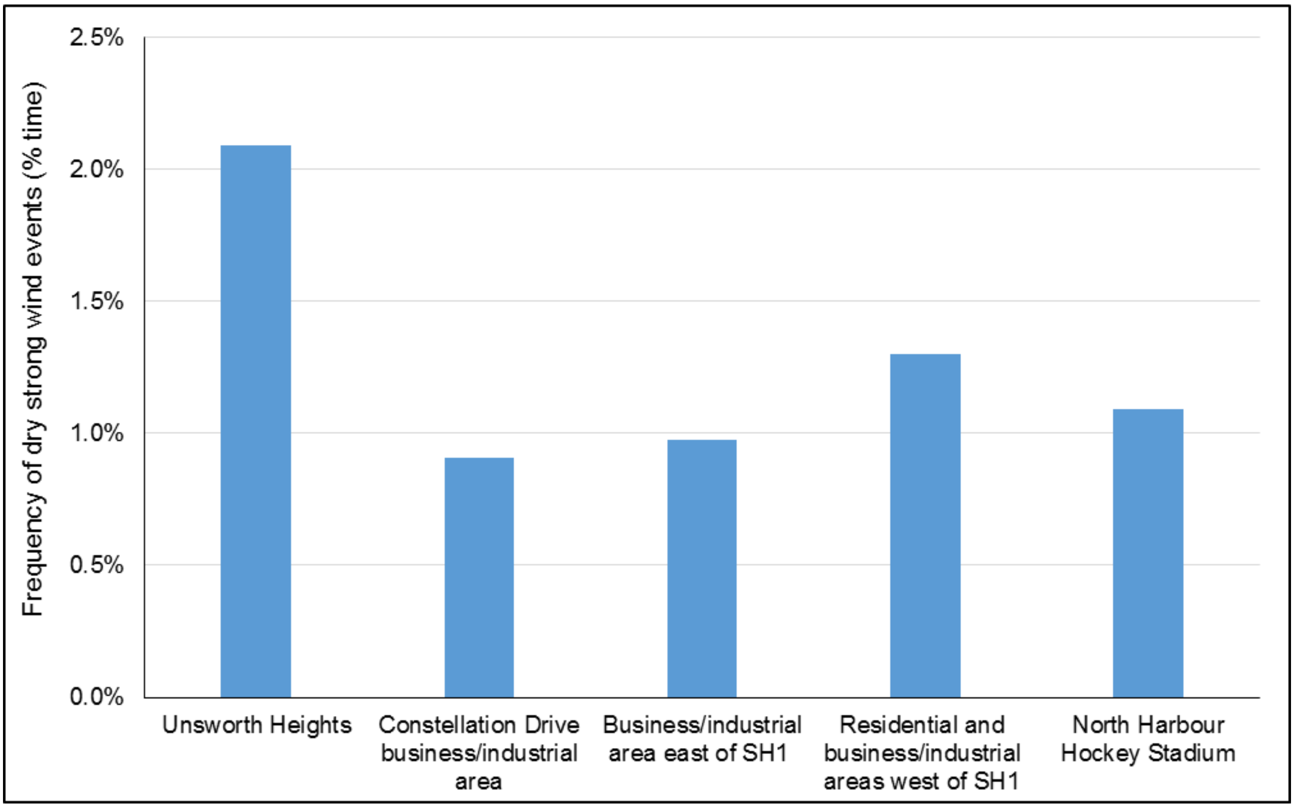
- Unsworth Heights (south of construction zones 1 and 2);
- Business/industrial area on Constellation Drive immediately east of SH1 (east of construction zones 1 and 2);
- North Harbour Hockey Stadium: (north of construction zones 1 and 2;
- Business/industrial areas immediately east of SH1 from SH18 up to Oteha Valley Road (east of construction zones 3, 4, 7 and 8); and
- Residential and business/industrial areas immediately west of SH1 from SH18 up to Oteha Valley Road (west of construction zones 3, 4, 7 and 8).

Figure 13 shows the frequency of dry strong wind events blowing from construction activities towards receptor groups (2014-2015 inclusive).

The data displayed in **Figure 12** and **Figure 13** shows:

- There is a higher risk of dust events occurring over the months of October through March;
- The frequency of high risk meteorological conditions is relatively low for each of the receptor groups (less than 2.5 % of total hours);
- Unsworth Heights has the highest exposure risk at 2 % of the time (approximately 175 hours per year); and
- The other receptors are at risk of dust events for around 1 % of the time (approximately 90 hours per year).

Figure 13 Frequency of dry strong wind events blowing from construction activities towards receptor groups (2014-2015 inclusive)



Source: Golder

5.2.2 Intensity

The intensity of dust events experienced by the receptor groups considered will be primarily driven by the size of the source and the separation distance between the dust generating activities and the receptor. As noted in Section 4.2 the EPA SA recommends a separation distance of 300 m for bulk storage activities. Many of the sensitive receptors considered in this assessment will be closer than 100 m from the dust generating activities required for the construction of the Project. Therefore it is concluded that the potential intensity of dust impacts from the construction of the Project is relatively high.

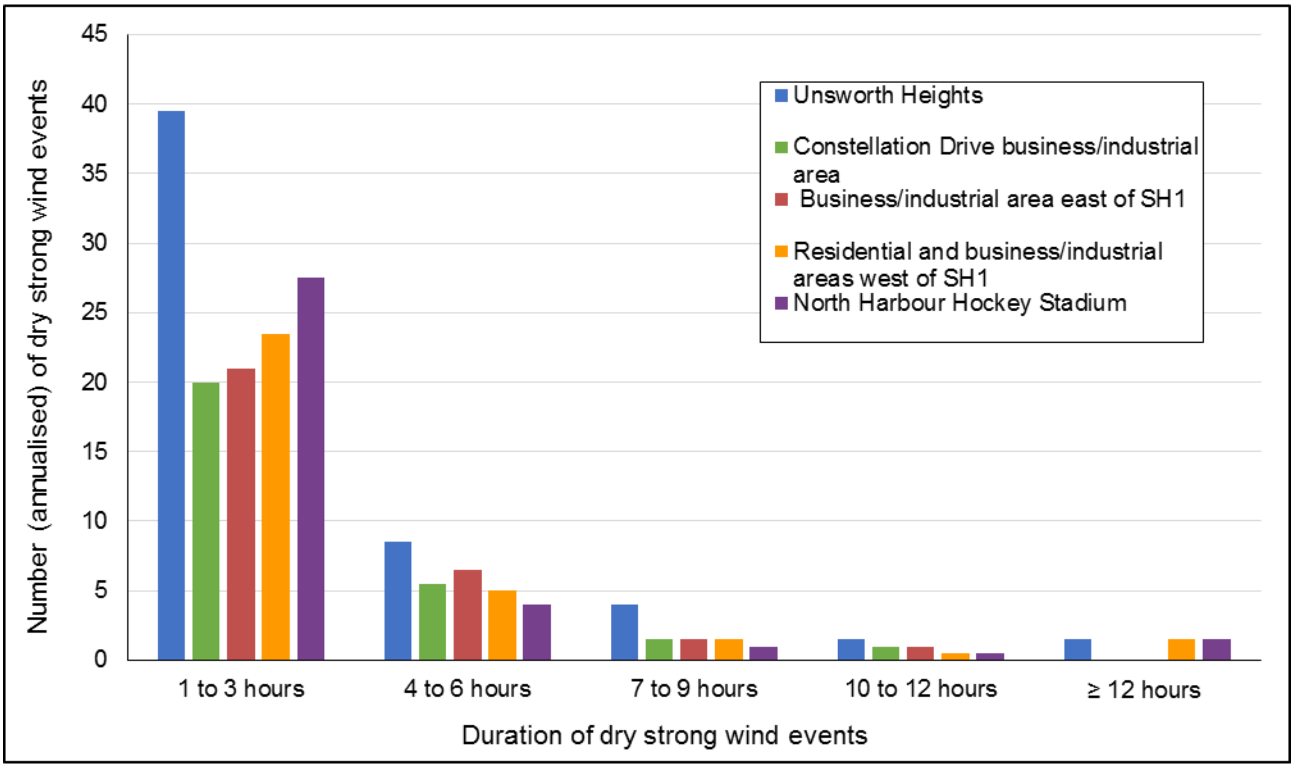
5.2.3 Duration

Figure 14 shows the number and duration of dry strong wind events blowing from construction activities towards the five different receptor groups (annual average for 2014-2015 inclusive). **Figure 14** shows the frequency of events with duration of:

- Three hours or less - between 20 and 40 times per year;
- Four to six hours - less than 10 times per year;
- Seven to nine hours - less than five times per year; and
- Greater than ten hours – one to two times per year.

Figure 14 shows that Unsworth Heights, shown in blue is predicted to experience a moderate number of short duration events (i.e., 40 events per year of up to 3 hours) and a low number of longer duration events (i.e., a total of approximately 15 events per year of 4 hours or longer). At other receptor locations, the occurrence of short duration events varies from moderate to low (i.e., 27 to 20 events per year) and rapidly decreases for longer duration events.

Figure 14 Number and duration of dry strong wind events blowing from construction activities towards receptor groups (annual average for 2014-2015 inclusive)



Source: Golder

5.2.4 Offensiveness

The offensiveness of dust is primarily determined by the size and colour of the particles. Smaller dust particles are considered to have a relatively high offensiveness as they can penetrate into smaller spaces, (including through closed doors and windows) and can be harder to clean off surfaces than larger particles. The colour of dust varies greatly with source. For example, black coal dust is generally considered to be relatively offensive, compared to lighter coloured dust from natural and local sources such as soil or pollen.

The majority of dust discharged from the construction activities of the Project is likely to be in the larger size range (> 20 micrometres) and most likely be coloured either grey (from road construction materials) or yellow (from the excavation of clay soils during construction).

In summary, the size and colour of the dust discharged from the construction activities of the Project determines that the offensiveness of this material is considered moderate.

5.2.5 Location

The construction activities of the Project will be generally located adjacent to established residential, outdoor recreation, business and industrial areas, none of which are significant sources of dust. However, some earthworks and construction activities are currently occurring within the Project area, particularly east of SH1 near Greville Road. These activities may generate dust and raise background concentrations in small localised areas adjacent to the locations where the earthworks and construction activities are taking place. In summary, generally the background levels of dust within the Project area are likely to be low.

Given the nature of the receiving environment and the currently low level of background dust, there will be an expectation that a high level of amenity will be maintained and therefore the sensitivity of receptors to the discharge of dust is considered to be high.

5.2.6 Summary of FIDOL assessment

From the FIDOL assessment it is concluded that during the construction phase of the Project there is a moderate to high potential for dust impacts to occur and for these impacts to be considered objectionable and/or offensive. Therefore it is crucial to identify the key sources of dust and have mitigation practices in place to minimise the amount of dust emitted.

6 Mitigation of Construction Effects

6.1 Measures to mitigate dust emissions

The key to mitigating the dust effects from construction is to identify effective control measures for each of the major sources of dust. **Table 7, Table 8**, **Table 9 and Table 10** respectively list the recommended dust control measures for:

- Haul roads, vehicles, unpaved and paved surfaces;
- Stockpiles, material handling and roadway construction;
- Construction support areas; and
- Wind protection and community liaison.

Table 7 Recommended dust control measures for haul roads, vehicles, unpaved and paved surfaces

Source of dust	Recommended mitigation measures
Sealed Haul Roads and paved surfaces	• The movement and handling of fine materials should be controlled to prevent spillages onto paved surfaces. • Minimise mud and dust track-out from unpaved areas by the use of wheel wash facilities. • Regular cleaning of paved surfaces, using a mobile vacuum sweeper or a water flushing system. • Covering of dusty loads to prevent spillage onto paved surfaces. • Speed controls on vehicle movements.
Unpaved surfaces (including unsealed haul roads)	• Wet suppression of unpaved areas should be applied during dry windy periods, using a water cart and/or fixed sprinklers. • Chemical stabilisation such as polymer additives may also be used in conjunction with wet suppression. • Re-vegetation of exposed surfaces. • Surface improvements. These include paving with concrete, asphalt or cobbles (for sites requiring extraordinarily hard wearing surface) or the addition of gravel or slag to the surface. • Speed controls on vehicle movements.
Vehicles	• Limiting vehicle speeds. A speed limit of 20 km/hr is commonly applied on industrial sites in New Zealand. • Limiting load size to avoid spillages. • Covering loads with tarpaulins or the use of enclosed bins to prevent dust re-entrainment from trucks. • Minimising travel distances through appropriate site layout and design. • The use of wheel and truck wash facilities at site exits.

Table 8 Recommended dust control measures for stockpiles, material handling and roadway construction

Source of dust	Recommended mitigation measures
Material stockpiles	• Wet suppression using sprinklers. • Covered storage of fine material. • Limiting the height and slope of the stockpiles can reduce wind entrainment. • Limiting drop heights from conveyors. • Wind breaks (Table 10) - wind speed near the pile surface is the primary factor affecting particle uptake from stockpiles. • Bunding of stockpiles. • Keep stockpiles of material to a minimum practical size. • Treat surfaces of stockpiles with dust suppressants. • Windspeed limits for disturbing stockpiles of fine material
Material handling	• Minimising drop heights. • Regular clean-up of any spillages. • Regular maintenance of hydraulic grabs to ensure complete closure.
Roadway construction	• Wet suppression of surfaces using water trucks. • Limiting vehicle speeds on unsealed surfaces.

Table 9 Recommended dust control measures for construction support areas

Source of dust	Recommended mitigation measures
Site planning	• Consider the location of activities within the site and their orientation in relation to prevailing winds and sensitivity of the downwind receptors. • Maximise buffer distances to the site boundary and to sensitive land uses. • Consider the need for screening, such as by earth bunds, shelter belts or natural topography.
Site design and operating procedures	• Ensure dust sources are adequately enclosed and that equipment is accessible for cleaning. • Implement a preventative maintenance programme to minimise equipment failure and unplanned downtime. • Educate staff about the importance of regulatory compliance and good management for achieving compliance. • Have a regime of good housekeeping. • Aim to conduct dusty operations during weather conditions that minimise emissions where no other mitigation option is available (e.g. avoid windy days for ground stripping, avoid windy, dry weather).
Fixed plant	• Minimise drop heights into hoppers and loading chutes. • Use sprinklers or water sprays around hoppers and other transfer points. • enclosure Hooding or of significant fugitive sources, with the emissions being ducted to bag filters or other dust control equipment.

Table 10 Wind protection and community liaison

Source of dust	Recommended mitigation measures
Wind protection	• Where necessary and practical create windbreaks to the following specifications: o height equal to the pile height. o length equal to the pile length at the base. o located at a distance of one pile height from the base of the pile. • Wind breaks may be constructed using horticultural cloth supported on poles.
Community consultation and negotiated solutions	• Communicating with the local community is important for building a good relationship and trust, which are a useful foundation for times when dust problems do occur. It is important to bring the community on side as part of the problem-solving process, both to help identify where problems lie and to negotiate solutions, including timeframes for implementation.

6.2 Construction air quality monitoring

6.2.1 Purpose

The key purpose of undertaking air quality monitoring during the construction of the Project is to ensure that potential dust effects are appropriately managed and mitigated to ensure that any adverse effects that do occur are not considered offensive or objectionable.

Given the relatively high risk of offensive or objectionable dust effects occurring during the construction of the Project, it is recommended that a comprehensive dust monitoring programme is implemented. The dust monitoring programme will provide real-time notification of dust events to the construction zone managers and therefore enable immediate remedial action to be undertaken.

6.2.2 Timing and duration

It is recommended that the construction dust monitoring begin as soon as possible following the start of construction and run for the duration of the construction programme. Because the Project covers such a large area, the monitoring programme will need to consider the start date and duration of the activities being undertaken in each of the construction zones and align monitoring with this timetable. The potential for dust to be discharged from some activities will vary with season, (e.g. excavation) and therefore the dust monitoring of some construction zones may reduce during the cooler and wetter months of the year.

