



AIR QUALITY ASSESSMENT
BUS DEPOT AT 15 JUBILEE AVE
WARRIEWOOD

McNally Management

28 August 2020

Job Number 20081164

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Air Quality Assessment

Bus Depot at 15 Jubilee Ave Warriewood

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TABLE OF CONTENTS

1	INTRODUCTION.....	1
2	PROJECT BACKGROUND.....	2
2.1	Local setting.....	2
2.2	Project description.....	4
3	AIR QUALITY CRITERIA.....	6
3.1	Preamble.....	6
3.2	Assessed pollutants.....	6
4	EXISTING ENVIRONMENT.....	8
4.1	Local climate	8
4.2	Local meteorological conditions.....	9
4.3	Local air quality monitoring.....	11
4.3.1	PM ₁₀ monitoring.....	11
4.3.2	PM _{2.5} monitoring.....	12
4.3.3	NO ₂ monitoring.....	13
4.3.4	CO monitoring.....	14
4.3.5	Estimated background levels.....	15
5	DISPERSION MODELLING APPROACH.....	17
5.1	Introduction.....	17
5.2	Modelling methodology.....	17
5.2.1	Meteorological modelling.....	17
5.2.2	Dispersion modelling.....	21
5.3	Emission estimation.....	21
6	DISPERSION MODELLING RESULTS.....	23
6.1	Assessment of Total (Cumulative) 24-hour average PM _{2.5} and PM ₁₀ Concentrations.....	23
7	SUMMARY AND CONCLUSIONS	25
8	REFERENCES.....	26

LIST OF APPENDICES

Appendix A – Selection of Meteorological Year

Appendix B – Isoleth diagram

Appendix C – Further detail regarding 24-hour PM_{2.5} and PM₁₀ analysis

LIST OF TABLES

Table 3-1: Applicable air quality impact assessment criteria	6
Table 4-1: Monthly climate statistics summary – Sydney (Observatory Hill).....	8
Table 4-2: Summary of PM ₁₀ levels from NSW DPIE monitoring (µg/m ³)	11
Table 4-3: Summary of PM _{2.5} levels from NSW DPIE monitoring (µg/m ³)	12
Table 4-4: Summary of NO ₂ levels from available NSW DPIE monitoring (µg/m ³)	13
Table 4-5: Summary of CO levels from available NSW DPIE monitoring (µg/m ³).....	14
Table 5-1: Summary of exhaust emissions for buses.....	22
Table 5-2: Summary of non-exhaust particulate matter emissions - combined tyre, break and road wear	22
Table 6-1: Summary modelling predictions – ground level concentrations.....	23
Table 6-2: NSW EPA contemporaneous assessment - maximum number of additional days above 24-hour average criterion	24

LIST OF FIGURES

Figure 2-1: Project location	2
Figure 2-2: Representative visualisation of the local topography surrounding the Project.....	3
Figure 2-3: Indicative site layout – Stage 1	4
Figure 2-4: Indicative site layout – Stage 2	5
Figure 4-1: Monthly climate statistics summary – Sydney (Observatory Hill).....	9
Figure 4-2: Annual and seasonal windroses for Terry Hills AWS (2015).....	10
Figure 4-3: 24-hour average PM ₁₀ concentrations.....	12
Figure 4-4: 24-hour average PM _{2.5} concentrations.....	13
Figure 4-5: Daily 1-hour maximum NO ₂ concentrations.....	14
Figure 4-6: Daily 1-hour maximum CO concentrations	15
Figure 5-1: Representative snapshot of wind field for the Project.....	18
Figure 5-2: Annual and seasonal windroses from CALMET (cell ref 5152)	19
Figure 5-3: Meteorological analysis CALMET (cell ref 5152)	20
Figure 5-4: Projected departures and arrivals for the Project.....	22

1 INTRODUCTION

Todoroski Air Sciences has prepared this report for McNally Management. It presents an assessment of the potential air quality impacts associated with the operation of a proposed Bus Depot at 15 Jubilee Avenue Warriewood, New South Wales (NSW) (hereafter referred to as the Project).

To assess the potential air quality impacts associated with the Project, this report incorporates the following aspects:

- ✦ A background and description of the Project;
- ✦ A review of the meteorological and air quality environment surrounding the Project site;
- ✦ A description of the dispersion modelling approach used to assess potential air quality impacts; and,
- ✦ Presentation of the predicted results and a discussion of the potential air quality impacts.

This air quality impact assessment has been prepared in general accordance with the NSW Environment Protection Authority (EPA) document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (**NSW EPA, 2017**).

2 PROJECT BACKGROUND

2.1 Local setting

The Project site is located within an existing industrial precinct approximately 5.7 kilometres (km) east of Terry Hills and 13.1km north of Manly. The Project is situated along Jubilee Avenue, 0.2 km from the intersection of Ponderosa Parade which experiences high traffic volumes. The surrounding industries include various commercial services including a plastic injection moulding operation, various warehousing and wholesalers, and pharmaceutical manufacturing. The nearest identified sensitive receptor to the Project is located directly adjacent to the east.

Figure 2-1 presents the location of the Project and the nearest sensitive receptor.



Figure 2-1: Project location

Figure 2-2 presents a representative three dimensional visualisation of the terrain features surrounding the Project location. The local topography is mostly flat, increasing to higher elevations to the west of the site. The Pacific Ocean is located approximately 2.2km directly east of the site and would foster good dispersion in the area due to sea-breeze effects.