6.2.3 Number and locations of monitoring sites

The Project covers a large area and the construction will be staged over the eight construction zones. The locations of the dust and meteorological monitors will be set to match the active construction zones, haul roads and support areas.

Monitoring will be undertaken at, or very near to, the locations of the most affected sensitive receptors for each construction zone and for some of the haul roads and construction support areas. Because of the large scale of some of the construction zones, the dust emissions may vary across the distances involved and therefore require more than one dust monitor.

Given the predominantly westerly wind flows of the area it is recommended that most dust monitoring will be undertaken to the east of the active construction zones and support areas.

6.2.4 Monitoring methods

The key parameters to be included in the construction air quality monitoring programme are:

- Total suspended particulate (TSP); and
- Wind speed and wind direction.

Continuous dust monitoring is becoming an increasingly important mitigation tool for construction activities in close proximity to sensitive locations. The equipment is typically based around an optical measurement system, and is readily portable, can be telemetered, and is capable of being run without mains power supply using a combination of batteries and solar panels.

Continuous dust monitoring methods are recommended for the Project construction air quality monitoring programme because of the close proximity of the construction zones and support areas to a large number of sensitive receptor locations. The purpose of the continuous monitoring is to provide site supervisors with an early warning that dust levels are increasing to the extent that immediate action is required and therefore to ensure that levels do not result in adverse dust effects for adjoining neighbours.

The continuous dust monitoring system will include an alarm system that, when the concentration of TSP exceeds a specified trigger level, sends a text message warning to the site manager or other nominated person who has the responsibility for managing dust effects on the site. The site manager or other nominated person should be available at all times to enable them to take immediate action as might be necessary to reduce dust emissions from the site.

Routine visual observations of dust will also be carried out by the site manager or other nominated person at regular intervals during each day of operation. The observations would check for the visible generation of dust emissions from land disturbance and the effectiveness of control measures. The purpose of these manual observations is to complement the continuous dust monitoring and ensure that the monitoring results are reflective of actual conditions.

Dust deposition monitoring, of the type that has been historically used for large construction sites, mines and quarry operations is not recommended for the Project. This is because deposition monitoring is only useful as a retrospective measure of whether dust deposition rates may have been elevated for a previous monitoring period. Sampling typically occurs over a 30-day period, and results may take another week to be available after samples are collected due to typical times taken to analyse the samples. As a result of this significant time delay, such monitoring is of no practical use in so far as the day to day management of dust emissions.

A number of recommended mitigation measures will be dependent on certain wind conditions being triggered, such as winds being above a certain wind speed and from a particular direction. In order to implement these mitigation measures, wind monitoring will need to be carried out at a representative location within the construction zones. The wind monitoring data should be recorded and an alarm system set up to notify the site operator when high risk wind conditions are occurring.

In some construction projects monitoring of PM_{10} and proxies for odour (such as volatile organic compounds – VOCs) may also be required depending on where the project is located and/or if soil disturbance is likely to result in the release of odour or other contaminants. This type of monitoring is not considered necessary for the Project construction process.

6.2.5 Incorporating construction air quality monitoring in the Dust Management Plan

The start dates, duration, monitoring methods, and locations for the construction air quality monitoring programme will be defined in the Dust Management Plan (DMP) (Section 6.3). The DMP will also define the trigger levels for the continuous monitoring of dust concentrations which will require immediate remedial action to be undertaken.

6.3 Dust management plan

A DMP is recommended to be developed with the primary environmental objective of allowing the construction of the Project in a manner that ensures there are no significant adverse dust impacts on the environment beyond the boundary of the construction zone.

The structure of the DMP should be designed to provide a logical, transparent and practical framework for the management of air emissions from the construction activities. It is recommended that the DMP:

- Describes the construction zone and support area site locations and the surrounding environment;
- Provides overview of the processes carried out in the construction zones and support area sites;
- Identifies the potential dust emissions sources and detail the controls that will be used to mitigate the emissions;
- Details the maintenance requirements for any dust prevention system;
- Lists the staff training requirements;
- Details the dust and meteorological monitoring programme:
  - Start date and duration;
  - Number and locations of monitoring sites;
  - Monitoring methods:
    - Dust.
    - Meteorology.
  - Trigger levels for immediate remedial action.
- Discusses complaints response and recording procedures;
- Details the records that are required to be kept as part of compliance with the DMP;
- Highlights the potential benefits of and process for the establishment and running of a community liaison group;
- Defines the roles and responsibilities in relation to the DMP of staff throughout the organisation; and
- Outlines the procedures for auditing and review of the DMP.

It is recommended that the DMP be reviewed and certified by the AC. The development of and compliance with DMP should be incorporated into the designation and/or resource consent conditions.

6.4 Summary of Key Findings: Project Construction

The key findings from the dust risk assessment are:

- The scale of the development is large;
- There are significant dust generating activities associated with the building of the Project;
- The meteorological conditions which create high potential for dust events occur relatively infrequently in the area;

- The intensity of dust events is potentially high because of the close proximity of the sources and receptors;
- The duration of any dust events that do occur, is most likely to be less than three hours;
- The size and colour of the dust discharged determines that the offensiveness of this material will be moderate; and
- Given the nature of the receiving environment and the currently low level of background dust, the sensitivity of receptors to the discharge of dust will be high.

Considering the assessment findings, it is concluded that during the construction phase of the Project there is a moderate to high potential for dust impacts to occur and for these impacts to be considered objectionable and/or offensive. Therefore it is crucial to identify the key sources of dust to have mitigation practices in place to minimise the amount of dust emitted, a monitoring programme to measure the effectiveness of the mitigation and develop a DMP to ensure the effective implementation of the dust mitigation measures and monitoring programme.

7 Method Used to Assess Roadway Operational Effects

7.1 Traffic modelling approach

The traffic modelling for the Project has been obtained from Flow Transportation Specialists Ltd (Flow), the Project transport specialists. In summary the assessment has been informed by a series of traffic and transport models:

- The Auckland Regional Transport (ART) model has been used to assess the likely public transport benefits of the Busway Extension, and to identify the anticipated changes in traffic flows, which have been fed through to the following traffic models; and
- The Upper Harbour SATURN traffic model (Upper Harbour model) has been used to identify the predicted performance of the road network.

Forecast traffic models have been developed for the years 2018, 2021, 2031 and 2041. Changes in forecast flows (between 2015 and 2031) have been derived from the ART model. The ART model has been run both without and with the Project, and the forecast changes in demands have fed through to the SATURN models.

The traffic modelling methods used by Flow have been validated by a third party and this data has been used to inform this air quality assessment. Further detail on the traffic modelling can be found in the report Assessment of Transport Effects provided at **Volume 3** of the lodgement package.

7.2 Traffic volumes and speeds

7.2.1 Traffic volumes

Flow predicted traffic volumes for roadway links associated with Project and without Project scenarios for 2015, 2021 and 2031. This traffic flow data was incorporated into the air quality assessment.

7.2.2 Vehicle speed

Based on advice provided by Flow it was assumed that speeds generally follow the speed limits (i.e. 50 kilometres per hour (kph) on all local roads, 80 kph on SH18 between Constellation Interchange and Albany Highway interchange, for the future reference case only, and 100 kph along the motorways). However, congestion and lower speeds were predicted by Flow in the following areas:

Do nothing Scenario (2021 and 2031):

- SH1 southbound in the morning peak, from Oteha Valley Road through to the Harbour Bridge, with average speeds of around 20kph;
- SH1 northbound in the evening peak, from Tristram Ave to Greville Road, with average speeds of around 40 kph;
- Around the Constellation interchange throughout the day; and
- At the SH18 intersections with Paul Matthews Road and Caribbean Drive and the SH18/Albany Highway interchange in the morning and evening peaks.

With Project scenario (2021 and 2031):

- SH1 southbound in the morning peak, from Oteha Valley Road through to the Harbour Bridge, with average speeds of around 20kph;
- SH1 northbound in the evening peak, from SH18 on ramp to Greville Road, with average speeds of around 70 kph; and
- Around the Constellation interchange and the new Paul Matthews Road/Caribbean Drive intersection, around the SH18/Albany Highway interchange in the morning and evening peaks, and at the Greville off ramp intersection in the evening peak.

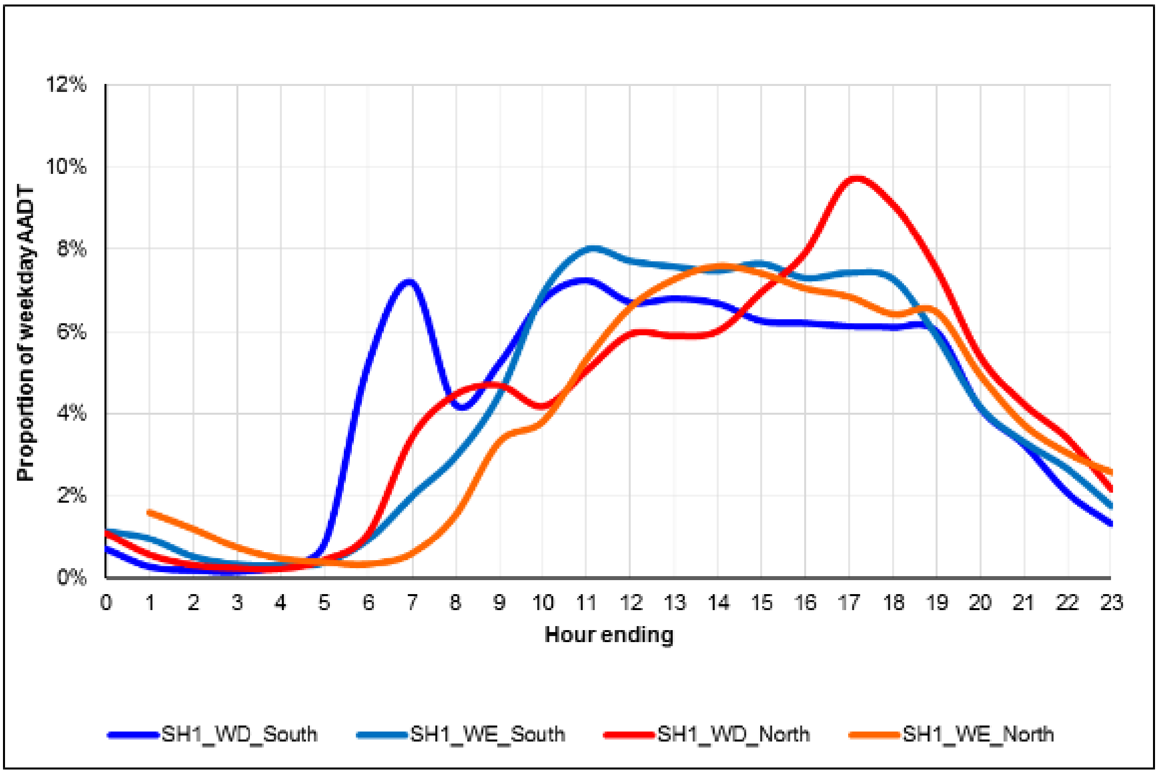
7.2.3 Diurnal pattern of traffic flows

The diurnal pattern of traffic flow was used to allocate the AADT to hours throughout the day. The diurnal pattern of traffic flow for three road types were considered:

- SH1;
- SH18; and
- Arterial roads.

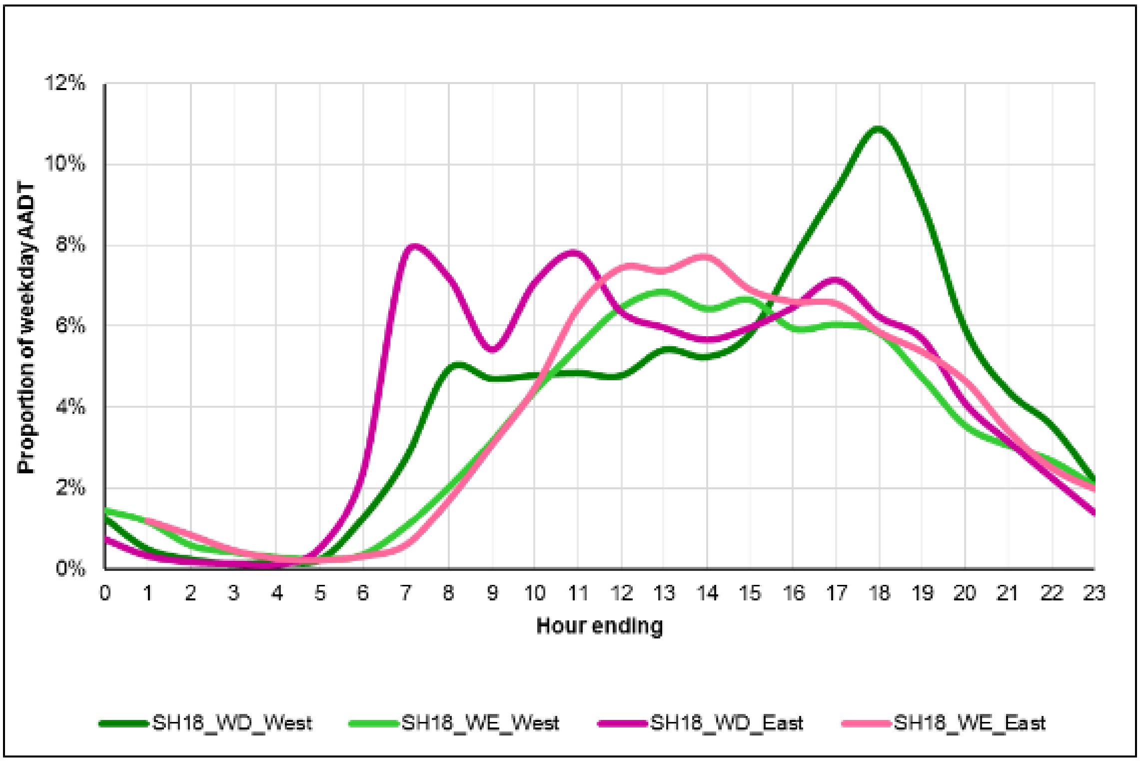
Figure 15, Figure 16 and Figure 17 show the diurnal pattern of traffic flow for weekdays (WD) and weekends (WE) for SH1, SH18 and arterial roads respectively.