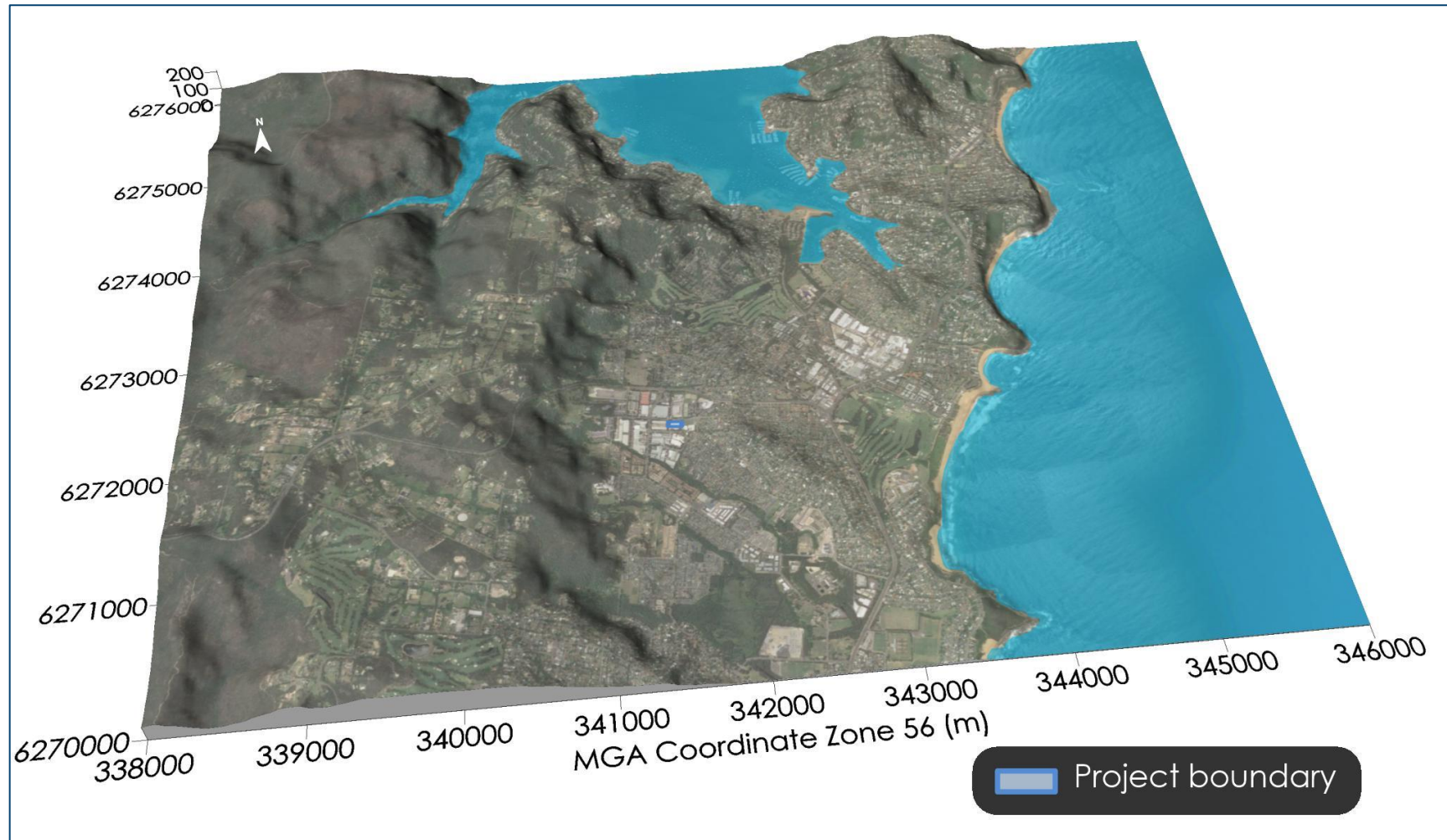


Figure 2-2: Representative visualisation of the local topography surrounding the Project

2.2 Project description

The Project proposes to construct and operate a bus depot at the site.

This would occur in two stages. In Stage 1 the depot would have the capacity to accommodate a total of 48 buses consisting of 33 parked on-site during the day and 15 parked on-site overnight. During Stage 2 the depot would have the capacity to accommodate a total of 43 buses consisting of 28 parked on-site during the day and 15 parked on-site overnight.

The Project would include features such as a wash station, fuel bay and electric charging stations to the west.

Figure 2-3 and Figure 2-4 present an indicative site layout of the Project during Stage 1 and Stage 2.