Figure 15 Diurnal pattern of traffic flow weekdays and weekends SH1



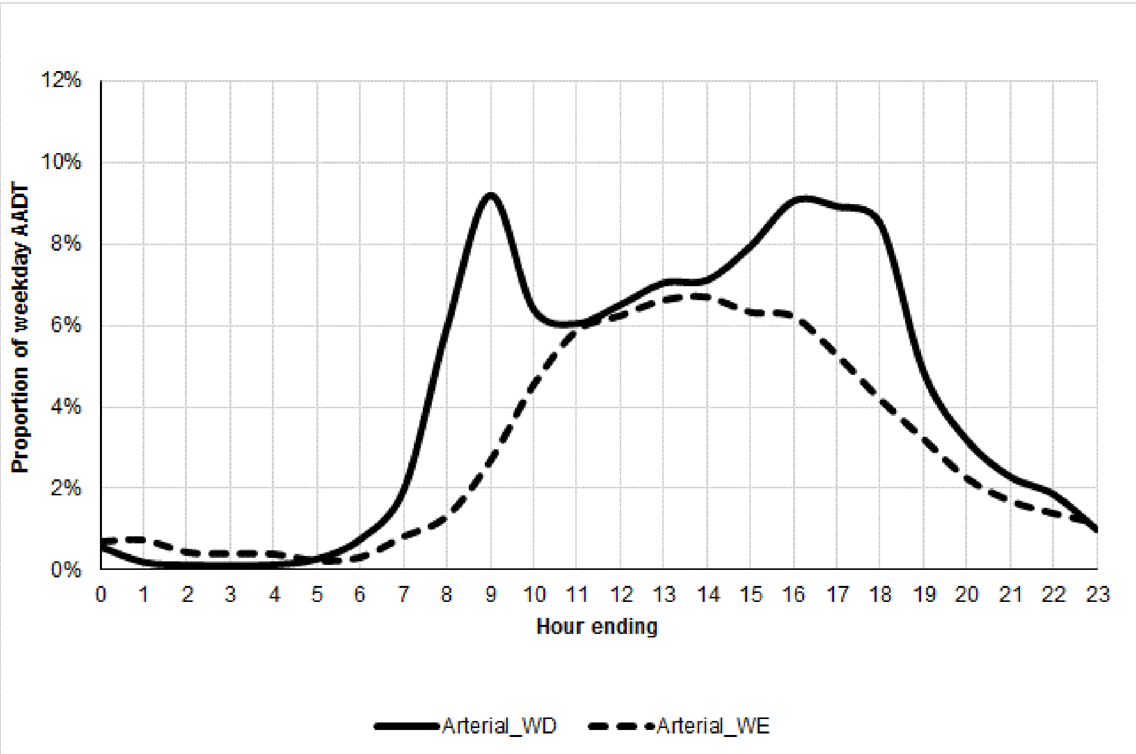
Source: Golder

Figure 16 Diurnal pattern of traffic flow weekdays and weekends on SH18



Source: Golder

Figure 17 Diurnal pattern of traffic flow weekdays and weekends on arterial roads



Source: Golder

7.3 Vehicle emission factors

The Vehicle Emissions Prediction Model (VEPM) has been developed by the NZ Transport Agency and AC to predict emissions from vehicles in the New Zealand fleet under typical road, traffic and operating conditions. VEPM is described in detail in the 'Vehicle Emissions Prediction Model (VEPM) Version 5.0 Development and User Information' report (Jones et al. 2011) and in the 'Vehicle Emissions Prediction Model (VEPM 5.1) users guide' (http://air.nzta.govt.nz/predictions/nz-vepm). The user guide states that the VEPM provides estimates that are suitable for air quality assessments and regional emissions inventories

Motor vehicle emission factors for this air quality assessment were calculated using VEPM version 5.1.

7.4 Vehicle fleet profile

Flow advised that the heavy duty vehicle proportion of the fleet was 5 % on all roads except on the Upper Harbour Highway (SH18) southbound off ramp where the proportion was 8 % and on the busway lanes where all vehicles were assumed to be buses.

The VEPM default values were used to specify the proportion of vehicle types within the light duty and heavy duty vehicle classes for each scenario year.

7.5 Calculating vehicle emission rates

Based on the above information, vehicle emission rates were calculated for three years:

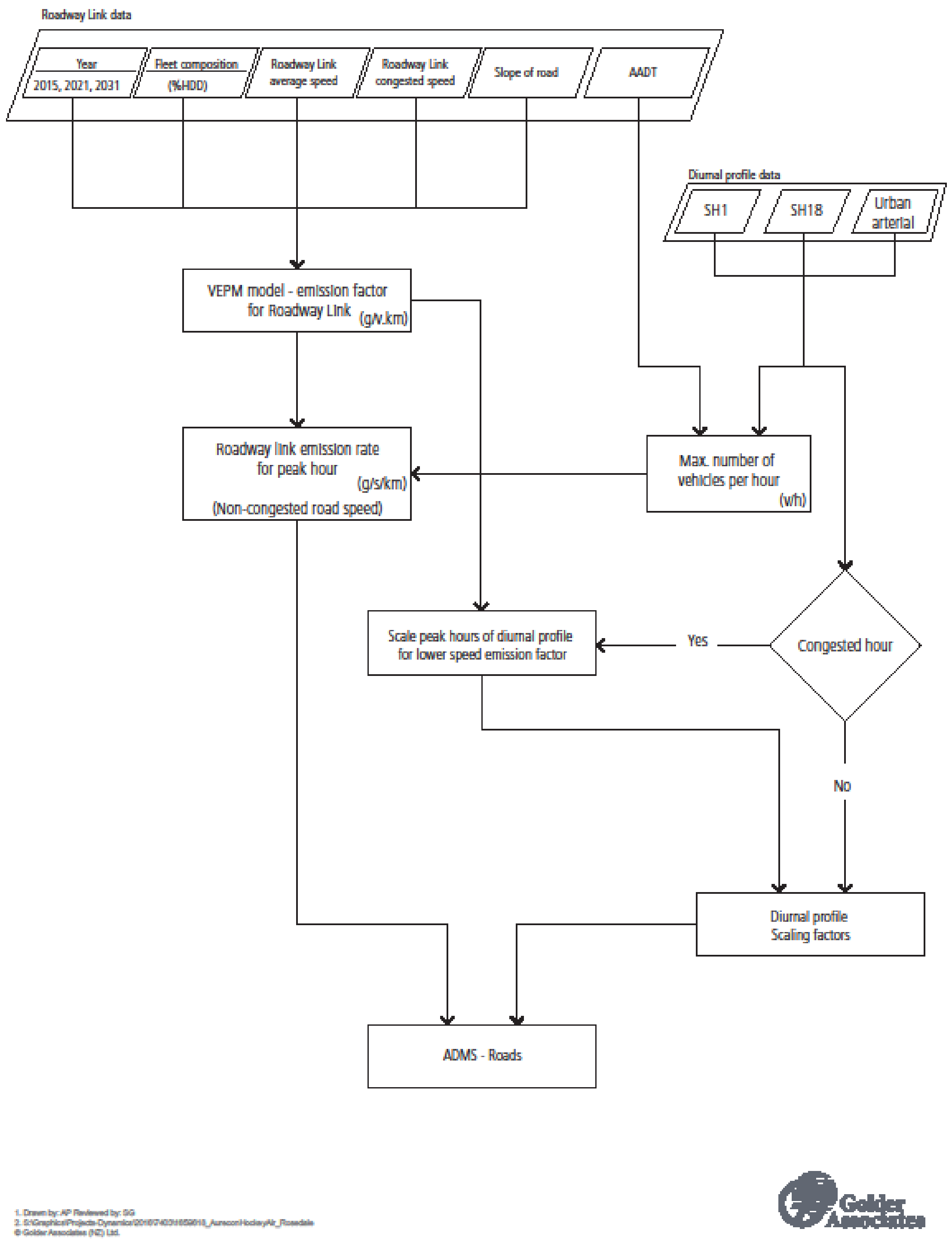
- Current year: 2015;
- Opening year: 2021 – (two scenarios: with and without the Project); and
- Opening year plus 10 years: 2031– (two scenarios: with and without the Project).

For each of these years, VEPM emission factors were generated for each road link within the network being modelled. For each road link VEPM was configured to incorporate the following characteristics:

- Incline of road (+6, +4, +2, 0, -2, -4, -6);
- Speed (20 to 100 km/hr); and
- Vehicle fleet composition (5, 8 or 100% HDD).

The VEPM emission factors are then formatted to meet the format requirements of the dispersion model. A flow chart showing the data inputs and process used to calculate the vehicle emission rates is shown in **Figure 18**. Examples of the VEPM vehicle emission factors used for the assessment are provided in **Appendix C**. The full set of results from the VEPM model runs completed for the Project are available from the report authors.

Figure 18 Data inputs and process used to calculate the vehicle emission rates



7.6 Dispersion modelling method

The ADMS-Roads model has been used for the assessment of the roadway operational effects of the Project. ADMS-Roads is a 'near road dispersion model', developed by Cambridge Environmental Research Consultants (CERC) and is a UK regulatory model for near road dispersion modelling assessments[3]. The latest version of the model (Version 4.0.1.0) has been used for this assessment.

A significant feature of the model compared to other models (such as CALINE or AUSROADS) used for air dispersion modelling roadway emissions, is that it provides realistic smooth changes in the characteristics of the atmosphere (CERC 2015) rather than unrealistic step changes used by CALINE or AUSROADS. ADMS-Roads has a number of other advantages, including the ability to simulate the influence of terrain on dispersion, accounting for hour varying emission rates for a large range of air contaminants and the ability to handle a large number of road sources.

7.7 Atmospheric chemistry of NOx

AC has produced a guidance document (Metcalfe, Wickham and Sridhar, 2014) which provides details on three NOx to NO_2 formation methods which are recommended for use within Auckland's airsheds. The three methods are named: Screening, Proxy and Detailed Chemistry Modelling. For the Project assessment the AC Proxy method was used because, of the three methods, it was considered that this best matched the scale and significance of the activity being assessed. The screening method was considered too simple and conservative. The detailed chemistry modelling approach would have required significantly more time and effort to undertake and would have provided more detailed information than was required for this assessment.

Details on the Proxy method are provided in **Appendix D**.

7.8 Modelling input data

The following sections provide a brief description of the input data used for the ADMS model. A full set of the ADMS configuration files and input data used for the assessment is available from the authors of this report upon request.

The ADMS-Roads model as configured for this study included the following inputs:

1. Roadway link emission rates;
2. Profiles of diurnal emission scaling factors to be applied to each roadway link;
3. Roadway link geometry and road width;
4. Meteorological data;
5. Terrain data; and
6. Receptor locations.

A schematic illustrating each input to the ADMS-Roads model is provided in **Figure 19.**

[3] ADMS-Roads has been assessed by detailed validation studies and inter-model comparisons that are reported on the CERC website ([3] http://www.cerc.co.uk/environmental-software/model-validation.html), - relevant studies include those by Stocker J et al (2013) and Sheng et al (2007).

7.8.1 Emission rates and diurnal profiles

The calculation of contaminant emission rates (in g/km/s) for each roadway link have been detailed in Section 7.5, and the diurnal scaling factors to apply to each roadway link in Section 7.2.3.

7.8.2 Roadway link geometry and width

The geometry representing the centreline of each roadway link, along with its road width were digitised into the ADMS-Roads model for the do-nothing and with Project scenarios. For the motorways, the roadway links were defined for each direction of traffic flow, whereas the arterial roads were defined as a single roadway link representing both directions of traffic flow. The roadway links were also defined based on the gradient change of the road being modelled. The VEPM model uses this information as one of the inputs when calculating contaminant emission rates for specific road links.

7.8.3 Meteorological input data

Meteorological data necessary to run the ADMS-Roads model was extracted from the AC's high-resolution three-dimensional CALMET data sets (H2 CALMET) for the North Shore area (Gimson N, Chilton R & Xie S 2010) for the years of 2005 and 2007. The meteorological data used to run CALMET is a different data set to that used to describe the meteorological conditions experienced in the Project area 2014-2015 (Section 3.3), although the data from the RWWTP 2005 and 2007 was used as an input in developing the CALMET data sets.

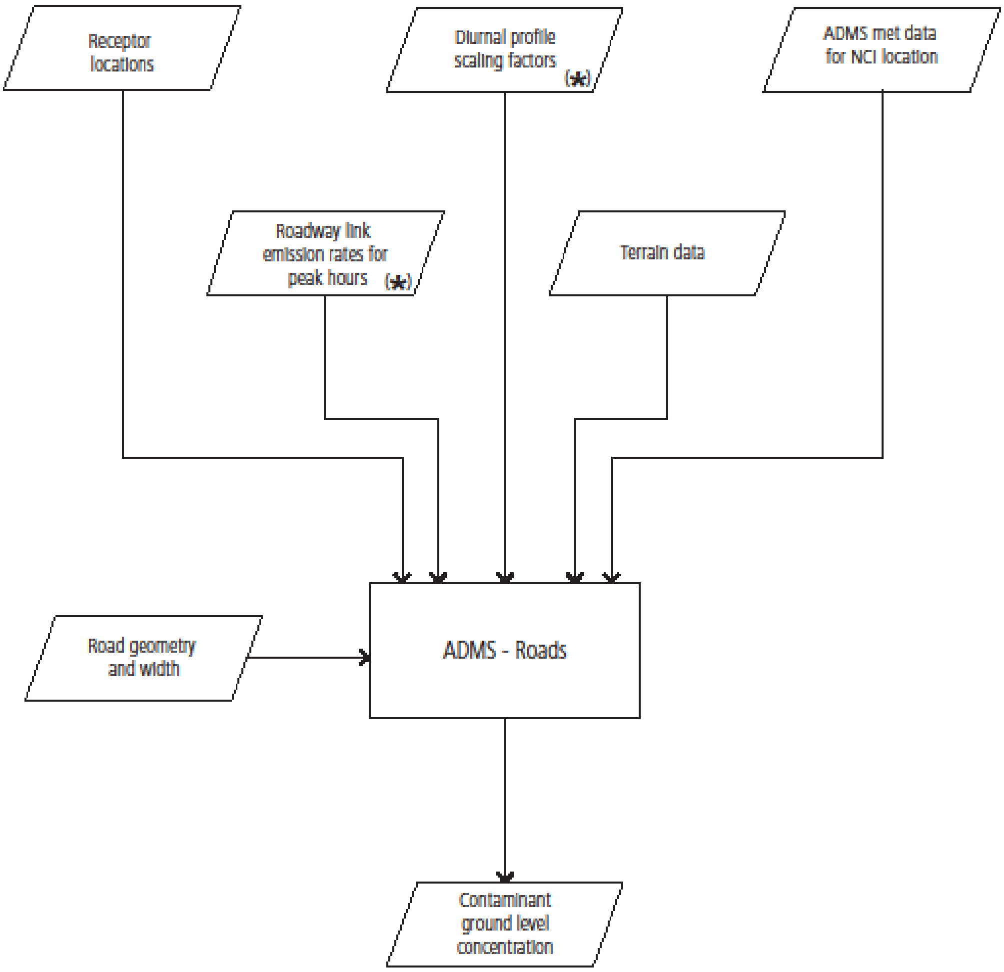
The H2 CALMET data sets were re-run by Golder with its original settings, but with an updated terrain and land use information (geo.dat), which provides more refined terrain data than originally used in the development of the data sets. This updated land use information also better reflects the changes in land use in the proximity of the Project since the original CALMET data set was developed.

Relevant meteorological parameters were extracted from the CALMET dataset for a single location for a representative elevation central to the route of the Project, and formatted for input to the ADMS-Roads model. Wind data for this location was compared to two additional locations (one at the north and the other at the south of the Project corridor) to confirm that variation in meteorology was minimal and that a dataset representing a central location would be sufficiently representative of the entire extent of the modelling domain.

7.8.4 Terrain

The ADMS-Roads model was run using the complex terrain option, which allows for the influence of nearby terrain to be taken into account when predicting contaminant concentrations. Terrain data covering the extent of the model domain area was developed at a 50 m horizontal resolution, which is considered sufficiently detailed. The terrain data used for the modelling is mapped in **Figure 6.**

Figure 19 Schematic of ADMS-Roads model inputs



* - See figure 16

1. Drawn by: AP Reviewed by: SG
2. S:\Graphics\Projects-Dynamics\2016\7403\1659818_AureconHockeyAir_Rosedale

7.8.5 Receptors and roadway links in the modelling domain

Receptor locations are geographic points where the model makes predictions of contaminant ground level concentrations. A nested receptor approach was used in order to provide a high level of spatial detail in the model predictions around the road sources where impacts will be greatest, with less detail further afield where concentrations are significantly lower and where spatial variation in concentrations is much less important. This approach minimises the number of receptors used in the model and consequently allows for a manageable computation time for the modelling runs. Additional receptor points were also located in and around each roadway link to improve the spatial resolution of concentration predictions that decrease rapidly with distance from the roadside. The following summarises the receptor grids and additional receptor locations used in the model, which are illustrated in **Figure 20**:

i) An outer coarse grid of 3 km by 5 km with a 300 m grid spacing;

ii) Five high resolution grids of varying extents, with a 50 m grid spacing; and

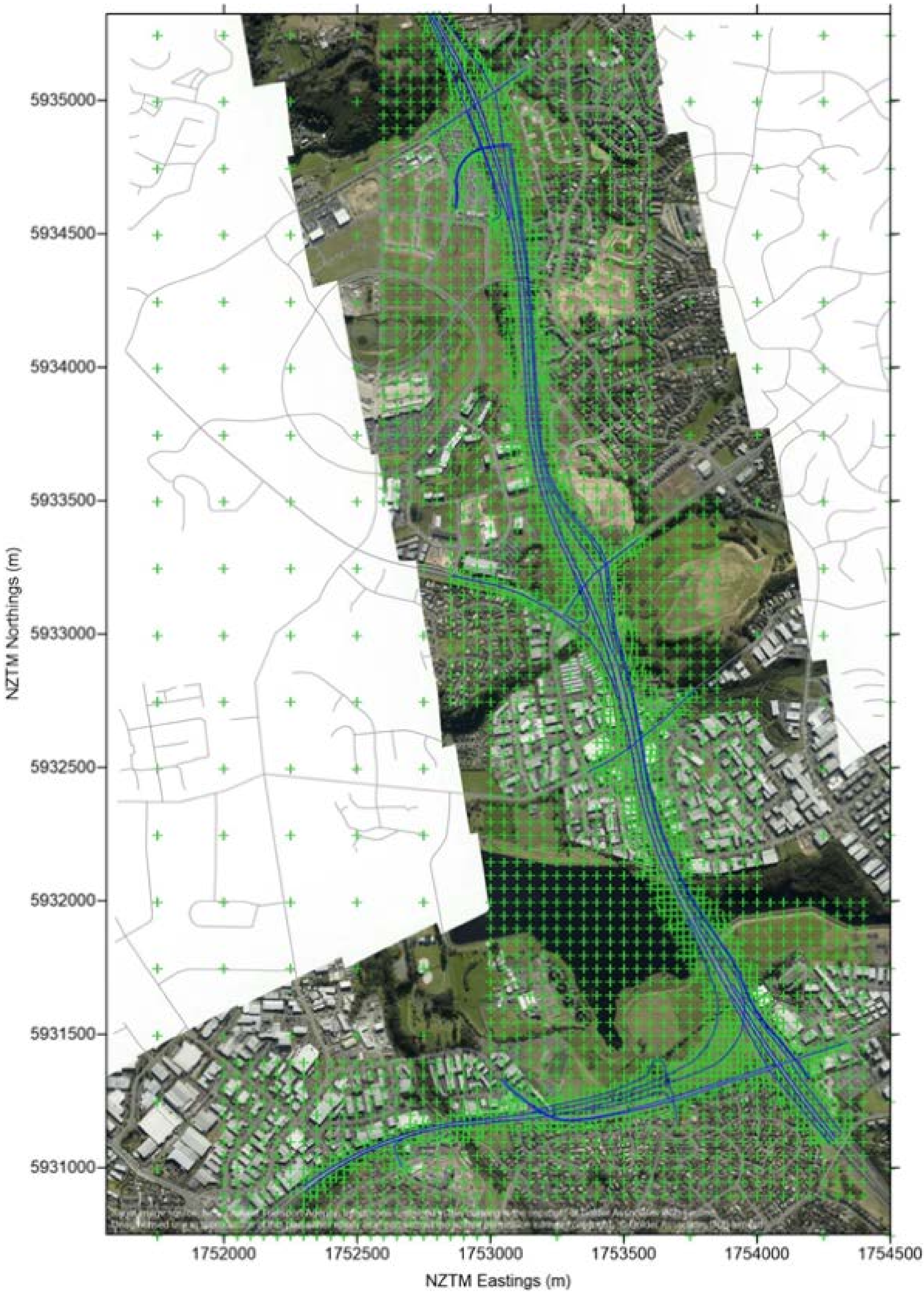
iii) Further receptor points (in excess of 1,200) were placed along the length of the road-links to further improve the resolution of the model outputs in the near field to those road links.

Figure 20 also shows the roadway links that were included in the modelling domain. The receptor locations include the sensitive receptors identified in Section 3.2.

7.9 Model outputs and post processing

For any dispersion model, hourly-averaged conditions can lead to over-prediction of concentrations. This can be due to a number of reasons, including hourly average meteorological conditions that do not occur in practice and therefore lead to unrealistically high GLC predictions that are outliers. To account for this, the MfE (2004) has recommended that for the receptor(s), the 99.9th percentile value of the modelled ground-level concentration be reported as the predicted maximum ground-level concentration likely to occur.

Figure 20 **Modelled receptor locations (green cross) overlaid on top of the roadway links (blue lines) for the Project scenario**



Source: Golder

7.10 Verification of the dispersion modelling results

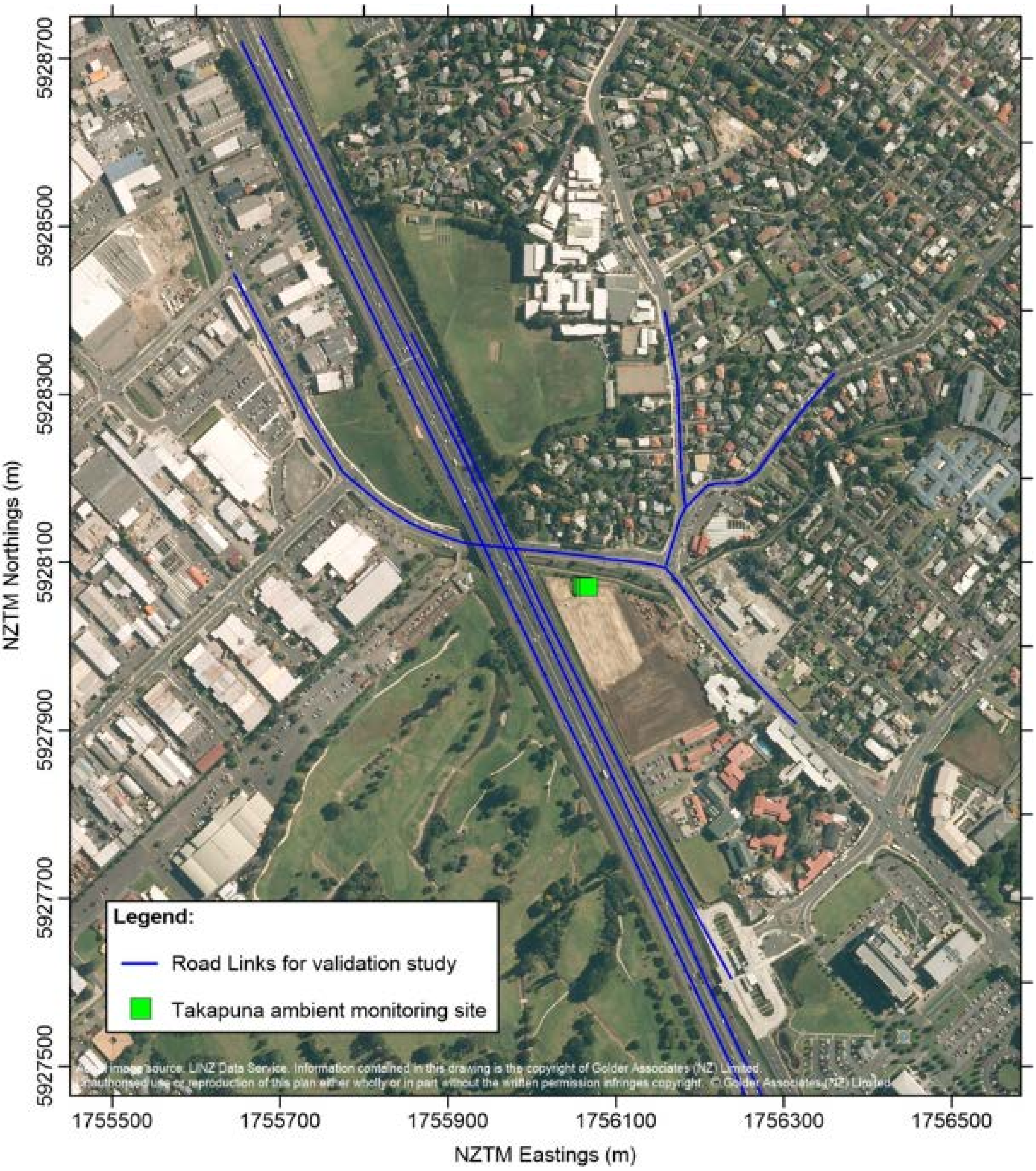
A verification study was carried out in order to assess the performance of the dispersion model in predicting pollutant concentrations. The verification study used the same modelling approach described in Sections 7.3 to 7.8 above, except that the modelling domain was shifted to a location where ambient monitoring results of various contaminants were available. AC's nearest ambient monitoring site to the Project location is the Takapuna site, located at the Westlake Girls High School on Wairau Road (**Figure 21**). This location is approximately 4 km south of the current intersection of SH1 and SH18. Contaminants monitored at the Takapuna site during 2015 included PM_{10}, $PM_{2.5}$, NO_x and CO. Ground level concentration results from the dispersion model were extracted for the monitoring site location and then compared with measured concentrations, providing a verification of how well the model performed at predicting contaminant levels.

The verification study was carried out for year 2015. The key similarities and differences in relation to the ADMS roads modelling set up for the Project are as follows:

1. Emission rates and diurnal profiles: these were defined in the same way as described in Section 7.8.1, using emission rates and diurnal profiles previously defined for the Project modelling and assigning them to the validation study roadway links based on corresponding characteristics (e.g., SH1 or urban arterial diurnal profile, fleet composition, vehicle speed, etc.).
2. Roadway link geometry and width: these were defined in a similar manner as described in Section 7.8.2, but for the roadways as shown in **Figure 18.** The verification study roadway links were further divided so that portions of the roads close to intersections were assumed to have a slower vehicle speed at all times. In addition, the roadway links corresponding to SH1 are located at a considerable height (i.e. approx. 5.4 m) in relation to Wairau Road where the monitoring site is located and therefore relative road heights were also used in this instance.
3. Meteorological data set: the same CALMET set as described in Section 7.8.3 was used, with the only difference being the extraction of the meteorological parameters for the Takapuna monitoring site location. It is noted that the meteorology for 2015 will differ from that of the modelled years 2005 and 2007. However, because these years are considered representative of the long term average meteorological conditions they are considered fit for purpose for the verification modelling.
4. Terrain: terrain data was used in the same manner as described in Section 7.8.4, but for the domain shown in **Figure 21.**
5. Receptors: to provide an indication of the spatial variation around the AC monitoring site, the receptor locations were included for model predictions in a similar manner as that described in Section 7.8.5, with gridded and discrete receptors defined around the roadway links for the validation study as follows:
    a. A 1 km by 1.5 km modelling domain centred on the verification study roadway links, with a 50 m grid spacing.
    b. Four discrete receptor points were included for the Takapuna monitoring site, representing the locations of the various inlets of contaminant monitoring equipment.
    c. Both gridded and discrete receptors were set to a height of 3 m above ground level, which corresponds to the height of the inlets of contaminant monitoring equipment.

Other items not listed above, such as the model outputs and post processing, were undertaken in the same manner as for the Project modelling.

Figure 21 Roadway links and monitoring site location for verification study



Source: Golder

8 Assessment of Effects: Operational Phase of the Project

8.1 Representative receptors and example results

The assessment of effects of the operational phase of the Project compares the predicted ground level concentrations of pollutants discharged from the vehicles using the roadways against the relevant air quality standard/s. The assessment has been undertaken for three years and two roadway scenarios (where applicable):

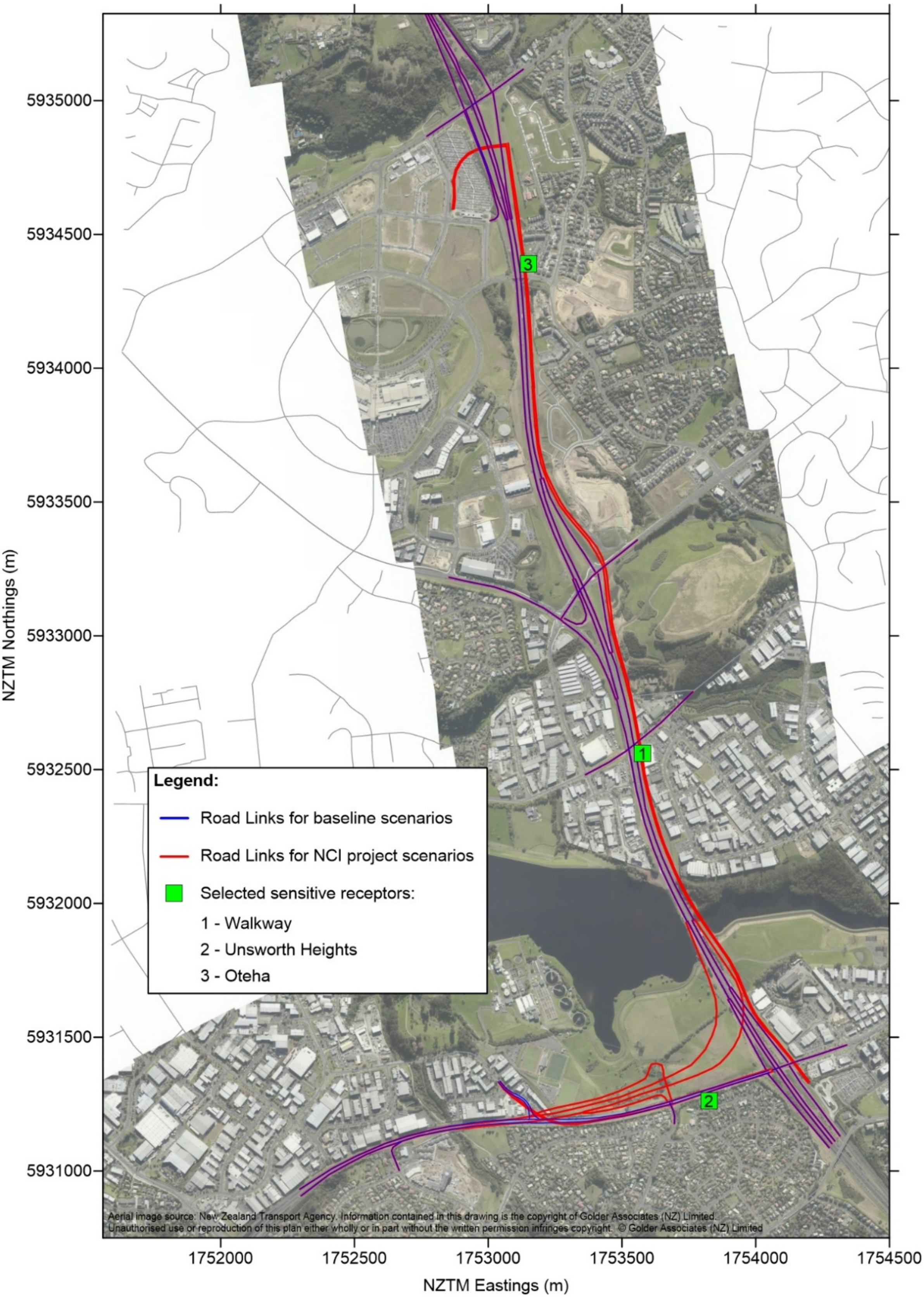
- Base case: 2015;
- Opening year: 2021 – (two scenarios: with and without the Project); and
- Opening year plus 10 years: 2031– (two scenarios: with and without the Project).

Given the scale of the development of the Project, the receiving environment is a wide area within which there is a varying degree of sensitivity and exposure to the pollutants. To simplify the presentation of results, while not losing any important detail, three representative receptors have been chosen for which detailed results are presented.

Due to the relatively high density of housing and the close proximity to the roadways, the sensitive receptors with the highest potential exposure to the contaminants discharged from the operational phases of the Project are considered to be the Unsworth Heights and Oteha residential areas. The location at which any person is likely to be exposed to the highest concentrations of pollutants is considered to be on the dedicated shared walking and cycling path to be located on the eastern side of the Northern Motorway. The locations of these three representative receptors is shown in **Figure 22**.