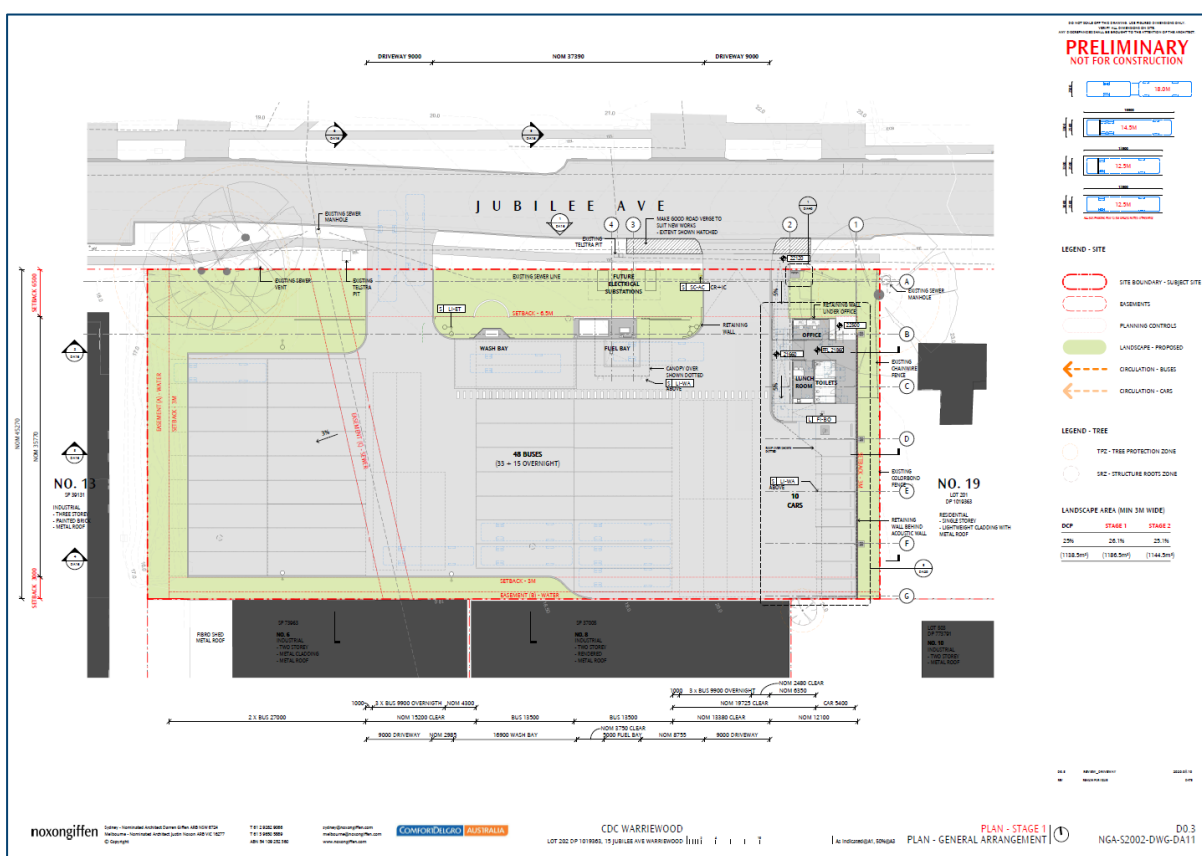


Figure 2-3: Indicative site layout – Stage 1

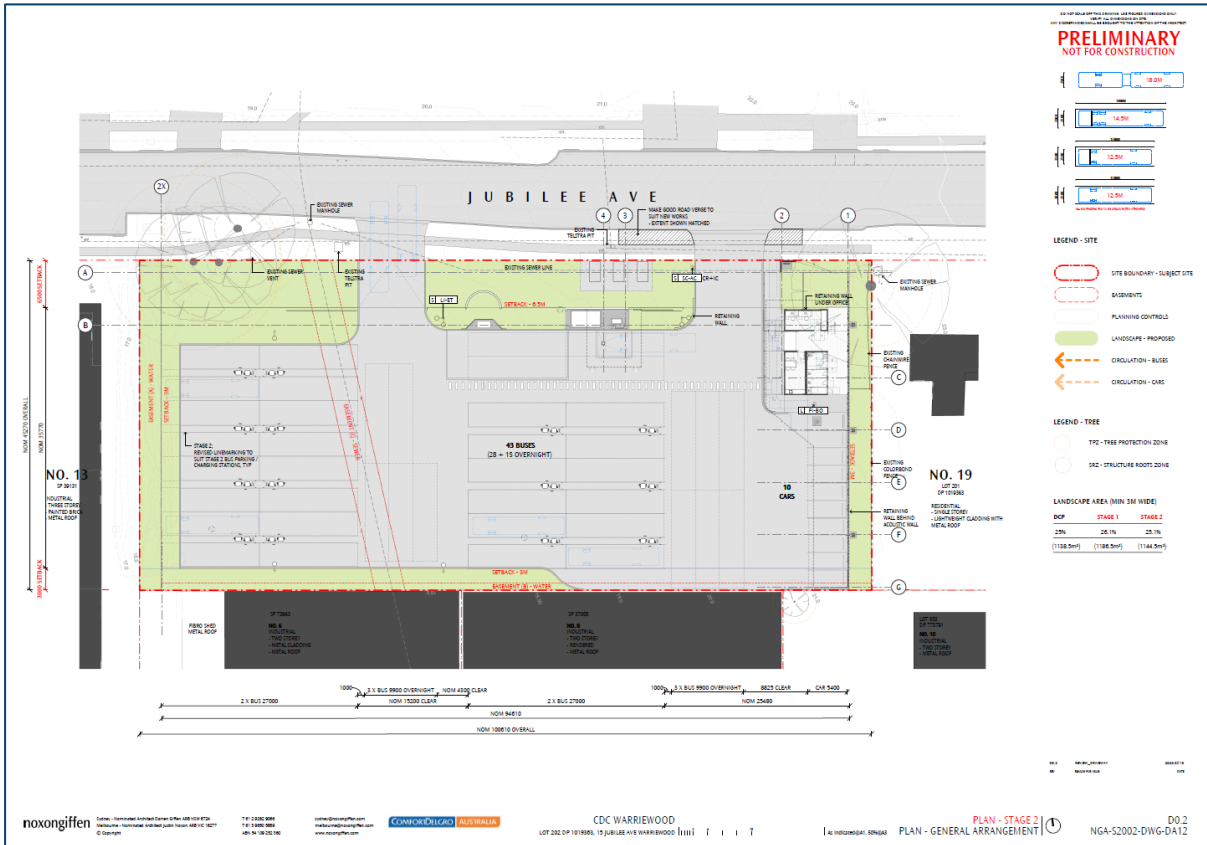


Figure 2-4: Indicative site layout – Stage 2

3 AIR QUALITY CRITERIA

3.1 Preamble

Air quality criteria are benchmarks set to protect the general health and amenity of the community in relation to air quality. The sections below identify the potential air emissions generated by the Project and the applicable air quality criteria.

The NSW EPA has developed criteria and methods for assessing acceptable levels of exposure to benzene in NSW. The criteria that apply in NSW are set out in the NSW EPA document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW EPA, 2017).

3.2 Assessed pollutants

Exhaust diesel emissions in the form of Volatile Organic Compound (VOC), oxides of nitrogen (NO_x), carbon monoxide (CO) and diesel particulate emissions have been considered. The key VOC pollutants from the diesel vapours with scope for any impact are benzene, formaldehyde, polycyclic aromatic hydrocarbons (PAH), toluene and xylene on the basis of composition in the fuel and potential for impact.

Table 3-1 summarises the air quality goals that are relevant to this assessment as outlined in the NSW EPA document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW EPA, 2017).

Table 3-1: Applicable air quality impact assessment criteria

Pollutant	Averaging Period	Impact	Percentile	Criterion (µg/m ³)	Criteria basis
TSP	Annual	Total	100	90	Health
PM ₁₀	Annual	Total	100	25	Health
	24 hour	Total	100	50	Health
PM _{2.5}	Annual	Total	100	8	Health
	24 hour	Total	100	25	Health
NO ₂	1 hour	Total	100	246	Health
	Annual	Total	100	62	Health
CO	1 hour	Total	100	30,000	Health
	Annual	Total	100	10,000	Health
Benzene	1 hour	Incremental	99.9	29	Health
Formaldehyde	1 hour	Incremental	99.9	20	Health
PAH (as benzo[a]pyrene)	1 hour	Incremental	99.9	0.4	Health
Toluene	1 hour	Incremental	99.9	360	Amenity (odour)
Xylenes	1 hour	Incremental	99.9	190	Amenity (odour)

Source: NSW EPA, 2017

It is noted that other pollutants would be present in the VOC vapours. These other substances do not require assessment as they are never present in the exhaust emissions at concentrations which would lead to greater impacts than would arise for the VOC pollutants assessed above. In other words, when the concentrations of the VOC pollutants assessed above are within criteria, all other VOC substances present in exhaust emissions will also be at concentrations within criteria.

Individual odorous air pollutants (i.e. toluene, xylene) have been assessed in this assessment. The criteria for these pollutants relate to odour amenity and the toluene and xylene concentrations would exceed the odour based criteria before exceeding health criteria.

It is also important to note that in NSW, the criteria for the some of relevant pollutants apply without consideration of background levels. In NSW, the criteria for these pollutants are set at stringent levels on the basis that only the effect due to the Project in isolation is assessed against the criterion value, i.e. the pollutant is assessed for incremental impact only. For those pollutants at which the pollutant is assessed for total impact, these apply with consideration of ambient background levels.



4 EXISTING ENVIRONMENT

This section describes the existing climate in the area surrounding the Project.

4.1 Local climate

Long-term climatic data from the Bureau of Meteorology weather station at Sydney (Observatory Hill) (Site No. 066062) were analysed to characterise the local climate in the proximity of the Project site.

Table 4-1 and **Figure 4-1** present a summary of data from the Sydney (Observatory Hill) collected over an approximate 37 to 162-year period for the various meteorological parameters.

The data indicate that January is the hottest month with a mean maximum temperature of 26.0 degrees Celsius (°C), July is the coldest month with mean minimum temperatures of 8.1°C.

Rainfall is generally higher during the first half of the year, with an average annual rainfall of 1213.4 millimetres (mm) over 99.6 days. The data show June is the wettest month with an average rainfall of 133.1mm over 8.8 days and September is the driest month with an average rainfall of 68.1mm over 7.1 days.

Relative humidity levels exhibit some variability over the year and seasonal fluctuations. Mean 9am relative humidity levels range from 61% in October to 74% in February, March, May and June. Mean 3pm humidity levels vary from 49% in August to 64% in February.

Wind speeds have a greater spread between the 9am and 3pm conditions during the cooler months of the year compared to the warmer months. The mean 9am wind speeds range from 7.9 kilometres per hour (km/h) in March to 13.3km/h in August. The mean 3pm wind speeds vary from 12.7km/h in May to 19.5km/h in November.

Table 4-1: Monthly climate statistics summary – Sydney (Observatory Hill)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Temperature													
Mean max. temp. (°C)	26.0	25.8	24.8	22.5	19.5	17.0	16.4	17.9	20.1	22.2	23.7	25.2	21.8
Mean min. temp. (°C)	18.8	18.9	17.6	14.8	11.6	9.3	8.1	9.0	11.1	13.6	15.7	17.6	13.8
Rainfall													
Rainfall (mm)	101.2	119.3	131.6	126.5	117.4	133.1	96.3	80.2	68.1	76.7	83.8	77.1	1213.4
No. of rain days	8.6	9.0	9.9	8.9	8.6	8.8	7.4	7.2	7.1	7.9	8.3	7.9	99.6
9am conditions													
Mean temp. (°C)	22.5	22.3	21.1	18.2	14.6	11.9	10.9	12.5	15.7	18.5	19.9	21.6	17.5
Mean R.H. (%)	71	74	74	72	74	74	71	66	62	61	66	67	69
Mean W.S. (km/h)	8.6	8.2	7.9	8.8	10.5	11.9	13.1	13.3	12.4	12.2	11.0	9.8	10.6
3pm conditions													
Mean temp. (°C)	24.8	24.9	24.0	22.0	19.4	16.9	16.4	17.5	19.2	20.7	22.1	23.8	21.0
Mean R.H. (%)	62	64	62	59	57	57	51	49	51	56	58	59	57
Mean W.S. (km/h)	17.9	16.8	15.2	13.8	12.7	13.6	15.3	17.6	18.3	19.1	19.4	19.5	16.6

Source: **Bureau of Meteorology, 2020**

RH = Relative Humidity, WS = Wind speed

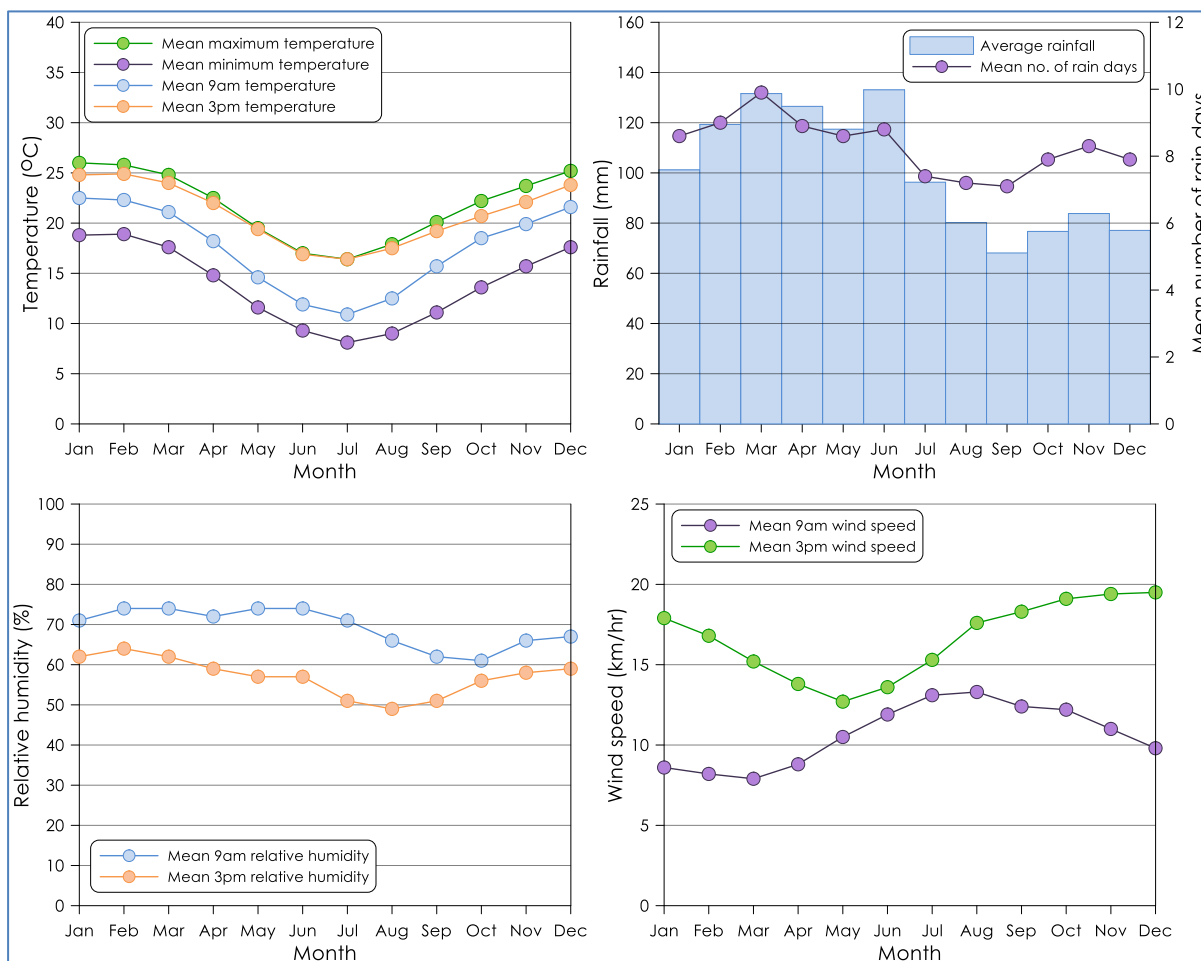


Figure 4-1: Monthly climate statistics summary – Sydney (Observatory Hill)

4.2 Local meteorological conditions

Annual and seasonal windroses generated from data from the Terry Hills Automatic Weather Station (AWS) during 2015 are presented in **Figure 4-2**. The Terry Hills AWS is located approximately 6.1km west-southwest of the Project.