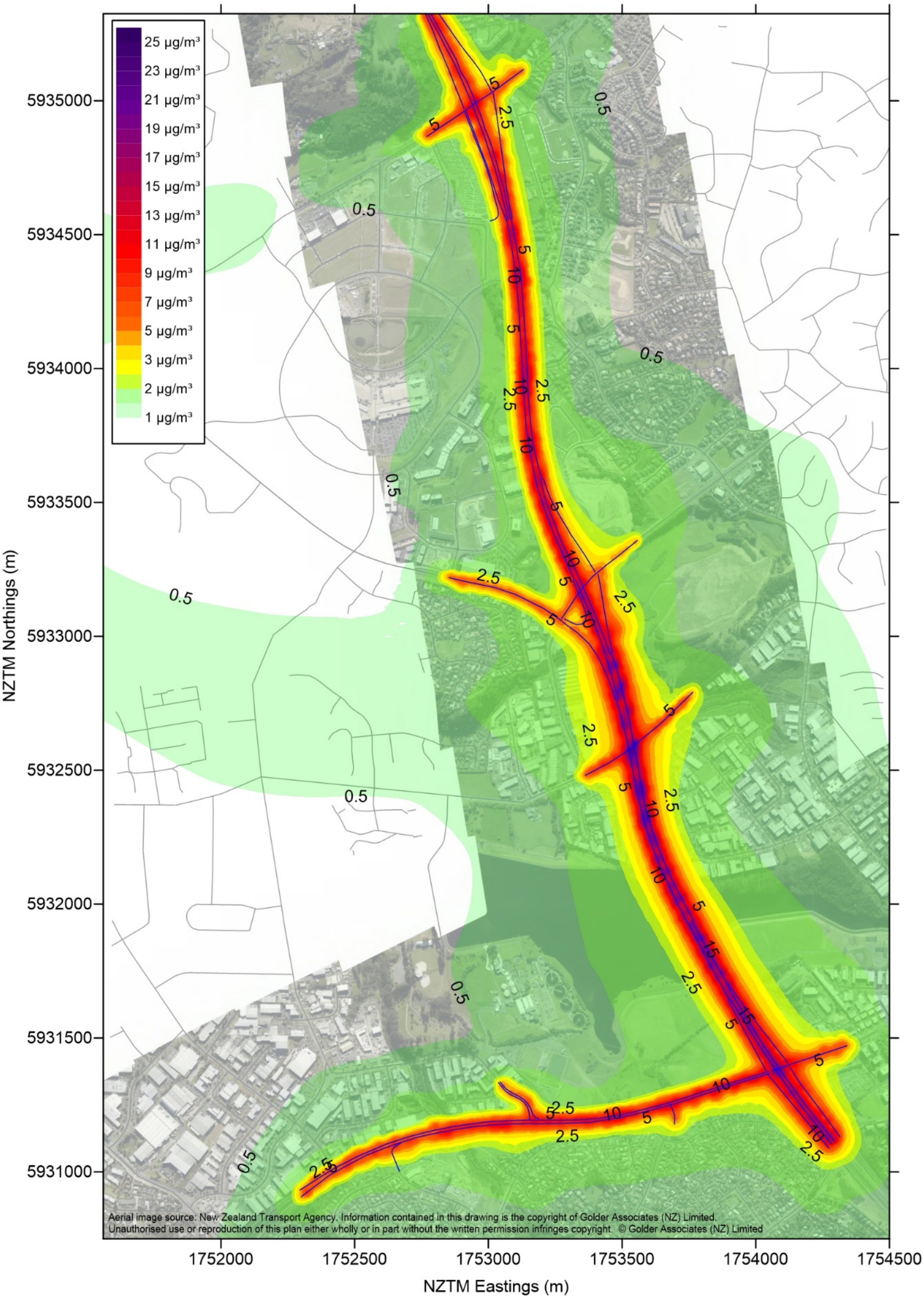
As examples of the data output from the dispersion modelling, **Figure 23** and **Figure 24** show modelled PM_{10} concentrations for 2021 without and with the Project respectively for the complete modelling domain. To illustrate that more spatially refined results can be extracted from the dispersion model output data, **Figure 25** shows modelled PM_{10} concentrations for 2021 without the Project for the sector of the modelling domain near the current intersection of SH1 and SH18.

Figure 22 Locations of the representative highly sensitive receptors within the Project Corridor



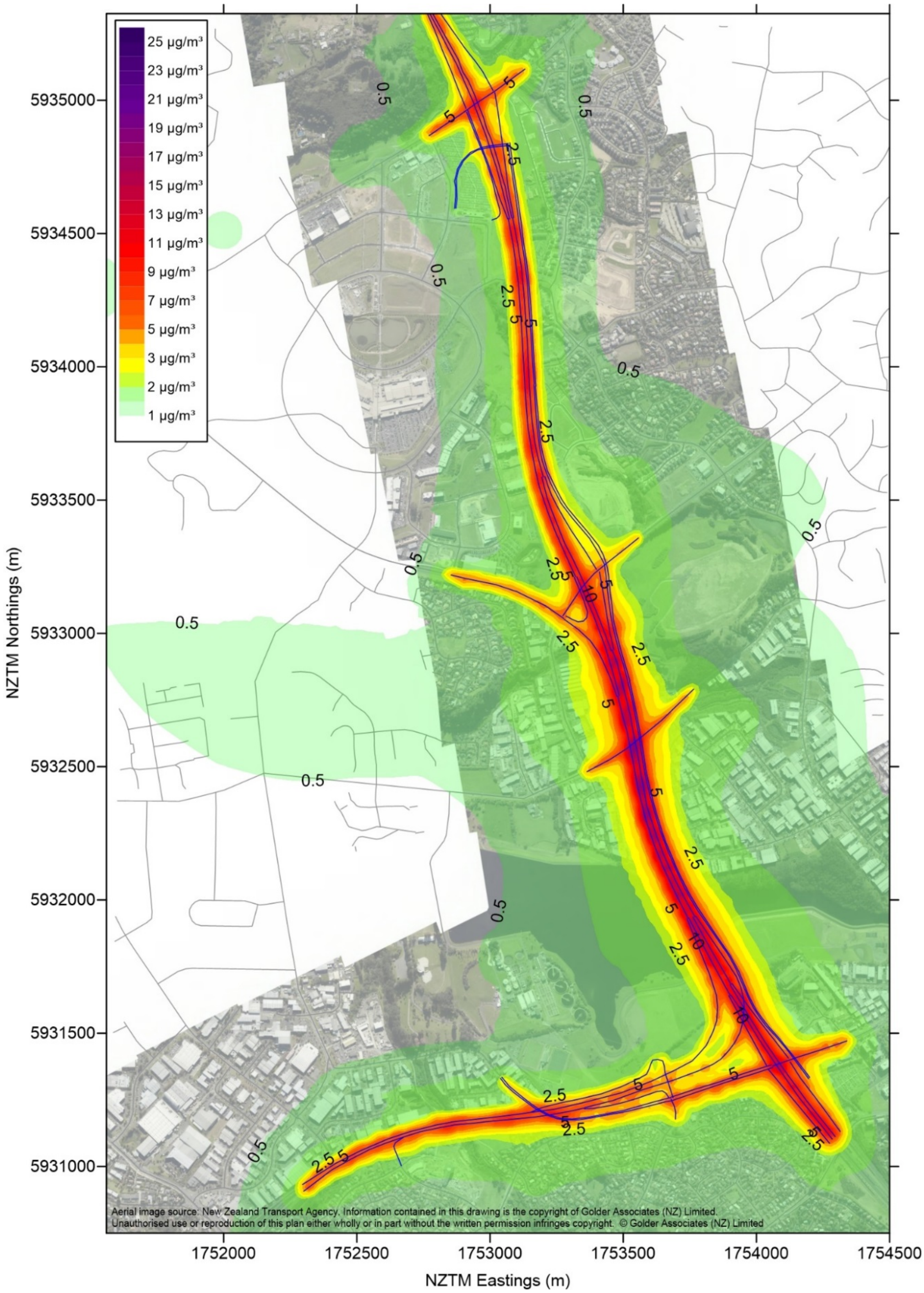
Source: Golder

Figure 23 Modelled 24-hour average PM_{10} concentrations 2021 without the Project



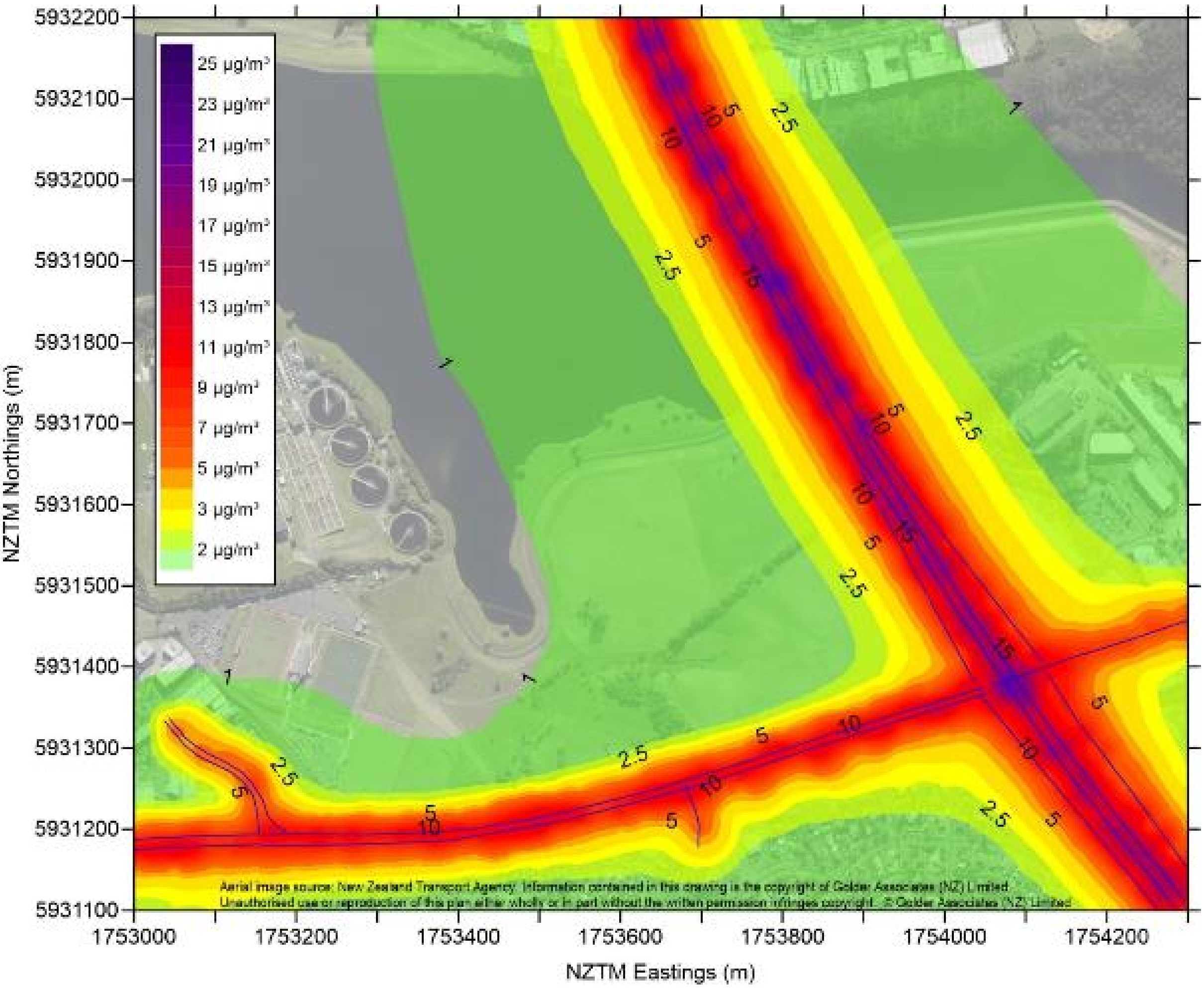
Source: Golder

Figure 24 Modelled 24-hour average PM_{10} concentrations 2021 –with Project



Source: Golder

Figure 25 Modelled 24-hour average PM_{10} concentrations 2021 – without Project detailed results

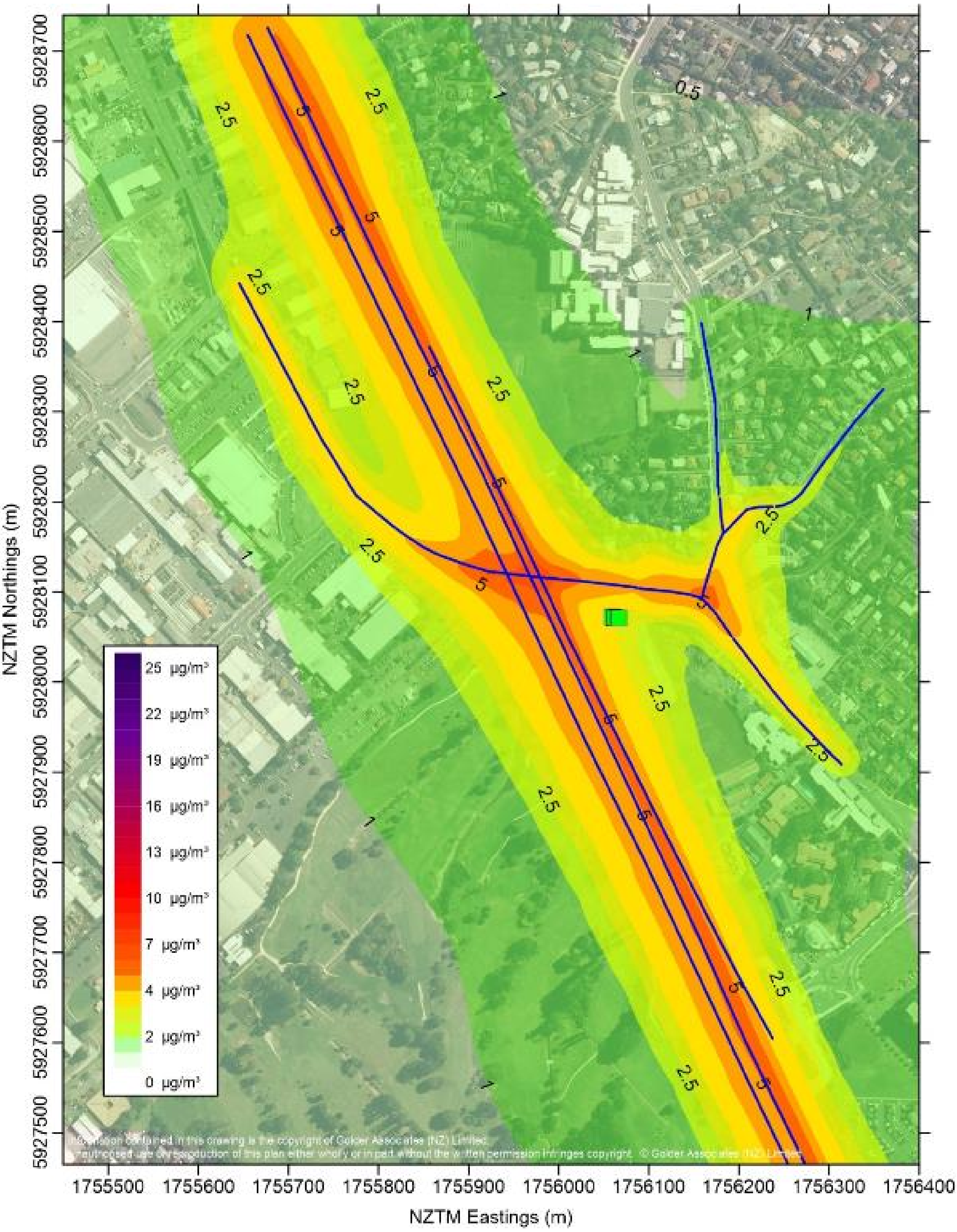


Source: Golder

8.2 Verification model run

An example of the verification model run outputs (24 hour average PM_{10} concentrations) is shown in **Figure 26.** The location of the AC Takapuna monitoring site is indicated by a green square. The modelled roadway links are shown as blue lines.