The 2015 calendar year was selected as the meteorological year for the dispersion modelling based on an analysis of statistical data trends in meteorological data recorded for the area as outlined in **Appendix A**.

On an annual basis, winds are varied and predominantly occur from the west and the west-northwest. In summer, winds predominantly occur from the northeast. The autumn distribution is similar to the annual distribution with varied winds predominantly from the west and west-northwest but with fewer winds from the northeast. In winter winds typically range from the southwest to the north. In spring, the winds from the northeast are most dominant.



Figure 4-2: Annual and seasonal windroses for Terry Hills AWS (2015)

4.3 Local air quality monitoring

The main sources of air pollutants in the area surrounding the Project would include emissions from agricultural activities, anthropogenic activities such as various industrial and commercial activities, motor vehicle exhaust and also natural sources such as the local sand dunes.

Ambient air quality monitoring data from the Project site are not available. Therefore, the available data from air quality monitors operated by the NSW Department of Planning Industry & Environment (DPIE) were used to quantify the existing background level for assessed pollutants at the Project site.

These include the Lindfield, Macquarie Park, Rozelle, Parramatta North and Prospect monitors. The location of these monitors relative to the Project site are approximately 17.3km, 18.8km, 23.8km, 30.2km and 37.1km, respectively.

4.3.1 PM₁₀ monitoring

A summary of the available PM₁₀ monitoring data from the NSW DPIE monitoring stations is presented in **Table 4-2**. Recorded 24-hour average PM₁₀ concentrations are presented in **Figure 4-3**.

A review of **Table 4-2** indicates that the annual average PM₁₀ concentrations for all monitoring stations reviewed were below the relevant criterion of 25µg/m³ with the exception of the Parramatta North and the Prospect monitor which exceeded the relevant criterion during the 2019 calendar year. Note that where there is insufficient data (i.e. less than 75% data availability) an annual average is not calculated. The maximum 24-hour average PM₁₀ concentrations were found to exceed the relevant criterion of 50µg/m³ on occasion during the review period.

Table 4-2: Summary of PM₁₀ levels from NSW DPIE monitoring (µg/m³)

Year	Lindfield	Macquarie Park	Rozelle	Parramatta North	Prospect	Criterion
Annual average						
2015	14.0	-	16.7	-	17.6	25
2016	15.4	-	16.8	-	18.9	25
2017	16.0	-	18.1	-	18.9	25
2018	18.0	17.2	18.4	21.6	21.9	25
2019	-	19.9	22.7	25.5	26.0	25
Maximum 24-hour average						
2015	56.4	-	60.3	-	68.7	50
2016	68.9	-	58.8	-	110.1	50
2017	46.3	49.6	54.1	35.1	61.1	50
2018	89.7	85.6	88.3	107.4	113.3	50
2019	59.5	187.3	142.7	195.3	182.8	50

It can be seen from **Figure 4-3** that PM₁₀ concentrations nominally peak in spring and summer with the warmer weather raising the potential for drier ground, elevating the occurrence of windblown dust.

A brief examination of the elevated PM₁₀ levels indicates that they typically correspond with regional dust events and bushfires which affect a wide area, this is particularly evident in 2019 as a result of the NSW bushfires in November and December (**NSW DPIE, 2019a & NSW DPIE, 2019b**). At other times, potential dust sources such as local agricultural sources, industrial activity and other such dust sources may have contributed to periods of elevated PM₁₀ levels.

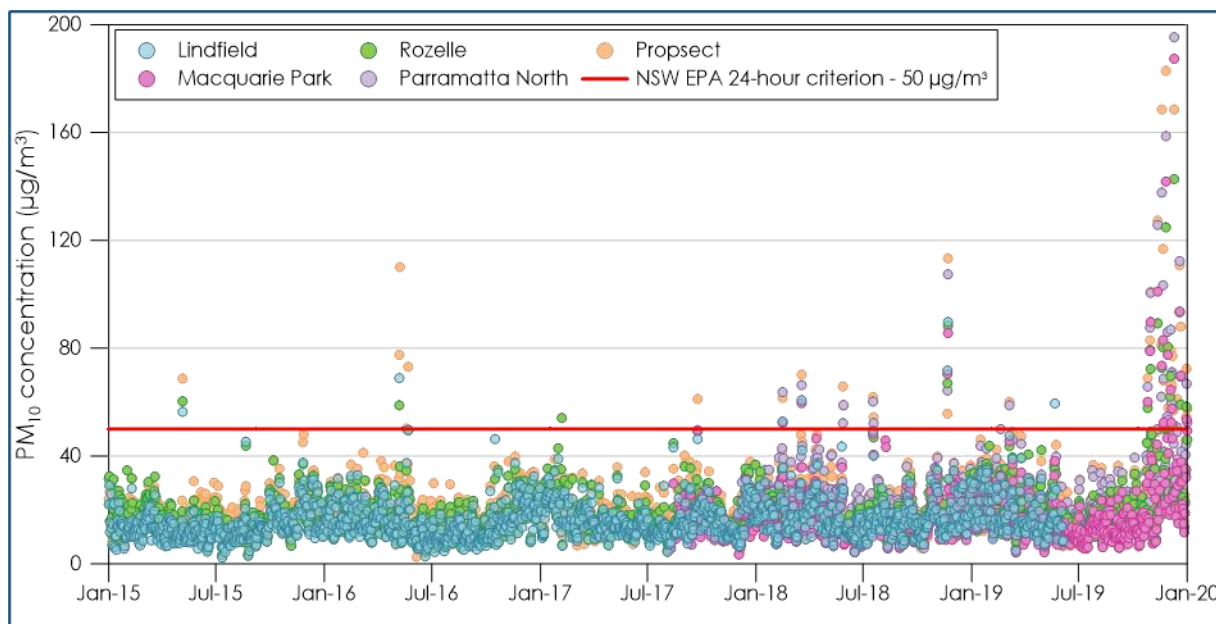


Figure 4-3: 24-hour average PM₁₀ concentrations

4.3.2 PM_{2.5} monitoring

A summary of the available data from the NSW DPIE monitoring stations is presented in **Table 4-3**. Recorded 24-hour average PM_{2.5} concentrations are presented in **Figure 4-4**. It is noted that the Lindfield monitor does not record measured PM_{2.5} data.

Table 4-3 indicates that the annual average PM_{2.5} concentrations for the monitoring stations were below the annual average criterion of 8µg/m³ with the exception of the Prospect monitor in 2015 and 2016, the Prospect and Parramatta North monitors in 2018 and in 2019 all monitors were above the annual average criterion. Note that where there is insufficient data (i.e. less than 75% data availability) an annual average is not calculated. The maximum 24-hour average PM_{2.5} concentrations were found to exceed the relevant criterion of 25µg/m³ on occasion during the review period.

Table 4-3: Summary of PM_{2.5} levels from NSW DPIE monitoring (µg/m³)

Year	Lindfield	Macquarie Park	Rozelle	Parramatta North	Prospect	Criterion
Annual average						
2015	-	-	7.2	-	8.2	8
2016	-	-	7.4	-	8.7	8
2017	-	-	7.2	-	7.7	8
2018	-	7.0	-	9.2	8.5	8
2019	-	9.2	10.3	10.5	11.9	8
Maximum 24-hour average						
2015	-	-	36.0	-	29.6	25
2016	-	-	49.4	-	84.9	25
2017	-	24.1	36.3	13.9	30.1	25
2018	-	58.4	19.2	42.1	47.5	25
2019	-	152.0	101.8	130.1	134.1	25

It can be seen from **Figure 4-4** that 24-hour average PM_{2.5} concentrations follow a seasonal trend with peaks occurring in winter periods and are likely associated with wood heater emissions. This is opposite

to the seasonal trend for PM₁₀ concentrations which have elevated levels during the warmer months. As mentioned, the very high PM_{2.5} levels seen in late 2019 are a result of the widespread NSW bushfires.

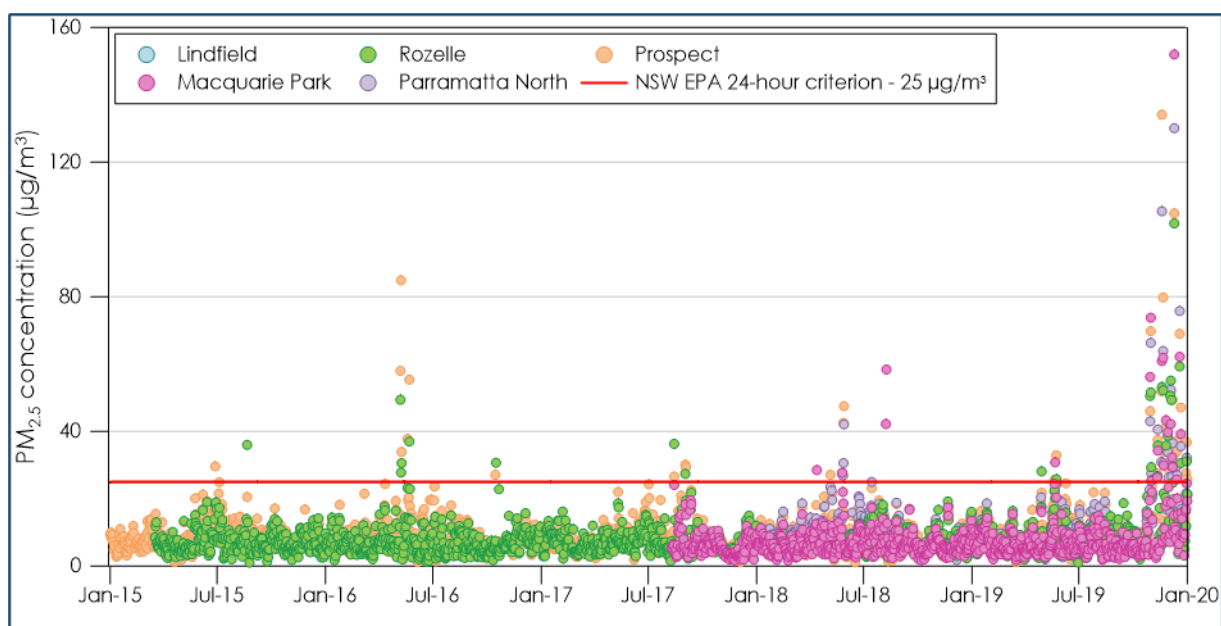


Figure 4-4: 24-hour average PM_{2.5} concentrations

4.3.3 NO₂ monitoring

A summary of the available NO₂ data from the NSW DPIE monitoring stations is presented in **Table 4-4**. The daily 1-hour maximum NO₂ concentrations are presented in **Figure 4-5**.

Table 4-4 indicates that the annual and maximum 1-hour average NO₂ concentrations for all monitors during the review period were below the respective criterion.

It can be seen from **Figure 4-5** that concentrations are generally higher in cooler months when temperatures are low and there is less sunlight, making it more difficult for NO₂ to convert to ozone (DECCW, 2010).

Table 4-4: Summary of NO₂ levels from available NSW DPIE monitoring (µg/m³)

Year	Lindfield	Macquarie Park	Rozelle	Parramatta North	Prospect	Criterion
Annual average						
2015	15.4	-	21.9	-	21.6	62
2016	14.4	-	21.9	-	20.1	62
2017	15.8	-	23.5	-	20.1	62
2018	15.5	11.4	20.2	22.0	18.7	62
2019	-	11.0	19.5	21.2	17.7	62
Maximum 1-hour average						
2015	82.0	-	123.0	-	108.7	246
2016	67.7	-	102.5	-	108.7	246
2017	84.1	75.9	125.1	82.0	123.0	246
2018	80.0	61.5	116.9	131.2	104.6	246
2019	65.6	53.3	184.5	143.5	100.5	246