Figure 26 Modelled 24-hour average PM_{10} concentrations 2021 – verification



Source: Golder

Table 11 compares the modelled and monitored concentration of pollutants at the AC Takapuna air quality monitoring site for 2015.

Table 11 **Comparison of the modelled and monitored concentration of pollutants at the AC Takapuna air quality monitoring site for 2015**

Pollutant / Averaging period	Maximum concentrations at the Takapuna monitoring site (μg/m³)		Ratio (modelled plus background) /monitored
	Modelled*	Monitored	
PM_{10} - 24h	36	31	1.2
PM_{10} - annual	15	13	1.1
$PM_{2.5}$ - 24h	22	25	0.9
$PM_{2.5}$ - annual	8	6	1.4
CO - 1h	8,100	3,300	2.5
CO - 8h (rolling average)	5,100	2,500	2.0
NO_2 - 1h (99.9th perc.)	145	77	1.9
NO_2 - 24h	85	45	1.9
NO_2 - annual	18	18	1.0

* Cumulative concentration = maximum predicted plus background or inclusion of NOx chemistry

Table 11 shows that the model predictions for:

- CO (1-hour and 8-hour) and NO_2 (1-hour and 24 –hour) are conservative (ratio between 1.9 and 2.5);
- PM_{10} and $PM_{2.5}$ (annual) are slightly conservative (ratio between 1.1 and 1.4);
- NO_2 (annual) matches the monitored value (ratio of 1.0); and
- $PM_{2.5}$ (24-hour) are slightly lower than the monitored value (ratio of 0.9).

In summary, the model verification results suggest that the model results are either conservative (higher than) or are close to matching the monitored concentrations. While the model verification shows there is some uncertainty in the absolute values predicted by the model, particularly for the shorter time averaging periods, the relative differences between the modelled Project scenarios are considered to be more certain. In summary, the model verification exercise shows that the model results are fit for purpose and do not require any scaling to enable them to usefully inform the Project assessment. The findings from the model verification exercise are considered when drawing conclusions from each of the Project scenario modelling runs.

It is useful to note the difference between model verification and model validation processes. Model verification indicates whether the model results can be used to usefully inform an assessment. Model validation is a more detailed process that quantitatively assesses the model's ability to predict concentrations. Model validation will often indicate the reasons for any under or over predictions occurring (e.g. the influence of assumed background concentrations). Model validation is beyond the scope of this assessment. However, given the assumptions used for the verification modelling, it is highly likely that a large proportion of the over prediction in the 1 to 24-hour average concentrations of CO and NO_2 are likely to be driven by the assumed background concentrations of these pollutants.

8.3 Without Project scenario

Table 12 shows the maximum predicted ground level concentrations (GLCs) of pollutants for the 2015 base-case scenario at the representative sensitive receptors.

Table 12 **Predicted ground level concentrations (GLCs) of pollutants for 2015 base-case scenario at the representative sensitive receptors.**

Pollutant / Averaging period	Modelled* GLCs (µg/m³)		Assessment criteria (µg/m³)	% of criteria for maximum GLG at residential receptor
	Unsworth Heights	Oteha		
PM_{10} - 24h	37.1	36.6	50	74%
PM_{10} - annual	15.4	14.2	20	77%
$PM_{2.5}$ - 24h	22.7	22.8	25	91%
$PM_{2.5}$ - annual	8.0	6.9	10	80%
CO - 1h	8,900	9,500	30,000	32%
CO - 8h (rolling average)	5,800	6,200	10,000	62%
NO_2 - 1h (99.9th perc.)	153.8	148.2	200	77%
NO_2 - 24h	91.9	87.8	100	92%
NO_2 - annual	17.7	17.4	40	44%

* Cumulative concentration = maximum predicted plus background or inclusion of NOx chemistry

The data displayed in **Table 12** indicates that at the representative receptors the ambient air quality standards are unlikely to be exceeded for:

- PM_{10}: 24-hour and annual averaging periods;
- $PM_{2.5}$: Annual;
- CO: 1 and 8-hour averaging periods; and
- NO_2: 1-hour and annual averaging periods.

The data displayed in **Table 12** indicates that at the representative receptors there is potential for exceedances of the ambient air quality standards for:

- $PM_{2.5}$: 24-hour averaging period (Oteha and Unsworth Heights receptors); and
- NO_2: 24-hour average (Unsworth Heights receptor).

The results of the model verification exercise indicated that the modelled concentrations of NO_2 for the 24-hour averaging period were approximately twice that of the monitored values. Because the model contains this degree of conservatism, in reality it is considered that the concentrations of NO_2 for the 24-hour averaging period are unlikely to exceed the relevant air quality standards.

The PM_{10} and $PM_{2.5}$ 24-hour and annual concentrations at the residential receptors range from 74 % to 91 % of the respective air quality standards. For assessing the cumulative 24-hour PM_{10} the AC recommended background value of 33 µg/m³ was assumed, which means the roadway contribution to the modelled cumulative concentration was in the order of 4 µg/m³ or approximately 10 % of the total cumulative effect. This indicates that the background concentration is the dominant proportion of the cumulative PM_{10} concentrations. The maximum 24-hour average PM_{10} concentration monitored at the AC Takapuna site over 2013 to 2015 was 32 µg/m³ (See **Appendix B**). The data from the AC Takapuna monitoring site suggests the AC recommended background concentration for PM_{10} (33 µg/m³) is most likely conservative. In summary, while the cumulative concentration for 24-hour average PM_{10} is 74 % of the relevant air quality standard, the approach used to include background concentrations suggests this is most likely a conservative result. While the maximum predicted cumulative concentration could be achieved on occasions, for the vast majority of the time concentrations are likely to be much lower than this value. Background contributions have a similar effect on the cumulative annual PM_{10} and 24-hour and annual $PM_{2.5}$ concentrations.

Table 13 and Table 14 show the maximum predicted ground level concentrations of pollutants for 2015, 2021 and 2031 without Project scenario at the Unsworth Heights and Oteha sensitive receptors respectively.

Table 13 Predicted ground level concentrations of pollutants for 2015, 2021 and 2031 without Project scenario at the Unsworth Heights sensitive receptor

Pollutant / Averaging period	Modelled* GLCs at Unsworth Heights receptor (µg/m³)			% change between 2015 and 2031
	2015	2021	2031	
PM_{10} - 24h	37.1	35.8	35.4	-5%
PM_{10} - annual	15.4	15.1	14.9	-3%
$PM_{2.5}$ - 24h	22.7	21.2	20.3	-10%
$PM_{2.5}$ - annual	8.0	7.6	7.4	-8%
CO - 1h	8,900	8,500	8,200	-7%
CO - 8h (rolling average)	5,800	5,500	5,300	-8%
NO_2 - 1h (99.9th perc.)	153.8	144.6	138.5	-10%
NO_2 - 24h	91.9	87.9	85.5	-7%
NO_2 - annual	17.7	16.6	15.9	-10%

* Cumulative concentration = maximum predicted plus background or inclusion of NOx chemistry

Table 14 Predicted ground level concentrations of pollutants for 2015, 2021 and 2031 without Project scenario at the Oteha sensitive receptor

Pollutant / Averaging period	Modelled* GLCs at Oteha receptor (µg/m³)			% change between 2015 and 2031
	2015	2021	2031	
PM_{10} - 24h	36.6	35.5	35.3	-4%
PM_{10} - annual	14.2	13.9	13.8	-3%
$PM_{2.5}$ - 24h	22.8	21.5	20.8	-8%
$PM_{2.5}$ - annual	6.9	6.5	6.3	-10%
CO - 1h	9,500	9,200	9,200	-3%
CO - 8h (rolling average)	6,200	5,900	5,800	-6%
NO_2 - 1h (99.9th perc.)	148.2	140.5	137.0	-8%
NO_2 - 24h	87.8	85.0	83.8	-4%
NO_2 - annual	17.4	16.4	16.0	-8%

* Cumulative concentration = maximum predicted plus background or inclusion of NOx chemistry

Table 13 and **Table 14** show between the years of 2015 and 2031 the concentrations of all pollutants are predicted to decrease at the residential receptors by between 3 % and 10 % depending on pollutant and location. There are two primary factors which are driving this change. Vehicle numbers are increasing, but the amount of contaminants being discharged from each vehicle is decreasing due to the influence of improved vehicle emission controls as newer vehicles enter the fleet. For the Project, the influence of reduced vehicle emissions is greater than the increased vehicle numbers and therefore the GLCs are predicted to decrease over time.

It is important to note that the cumulative concentrations displayed in **Table 13** and **Table 14** assume that the background concentrations of pollutants do not change over this period of 16 years. However, in reality because of the influence of national and regional air quality management strategies, background concentrations (pollutants from other sources) are likely to decrease. A decrease in background concentrations would mean the decrease in concentrations of pollutants at the residential receptors between 2015 and 2031 would be greater than those displayed in **Table 13** and **Table 14**. This assessment has not attempted to estimate the change in background concentrations over time, but it is considered that the decrease of pollutants presented in **Table 13** and **Table 14** is likely to be a conservative estimate (i.e. in reality the decrease over time is likely to be greater).

8.4 With Project scenario

Table 15 shows the maximum predicted ground level concentrations (GLCs) of pollutants for the 2021 with Project scenario at the representative sensitive receptors and compares this with the assessment criteria to establish whether the criteria are likely to be exceeded. Note that for the SUP receptor only the 1-hour assessment criteria are used due to the short exposure time for people using the walkway (likely to be 1 hour or less).

Table 15 Predicted ground level concentrations (GLCs) of pollutants for 2021 with Project scenario at the representative sensitive receptors.

Pollutant / Averaging period	Modelled* GLCs (µg/m³)			Assessment criteria (µg/m³)	% of criteria for SUP receptor	% of criteria for maximum GLG at residential receptor
	SUP	Unsworth Heights	Oteha			
PM_{10} - 24h	NA	35.8	36.1	50	NA	72%
PM_{10} - annual	NA	15.0	14.1	20	NA	75%
$PM_{2.5}$ - 24h	NA	21.2	21.9	25	NA	88%
$PM_{2.5}$ - annual	NA	7.5	6.7	10	NA	75%
CO - 1h	10,500	8,600	9,400	30,000	35%	31%
CO - 8h (rolling average)	NA	5,500	6,100	10,000	NA	61%
NO_2 - 1h (99.9th perc.)	184.1	147.9	147.2	200	92%	74%
NO_2 - 24h	NA	87.5	87.6	100	NA	88%
NO_2 - annual	NA	16.2	17.3	40	NA	43%

* Cumulative concentration = maximum predicted plus background or inclusion of NOx chemistry

The data displayed in **Table 15** indicates that at the representative receptors the ambient air quality standards are unlikely to be exceeded for any of the pollutants at either of the residential receptors. The maximum 1-hour average NO_2 concentration at the SUP receptor is relatively high but still below the relevant assessment criteria.

The discussion provided in Section 8.3 on the influence of assumed background concentrations on cumulative concentrations of PM_{10} and $PM_{2.5}$ also applies to the “with Project scenarios”. In summary, due to assumptions made on background concentrations for PM_{10} and $PM_{2.5}$, the cumulative values presented in **Table 15** are likely to be conservative.

Table 16 and Table 17 respectively show the maximum predicted ground level concentrations of pollutants for 2021 with and without Project scenarios at the Unsworth Heights and Oteha sensitive receptors and the relative change in concentrations between these two scenarios.

Table 16 **Predicted ground level concentrations of pollutants for 2021 with and without Project scenarios at the Unsworth Heights sensitive receptor**

Pollutant / Averaging period	2021 – Modelled* GLCs at Unsworth Heights (µg/m³)		% change
	Without Project	With Project	
PM_{10} - 24h	35.8	35.8	0%
PM_{10} - annual	15.1	15.0	-1%
$PM_{2.5}$ - 24h	21.2	21.2	0%
$PM_{2.5}$ - annual	7.6	7.5	-1%
CO - 1h	8,500	8,600	2%
CO - 8h (rolling average)	5,500	5,500	0%
NO_2 - 1h (99.9th perc.)	144.6	147.9	2%
NO_2 - 24h	87.9	87.5	0%
NO_2 - annual	16.6	16.2	-2%

* Cumulative concentration = maximum predicted plus background or inclusion of NOx chemistry

Table 17 **Predicted ground level concentrations of pollutants for 2021 with and without Project scenarios at the Oteha sensitive receptor**

Pollutant / Averaging period	2021 – Modelled* GLCs at Oteha (µg/m³)		% change
	Without Project	With Project	
PM_{10} - 24h	35.5	36.1	2%
PM_{10} - annual	13.9	14.1	1%
$PM_{2.5}$ - 24h	21.5	21.9	2%
$PM_{2.5}$ - annual	6.5	6.7	2%
CO - 1h	9,200	9,400	3%
CO - 8h (rolling average)	5,900	6,000	3%
NO_2 - 1h (99.9th perc.)	140.5	147.2	5%
NO_2 - 24h	85.0	87.6	3%
NO_2 - annual	16.4	17.3	5%

* Cumulative concentration = maximum predicted plus background or inclusion of NOx chemistry

Table 16 shows the concentrations of pollutants at the Unsworth Heights receptor are likely to be similar with or without the Project. **Table 17** shows the concentrations of pollutants at the Oteha receptor are likely to increase slightly, between +1 and + 5 % with the Project.

Table 18 and **Table 19** respectively show the maximum predicted ground level concentrations of pollutants for 2021 and 2031 with Project scenario at the Unsworth Heights and Oteha receptors.

Table 18 **Predicted ground level concentrations of pollutants for 2021 and 2031 with Project scenario at the Unsworth Heights sensitive receptor**

Pollutant / Averaging period	Modelled* GLCs at Unsworth Heights (µg/m³)		% change
	2021	2031	
PM_{10} - 24h	35.8	35.5	-1%
PM_{10} - annual	15.0	14.9	-1%
$PM_{2.5}$ - 24h	21.2	20.3	-4%
$PM_{2.5}$ - annual	7.5	7.3	-3%
CO - 1h	8,600	8,400	-3%
CO - 8h (rolling average)	5,500	5,400	-3%
NO_2 - 1h (99.9th perc.)	147.9	142.2	-4%
NO_2 - 24h	87.5	85.4	-2%
NO_2 - annual	16.2	15.6	-4%

* Cumulative concentration = maximum predicted plus background or inclusion of NOx chemistry

Table 19 **Predicted ground level concentrations of pollutants for the 2021 and 2031 with Project scenario at the Oteha sensitive receptor**

Pollutant / Averaging period	2021 – Modelled* GLCs at Oteha (µg/m³)		% change
	2021	2031	
PM_{10} - 24h	36.1	35.6	-1%
PM_{10} - annual	14.1	13.9	-1%
$PM_{2.5}$ - 24h	21.9	21.0	-4%
$PM_{2.5}$ - annual	6.7	6.3	-5%
CO - 1h	9,200	9,400	1%
CO - 8h (rolling average)	5,900	6,100	-1%
NO_2 - 1h (99.9th perc.)	147.2	142.3	-3%
NO_2 - 24h	87.6	85.9	-2%
NO_2 - annual	17.3	16.7	-4%

* Cumulative concentration = maximum predicted plus background or inclusion of NOx chemistry

Table 18 and **Table 19** shows between the years of 2021 and 2031 the concentrations of all pollutants are predicted to decrease at the Unsworth Heights and Oteha receptor by between 1 % and 4 %. The reasons for this decrease are the same as those detailed for the base-case scenario described in Section 8.3.

8.5 Regional effects of the Project

The air quality assessment needs to consider the regional effects of the Project development on air quality. This assessment is based on the traffic flow information contained in the Assessment of Transport Effects prepared by Flow and provided at **Volume 3** of the AEE.