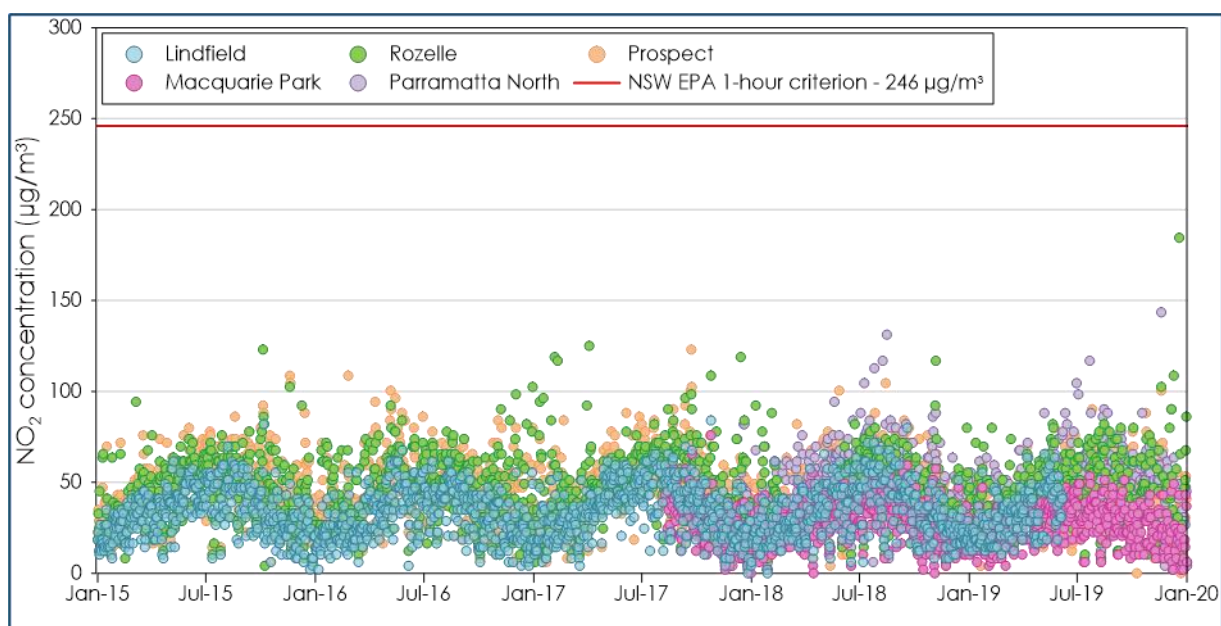


Figure 4-5: Daily 1-hour maximum NO₂ concentrations

4.3.4 CO monitoring

A summary of the available CO data from the NSW DPIE monitoring stations is presented in

Table 4-4. The daily 1-hour maximum CO concentrations are presented in **Figure 4-6**. It is noted that Lindfield monitor does not record measured CO data.

Table 4-4 indicates that the maximum 1-hour and 8-hour average CO concentrations for all monitors during the review period are well below the respective criterion.

Figure 4-6 shows a similar seasonal trend to the NO₂ data with levels increasing during the cooler months.

Table 4-5: Summary of CO levels from available NSW DPIE monitoring (µg/m³)

Year	Lindfield	Macquarie Park	Rozelle	Parramatta North	Prospect	Criterion
Maximum 1-hour average						
2015	-	-	1,920	-	2,280	30,000
2016	-	-	2,040	-	1,920	30,000
2017	-	-	1,440	-	1,920	30,000
2018	-	5,280	-	1,560	1,560	30,000
2019	-	7,080	6,240	6,840	6,600	30,000
Maximum 8-hour average						
2015	-	-	1,320	-	1,800	10,000
2016	-	-	1,440	-	1,800	10,000
2017	-	-	1,080	-	1,320	10,000
2018	-	3,000	-	1,320	1,320	10,000
2019	-	4,200	2,640	3,840	3,360	10,000

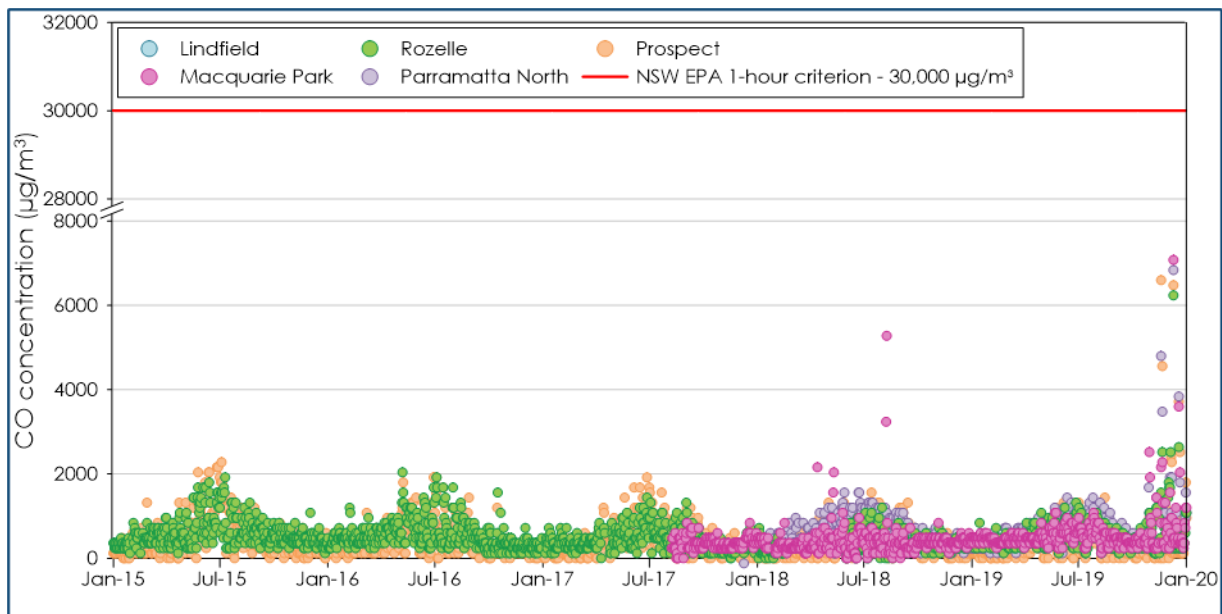


Figure 4-6: Daily 1-hour maximum CO concentrations

4.3.5 Estimated background levels

As outlined above, there are no readily available site-specific monitoring data, and therefore the background air quality levels from the nearest NSW DPIE monitoring station (Lindfield monitor) for the 2015 calendar year were used to represent the background levels for the Project.

The 2015 calendar period corresponds to the period of meteorological modelling based on an analysis of long-term data trends in meteorological data recorded for the area as outlined in **Appendix A**.

4.3.5.1 PM_{10}

Annual average PM_{10} values from the Lindfield DPIE monitor for the 2015 calendar year were used to represent the background levels for the Project (see **Table 4-2**).

4.3.5.2 $PM_{2.5}$

As noted, the Lindfield monitor does not record measured $PM_{2.5}$ data. To account for this, the average ratio of $PM_{2.5}$ and PM_{10} concentrations from the other reviewed monitoring stations during 2015 was applied to the measured PM_{10} concentrations at the Lindfield monitor. This estimates an approximate annual average $PM_{2.5}$ concentration of $6.3\mu\text{g}/\text{m}^3$. These estimated concentrations are comparable with levels measured at the Rozelle and Prospect monitors.

4.3.5.3 TSP

In the absence of available data, estimates of the annual average background TSP and deposited dust concentrations can be determined from a relationship between PM_{10} and TSP concentrations and the measured PM_{10} levels.

This relationship assumes that an annual average PM_{10} concentration of $25\mu\text{g}/\text{m}^3$ corresponds to a TSP concentration of $90\mu\text{g}/\text{m}^3$. This assumption is based on the NSW EPA air quality impact criteria.

Applying this relationship with the measured annual average PM₁₀ concentration of 14.0µg/m³ indicates an approximate annual average TSP concentration and deposition value of 50.4µg/m³.

4.3.5.4 NO₂

Maximum 1-hour average and annual average NO₂ values from the Lindfield DPIE monitor for the 2015 calendar year were used to represent the background levels for the Project (see **Table 4-4**).