8.5.1 Traffic flow

This section provides a summary of the regional effects of the Project on traffic flow. A detailed discussion of the traffic modelling can be found in the Assessment of Transport Effects provided at **Volume 3**.

The Project is predicted to result in an increase in traffic on the Northern Motorway and the Upper Harbour Highway. It is additionally predicted to result in various changes in flows on other adjacent arterial routes; generally reductions but with some exceptions. **Figure 27** illustrates the forecast changes in daily traffic flows by 2031 across the wider network resulting from the Project. Increases in flows due to the Project are shown as green bands while decreases are shown as blue bands.

Figure 27 2031 Daily Traffic Flow Difference Plot showing increases (green) and decreases (blue)

Source: Flow

The Project is predicted to increase flows along both SH1 and SH18. Decreases are forecast on a number of parallel routes, most notably on:

- Albany Highway (reductions of up to 5,600 vehicles per day predicted, or 22%);
- Rosedale Road (reductions of up to 4,800 vehicles per day predicted, or 19%);
- Bush Road (reductions approximately 4,500 vehicles per day predicted, or 14%);
- William Pickering Drive (reductions of approximately 4,000 vehicles per day predicted, or 24%);
- Paul Matthews Road (reductions of approximately 3,300 vehicles per day predicted, or 13%);
- Apollo Drive (reductions of approximately 3,000 vehicles per day predicted, or 11%);
- East Coast Road (reductions of up to 2,900 vehicles per day predicted, or 8%); and
- Sunset Road (reductions of approximately 2,900 vehicles per day predicted, or 17%).

Conversely, traffic flows are predicted to increase on several arterial routes, particularly those that feed the Greville and Oteha Valley interchanges. Most notable among these is Albany Expressway, which is predicted to increase by up to 4,400 vehicles per day west of SH1 (an 11% increase).

In general, the Project is predicted to result in a decrease in forecast traffic flows on local streets, except for those closest to and that connect directly to Greville and Oteha Valley Interchanges.

8.5.2 Air quality

The effect of the Project on regional air quality will be driven by three overriding factors:

- An overall increase in vehicle numbers across the area of assessment;
- Improved traffic flow on motorways; and
- A shift in vehicle numbers from local roads to highways.

On a local scale the Project is predicted to:

- Increase vehicle numbers on some arterials and the state highways (relatively large increases are noted for Greville and Oteha Valley arterial Roads); and
- Decrease vehicle numbers on other arterials and the local roads.

For the areas close to the local and arterial roads on which vehicle numbers are predicted to reduce, there is likely to be a corresponding improvement in air quality (blue roads in **Figure 27**). For the areas close to the arterial roads and highways on which vehicle numbers are predicted to increase (green roads in **Figure 27**) the air quality is likely to decline slightly. On balance, if the Project achieves the aim of increasing network capacity, traffic will flow more freely through the region and the total vehicle emissions should decline. Therefore, on an airshed scale there is likely to be a slight net benefit for regional air quality as compared to the air quality if the Project was not built.

8.6 Mitigation of Operational Effects

Mitigation options to reduce the potential for adverse air quality effects from roading projects only need to be considered when significant adverse effects may occur. The conclusions from the assessment of operational effects of the Project on air quality suggest that exceedances of the relevant air quality standards are unlikely to occur, so there is no need for mitigation of operational air quality effects.

8.7 Summary of Key Findings: Project Operation

The assessment of effects of the operational phase of the Project was undertaken using a dispersion model which calculates GLCs of pollutants that are discharged from the vehicles using the roadways. The predicted GLCs were compared to ambient air quality standards to assess whether or not the vehicle emissions had a significant effect on air quality in the areas adjacent to the roadways.

The results of the dispersion model were verified by comparing modelled GLCs against monitored concentrations for the roadways around the AC’s Takapuna air quality monitoring site. The results from the verification modelling suggest that the ADMS model results are either conservative (higher than) or are close to matching the monitored concentrations. The model verification exercise shows that the model results are fit for purpose and do not require any scaling to enable them to usefully inform this assessment.

Three representative receptors were used to assess the impacts of the operational phase of the project, two residential receptors and one located on the SUP at a location where the highest GLCs were predicted to occur.

The analysis of the 2015 base case scenario results show that none of the air quality standards are likely to be exceeded, although that for $PM_{2.5}$ (24-hour average) may come close. For the particulate pollutants, the Project contribution to the cumulative concentration is relatively small at approximately 10 % of the total. The analysis of the 2021 with Project scenario results show that none of the air quality standards are likely to be exceeded.

A comparison of the GLC pollutants for 2021 without Project and with Project scenarios shows that with the Project being built the concentrations of pollutants at the residential receptors are likely to remain at similar levels (Unsworth Heights) or increase slightly (Oteha).

A comparison of the 2021 and 2031 results, for both the with and without Project scenarios, show that effects are likely to decrease over time as the positive effects of lower vehicle emissions outweigh the effect of increased vehicle numbers.

The predicted changes in pollutant concentrations between scenarios and between years is relatively small (less than 10 %) and given the uncertainty contained in the modelling the amount of change should be considered indicative rather than precise.

The Project will increase network capacity, therefore, traffic will flow more freely through the region, the total emissions will decline and, on an airshed scale, this is likely to result in a slight net benefit for regional air quality as compared to the air quality if the Project was not built.

The conclusions from the assessment of operational effects of the Project on air quality suggest that exceedances of the relevant air quality standards are unlikely to occur, so there is no need for mitigation or a post project air quality monitoring programme.

9 References

AWMA 2000. Air Pollution Engineering Manual – Second Edition. Air and Waste Management Association. Edited by John Wiley & Sons Incorporated. ISBN 0-471-33333-6. Canada.

AC, 2013. The Proposed Auckland Unitary Plan (Decision Version). http://unitaryplan.aucklandcouncil.govt.nz/pages/plan/Book.aspx?exhibit=ACDecision. Accessed 11 November 2016.

Carslaw, D.C., Beevers, S.D., Tate, J.E., Westmoreland, E.J., Williams, M.L., 2011. Recent evidence concerning higher NOx emissions from passenger cars and light duty vehicles, Atmospheric Environment, 45 (39), 7053-7063.

CERC 2015. ADMS-Roads User Guide – Version 4. Cambridge Environmental Research Consultants Limited.

EPA SA, 2016. Evaluation distances for effective air quality and noise management, August 2016. http://www.epa.sa.gov.au/environmental_info/air_quality/assistance_and_advice. Accessed 01 September 2016.

Gimson N, Chilton R & Xie S 2010. Meteorological Datasets for the Auckland Region – User Guide. Report prepared by Golder Associates (NZ) Limited for Auckland Regional Council. Auckland Regional Council Technical Report 2010/022.

Metcalfe, J., Wickham, L and Sridhar, S (2014). Use of background air quality data in resource consent applications. Prepared by Emission Impossible Ltd for Auckland Council. Auckland Council guideline document, GD2014/01

MfE 2004. Good Practice Guide for Atmospheric Dispersion Modelling. MfE report number 522. ISBN: 0-478-18941-9. https://www.mfe.govt.nz/sites/default/files/atmospheric-dispersion-modelling-jun04.pdf. Accessed 01 September 2016.

MfE 2014, 2011. Users' guide to the revised National Environmental Standards for air quality. Updated 2014. Ministry for the Environment Report Publication number: ME 1141. https://www.mfe.govt.nz/sites/default/files/2011-user-guide-nes-air-quality.pdf. Accessed 13 July 2016.

Ministry for the Environment, 2001. Good practice guide for assessing and managing the environmental effects of dust emissions. www.mfe.govt.nz

NZTA, 2014. Guide to assessing air quality impacts from state highway projects. Version 2.0, December 2015, DRAFT. http://air.nzta.govt.nz/sites/default/files/Air_quality_assessment_guide_v2.0_Draft.pdf. Accessed 13 August 2016.

Stocker J, Heist D, Hood C, Isakov V, Carruthers D, Perry S, Snyder M, Venkatram A, Arunachalam S, 2013. Road source model intercomparison study using new and existing datasets. Presented at the 13th Annual CMAS Conference, Chapel Hill, NC, October 27-29, 2014

Sheng X, Carruthers D, Leversedge D, 2007. ADMS-Roads validation and its application for traffic management schemes. Proceedings of the 11th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes.

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Appendices

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18 Upper Harbour Hwy 2·5
21 Tristram Ave 5·5
Auckland Cra

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Appendix A
Seasonal and annual wind roses

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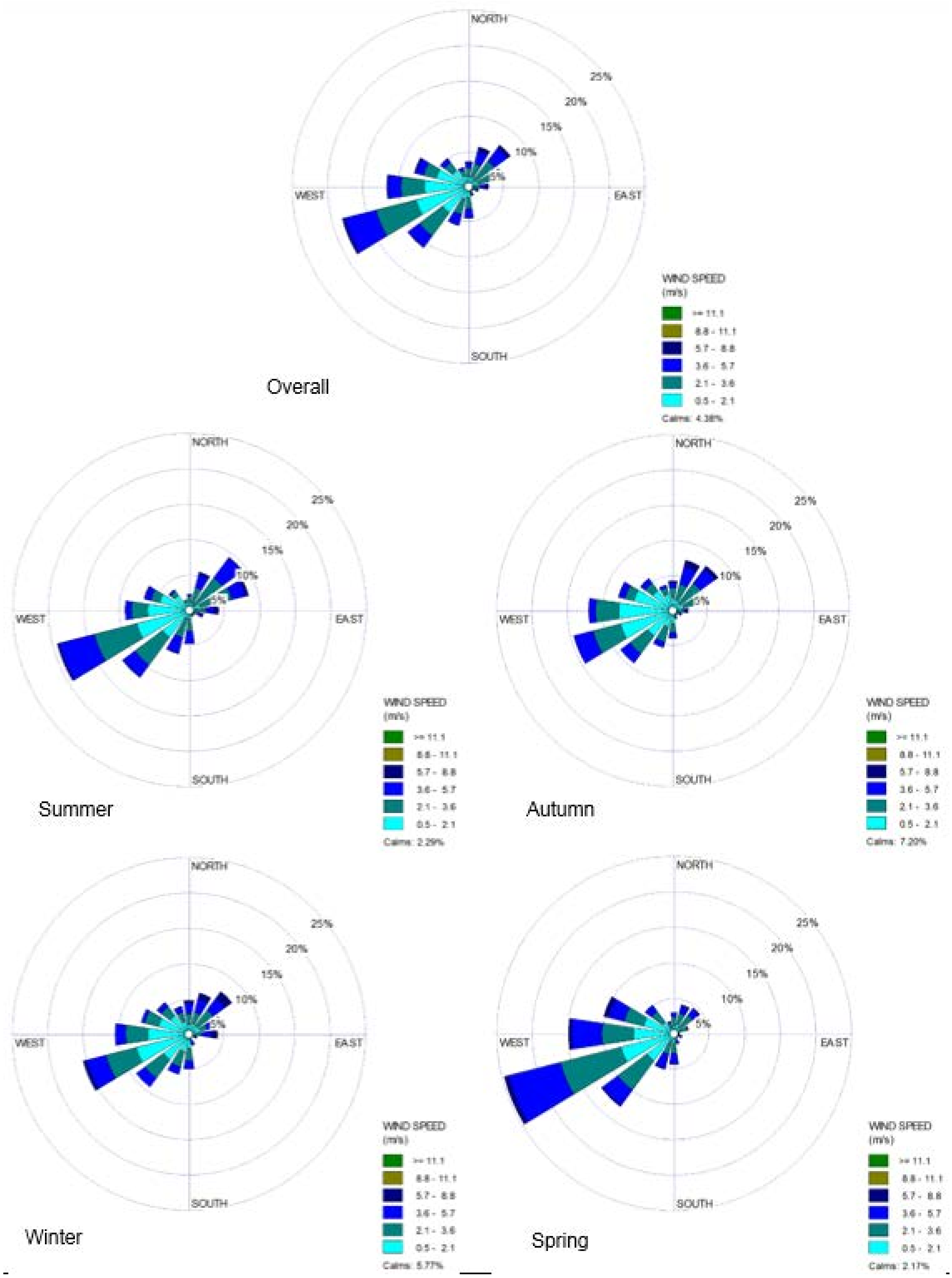
Figure A1 Seasonal and annual wind roses



Source: Golder

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Appendix B

Air Quality Data – Auckland Council Northern Motorway (SH1) Takapuna site

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Figure B1 Location of the AC Takapuna air quality monitoring site

Source: Golder

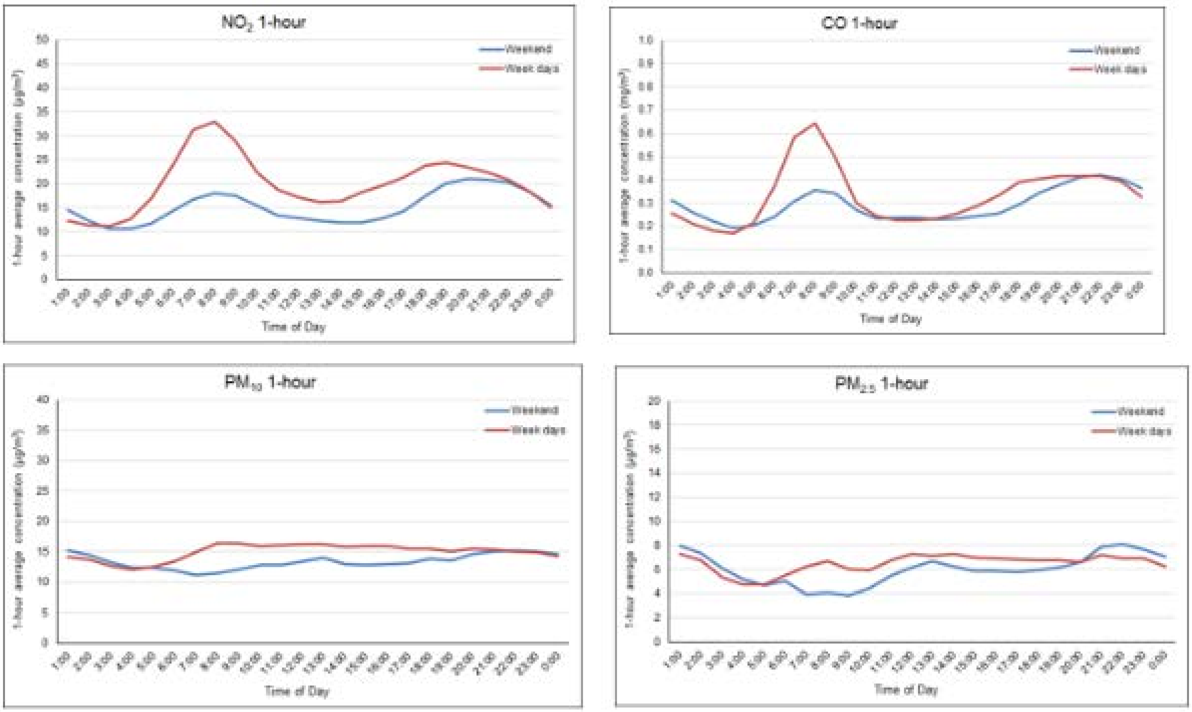
Summary of data

Table B1 Summary air quality statistics AC Takapuna site, 01 January 2013 to 31 December 2015

Contaminant/ Averaging period	Unit	mean	75th %ile	90th %ile	95th %ile	Max	No of NES/ AAAQS exceedances
NO_2 1-hour	µg/m³	18.8	26.4	38.5	46.0	97.7	0
NO_2 24-hour	µg/m³	18.8	25.4	32.7	36.00	47.4	0
CO 1-hour	mg/m³	0.3	0.4	0.7	1.0	3.8	0
CO 8-hour	mg/m³	0.3	0.4	0.7	0.9	2.6	0
PM_{10} 24-hour	µg/m³	14.5	17.2	20.5	22.8	32.6	0
$PM_{2.5}$ 24 -hour	µg/m³	6.3	7.2	9.8	12.1	28.2	2

Diurnal patterns of pollutant concentrations.

Figure B2 Weekday and Weekend diurnal patterns of NO_2 (a), CO(b), PM_{10}(c) and $PM_{2.5}$(d)



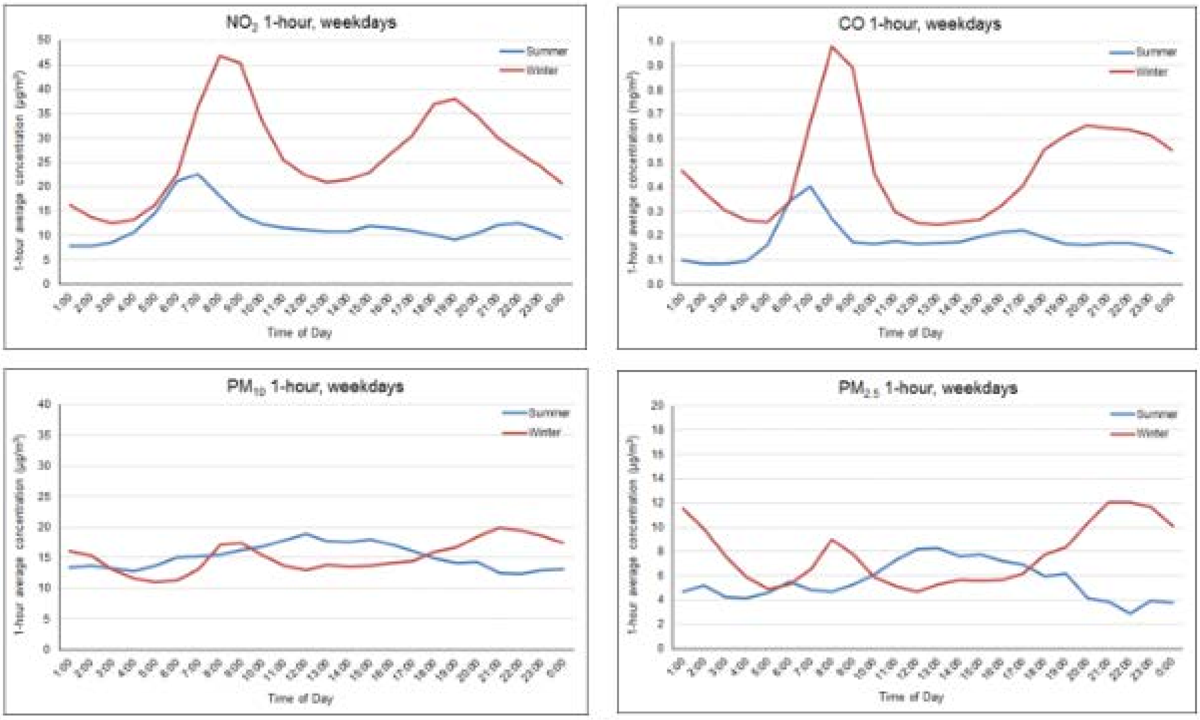
Source: Golder

Seasonal Variation of pollutant concentrations.

Table B2 **Seasonal variation of mean pollutant concentrations AC Takapuna site, 1 January 2013 to 31 December 2015**

Contaminant/ Averaging period	Unit	Summer (Dec., Jan. and Feb) average	Autumn (Mar., Apr. and May) average	Winter (Jun., Jul. and Aug.) average	Spring (Sep., Oct. and Nov.) average
NO_2 1-hour	µg/m³	11.3	20.5	25.5	17.5
NO_2 24-hour	µg/m³	11.3	20.5	25.4	17.5
CO 1-hour	mg/m³	0.2	0.4	0.5	0.3
CO 8-hour	mg/m³	0.2	0.4	0.5	0.3
PM_{10} 24-hour	µg/m³	14.5	14.6	15.0	13.7
$PM_{2.5}$ 24 -hour	µg/m³	5.4	6.4	7.8	5.6

Figure B3 **Summer and winter weekday diurnal patterns of NO_{2}(a), CO(b), PM_{10}(c) and $PM_{2.5}$(d)**



Source: Golder

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Appendix C
Examples of VEPM Emission Factors

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Vehicle Emissions Prediction Model

Entry required in white cells. Entry optional in grey cells

Year	2021
Run Number	1

Run Model

Repeat a Previous Run

Fleet Profile

	Weight category	Fuel type	% of VKT default values 2021	% of VKT optional user entry
Cars	< 3.5 t	petrol	62.3%	72.21%
	< 3.5 t	diesel	11.8%	7.73%
	< 3.5 t	hybrid	2.5%	0.36%
LCV	< 3.5 t	petrol	2.1%	3.52%
	< 3.5 t	diesel	14.0%	12.16%
	< 3.5 t	hybrid	0.7%	0.03%
HCV	3.5 - 7.5 t	diesel	1.4%	0.84%
	7.5 - 12 t	diesel	0.7%	0.44%
	12 - 15 t	diesel	0.2%	0.11%
	15 - 20 t	diesel	0.3%	0.17%
	20 - 25 t	diesel	1.1%	0.66%
	25 - 30 t	diesel	1.1%	0.63%
	> 30 t	diesel	1.3%	0.75%
Buses	> 3.5 t	diesel	0.6%	0.39%
				100%

Average Speeds

cars	50	km/h
LCV's	50	km/h
HCV's/buses	50	km/h

Note: valid HCV speed range for selected load and gradient is 6 - 72 km/h

Optional Inputs

	default values	optional user entry	options
average trip length (km)	9.1		8 to 25
ambient temperature °C	13.1		-10 to 30°
petrol fuel type - see worksheet	6		0 to 7
diesel fuel type - see worksheet	5		0 to 5
consider cold start?	yes		no
consider degradation?	yes		no
% of catalyst not working - old vehicles	15%		0-100%
% of catalyst not working - new vehicles	0%		0-100%
Gradient	0%	-6%	±2, 4, 6
Heavy vehicles: load	50%		0, 100%

Number of wheels

Vehicle type	default values	optional user entry
Car	4	
LCV	4	
HCV 3.5-7.5 t	6	
HCV 7.5-12 t	6	
HCV 12-15 t	8	
HCV 15-20 t	8	
HCV 20-25 t	8	
HCV 25-30 t	8	
HCV >30 t	8	
Buses >3.5 t	6	
Brake and tyre PM output	PM10	

Output Summary

Runs					fleet composition													
					Light Duty Vehicles <3.5t						Diesel HCV >3.5t							
Run number	year	Speed Car	speed LCV	Speed HCV	% car petrol	% car diesel	% car hybrid	% LCV petrol	%LCV diesel	%LCV hybrid	% buses	% HCV 3.5-7.5 t	% HCV 7.5-12t	% HCV 12-15t	% HCV 15-20t	% HCV 20-25t	% HCV 25-30t	% HCV >30t
1	2021	50	50	50	72.2%	7.7%	0.4%	3.5%	12.2%	0.0%	0.4%	0.8%	0.4%	0.1%	0.2%	0.7%	0.6%	0.8%
2	2021	50	50	50	72.2%	7.7%	0.4%	3.5%	12.2%	0.0%	0.4%	0.8%	0.4%	0.1%	0.2%	0.7%	0.6%	0.8%
3	2021	50	50	50	72.2%	7.7%	0.4%	3.5%	12.2%	0.0%	0.4%	0.8%	0.4%	0.1%	0.2%	0.7%	0.6%	0.8%
4	2021	50	50	50	71.5%	7.6%	0.4%	3.5%	12.0%	0.0%	0.5%	1.1%	0.6%	0.1%	0.2%	0.8%	0.8%	0.9%
5	2021	50	50	50	71.5%	7.6%	0.4%	3.5%	12.0%	0.0%	0.5%	1.1%	0.6%	0.1%	0.2%	0.8%	0.8%	0.9%
6	2021	50	50	50	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
7	2021	80	80	80	72.2%	7.7%	0.4%	3.5%	12.2%	0.0%	0.4%	0.8%	0.4%	0.1%	0.2%	0.7%	0.6%	0.8%
8	2021	80	80	80	72.2%	7.7%	0.4%	3.5%	12.2%	0.0%	0.4%	0.8%	0.4%	0.1%	0.2%	0.7%	0.6%	0.8%
9	2021	80	80	80	72.2%	7.7%	0.4%	3.5%	12.2%	0.0%	0.4%	0.8%	0.4%	0.1%	0.2%	0.7%	0.6%	0.8%
10	2021	80	80	80	72.2%	7.7%	0.4%	3.5%	12.2%	0.0%	0.4%	0.8%	0.4%	0.1%	0.2%	0.7%	0.6%	0.8%
11	2021	80	80	80	71.5%	7.6%	0.4%	3.5%	12.0%	0.0%	0.5%	1.1%	0.6%	0.1%	0.2%	0.8%	0.8%	0.9%
12	2021	80	80	80	71.5%	7.6%	0.4%	3.5%	12.0%	0.0%	0.5%	1.1%	0.6%	0.1%	0.2%	0.8%	0.8%	0.9%
13	2021	80	80	80	71.5%	7.6%	0.4%	3.5%	12.0%	0.0%	0.5%	1.1%	0.6%	0.1%	0.2%	0.8%	0.8%	0.9%
14	2021	80	80	80	71.5%	7.6%	0.4%	3.5%	12.0%	0.0%	0.5%	1.1%	0.6%	0.1%	0.2%	0.8%	0.8%	0.9%
15	2021	80	80	80	71.5%	7.6%	0.4%	3.5%	12.0%	0.0%	0.5%	1.1%	0.6%	0.1%	0.2%	0.8%	0.8%	0.9%
16	2021	80	80	80	71.5%	7.6%	0.4%	3.5%	12.0%	0.0%	0.5%	1.1%	0.6%	0.1%	0.2%	0.8%	0.8%	0.9%
17	2021	80	80	80	71.5%	7.6%	0.4%	3.5%	12.0%	0.0%	0.5%	1.1%	0.6%	0.1%	0.2%	0.8%	0.8%	0.9%
18	2021	80	80	80	69.2%	7.4%	0.3%	3.4%	11.7%	0.0%	0.8%	1.7%	0.9%	0.2%	0.3%	1.3%	1.3%	1.5%
19	2021	80	80	80	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
20																		

fleet weighted emissions factors

CO	CO2	VOC	NOx	$PM_{2.5}$	PM	FC
g/km	g/km	g/km	g/km	exhaust g/km	brake&tyre g/km	l/100km
1.71	183.00	0.14	0.09	0.0087	0.0102	7.88
2.03	190.88	0.14	0.22	0.0108	0.0102	8.18
2.20	204.61	0.14	0.35	0.0121	0.0102	8.69
1.87	184.25	0.14	0.14	0.0099	0.0102	7.92
2.18	208.61	0.14	0.37	0.0130	0.0102	8.83
0.13	77.18	0.06	0.45	0.0558	0.0136	2.89
1.90	185.42	0.11	0.24	0.0106	0.0102	7.93
2.08	200.01	0.11	0.38	0.0119	0.0102	8.48
4.28	219.04	0.11	0.55	0.0151	0.0102	9.19
7.21	236.93	0.11	0.73	0.0177	0.0102	9.85
1.55	177.54	0.11	0.09	0.0083	0.0102	7.63
1.73	178.90	0.11	0.15	0.0092	0.0102	7.68
1.88	185.26	0.11	0.24	0.0111	0.0102	7.92
2.06	203.50	0.11	0.40	0.0127	0.0102	8.60
4.24	227.29	0.11	0.59	0.0162	0.0102	9.48
7.14	249.65	0.11	0.78	0.0187	0.0102	10.32
10.07	277.00	0.11	1.01	0.0289	0.0102	11.34
2.01	213.98	0.11	0.47	0.0148	0.0103	8.96
0.46	438.20	0.11	2.48	0.0875	0.0136	16.37

optional model inputs																		
avg trip length	amb temp	petrol type	diesel type	cold start?	degrad-ation?	% cats old car	% cats new	% grade	% load	number of wheels								Brake and Tyre PM
										HCV 3.5-7.5 t	HCV 7.5-12t	HCV 12-15t	HCV 15-20t	HCV 20-25t	HCV 25-30t	HCV >30 t	buses	
km	°C	0 to 6	0 to 5	yes/no	yes/no	0-100%	0-100%	-6 to 6%	0-100%									
								-6%										PM10
								-2%										PM10
																		PM10
								-4%										PM10
																		PM10
								-4%										PM10
								-2%										PM10
																		PM10
								2%										PM10
								4%										PM10
								-6%										PM10
								-4%										PM10
								-2%										PM10
																		PM10
								2%										PM10
								4%										PM10
								6%										PM10
																		PM10
																		PM10

Appendix D

Atmospheric chemistry of NOx

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Ambient air contains around 78% nitrogen (N_2). The combustion of any fuel in the presence of air forms nitrogen oxides (NOx). NOx is primarily a mixture of nitric oxide (NO) and nitrogen dioxide (NO_2). NO usually makes up around 80 per cent (by volume) of the total NOx discharged from a vehicle fleet with the remaining 20 % being NO_2. With respect to human health, NO_2 is the pollutant of most concern. The ratio of NO/NO_2 will vary from vehicle to vehicle. The NO/NO_2 ratio tends to be higher for newer diesel vehicles (>25%) and lower for petrol vehicles (~15%) (Carslaw *et. al*. 2011).

In the atmosphere NO reacts with ozone (O_3) to form NO_2 and oxygen (O_2) as detailed in the following chemical reaction:

$NO + O_3 \rightarrow NO_2 + O_2$

NO_2 discharged from vehicle tailpipes is called primary NO_2 and that formed by the reaction of NO with O_3 is called secondary NO_2. The air quality assessment must account for both primary and secondary NO_2. The primary NO_2 is estimated by dispersion modelling (as detailed in Section 7). There are a number of methods available for estimating the ambient concentration of secondary NO_2.

AC has produced a guidance document (Metcalfe, Wickham and Sridhar, 2014) which provides details on three NO to NO_2 formation methods which are recommended for use within Auckland's airsheds. The three methods are named: Screening, Proxy and Detailed Chemistry Modelling. For the Project assessment the AC Proxy method was used of the three methods, it was considered that this best matched the scale and significance of the activity being assessed. The screening method was considered too simple and conservative. The detailed chemistry modelling approach would have required significantly more time and effort to undertake and would have provided more detailed information than was required for this assessment.

The AC Proxy method assumes that all of the nitric oxide is converted into nitrogen dioxide, but that this process is limited by the availability of ozone as follows:

$[NO_2] = [NOx]$ modelled x $F(NO_2) + [\text{Proxy } NO_2]$

Where

- [NOx] modelled = the nitrogen oxides concentration at the receptor estimated from the modelled nitrogen oxides emission.
- $F(NO_2)$ = is the mass fraction of nitrogen dioxide in the nitrogen oxides emissions from the source (0.2 assumed for the Project).
- [Proxy NO_2 = NO_2 + Ozone]
    - AC provides default values for [Proxy NO_2]. These are:
        - Roadside 1-hour = 113 $\mu g/m^3$
        - Roade side 24 hour = 75 $\mu g/m^3$

As an example, for a roadside site the one hour average NO_2 concentration is estimated by the Proxy method using the following input data:

- NOx (modelled) = 150 $\mu g/m^3$
- $F(NO_2)$= 0.20
- Proxy NO_2 = 113 $\mu g/m^3$

Using this input data with the proxy method would give us an NO_2 concentration of:

- 150 μg/m^3 (NO_2) = (150 x 0.2) + 113.

The AC guidance does not provide a proxy value for estimating annual average NO_2 concentrations. In absence of this data, a simplistic and conservative approach was taken by adopting AC's recommended annual average NO_2 concentration for urban Auckland (113 μg/m^3) as the Proxy NO_2 value used in the above equation.

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