4.3.5.5 CO

As noted, the Lindfield monitor does not record measured CO data. To account for this, the 1-hour and 8-hour average concentrations have been estimated as an average from the other reviewed monitoring stations during 2015. This estimates an approximate maximum 1-hour and 8-hour average CO concentration of 2,100µg/m³ and 1,560µg/m³, respectively.

4.3.5.6 Summary of background levels

The background air quality levels applied in this assessment are as follows:

- ✦ 24-hour average PM_{2.5} concentrations - variable;
- ✦ Annual average PM_{2.5} concentrations – 6.3µg/m³;
- ✦ 24-hour average PM₁₀ concentrations – variable;
- ✦ Annual average PM₁₀ concentrations – 14.0µg/m³;
- ✦ Annual average TSP concentrations – 50.4µg/m³;
- ✦ 1-hour average NO₂ concentrations – 82µg/m³;
- ✦ Annual average NO₂ concentrations – 15.4µg/m³;
- ✦ 1-hour average CO concentrations – 2,100µg/m³; and,
- ✦ 8-hour average CO concentrations – 1,560µg/m³.

5 DISPERSION MODELLING APPROACH

5.1 Introduction

The following sections are included to provide the reader with an understanding of the model and modelling approach.

For this assessment the CALPUFF modelling suite is applied to dispersion modelling. The CALPUFF model is an advanced “puff” model that can deal with the effects of complex local terrain on the dispersion meteorology over the entire modelling domain in a three dimensional, hourly varying time step. CALPUFF is an air dispersion model approved by NSW EPA for use in air quality impact assessments. The model setup used is in general accordance with methods provided in the NSW EPA document *Generic Guidance and Optimum Model Setting for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia'* (TRC Environmental Corporation (TRC), 2011).

5.2 Modelling methodology

Modelling was undertaken using a combination of The Air Pollution Model (TAPM) and the CALPUFF Modelling System. The CALPUFF Modelling System includes three main components: CALMET, CALPUFF and CALPOST and a large set of pre-processing programs designed to interface the model to standard, routinely available meteorological and geophysical datasets.

TAPM is a prognostic air model used to simulate the upper air data for CALMET input. The meteorological component of TAPM is an incompressible, non-hydrostatic, primitive equation model with a terrain-following vertical coordinate for 3D simulations. The model predicts the flows important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analysis.

CALMET is a meteorological model which uses the geophysical information and observed/simulated surface and upper air data as inputs and develops wind and temperature fields on a 3D gridded modelling domain.

CALPUFF is a transport and dispersion model that advects “puffs” of material emitted from modelled sources, simulating dispersion processes along the way. It typically uses the 3D meteorological field generated by CALMET.

CALPOST is a post processor used to process the output of the CALPUFF model and produce tabulations that summarise the results of the simulation.

5.2.1 Meteorological modelling

TAPM was applied to the available data to generate a 3D upper air data file for use in CALMET. The centre of analysis for TAPM was 33deg40.5min south and 151deg17.5min east. The simulation involved an outer grid of 30km, with three nested grids of 10km, 3km and 1km with 35 vertical grid levels.

The CALMET domain was run on a 10 x 10km area with 0.1km grid resolution. The available meteorological data for the 2015 calendar year from the Terry Hills AWS meteorological station was included in this run. The 2015 calendar year was selected as the meteorological year for the dispersion



modelling based on analysis of statistical data trends in meteorological data recorded for the area as outlined in **Appendix A**.

Local land use and detailed topographical information was included in the simulation to produce realistic fine scale flow fields (such as terrain forced flows) in surrounding areas (**Figure 5-1**).

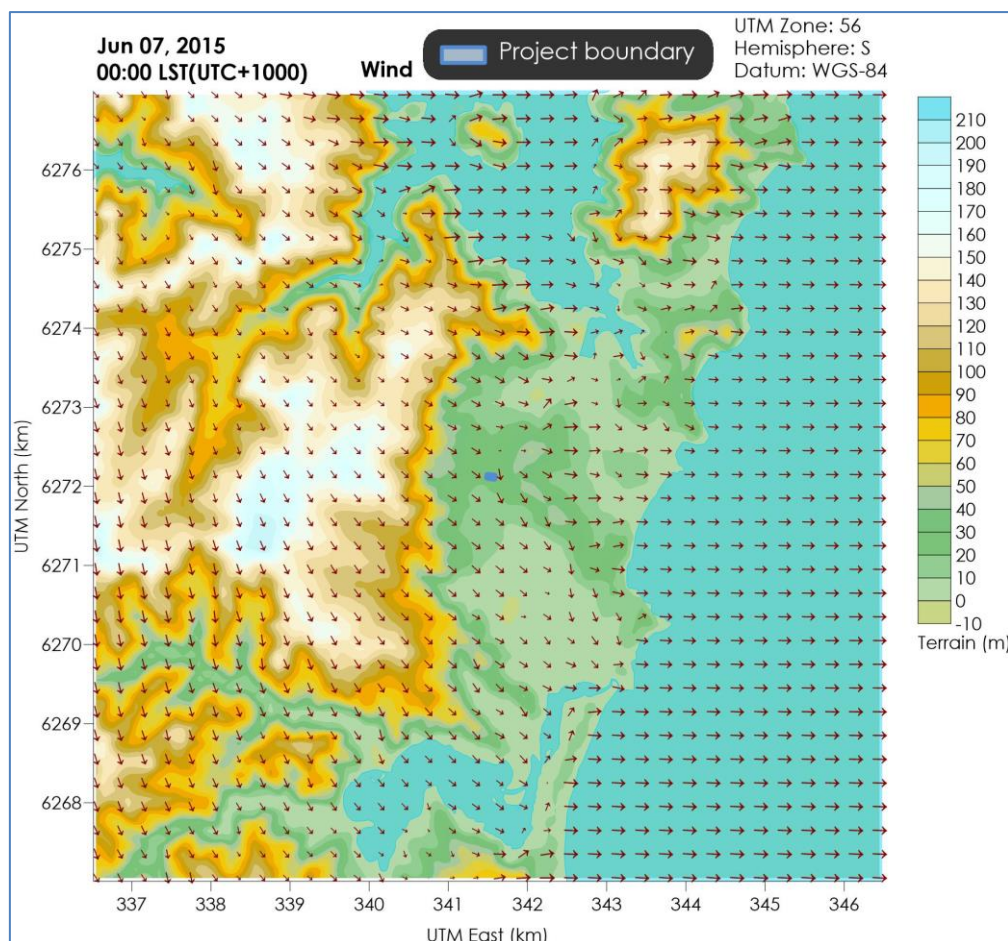


Figure 5-1: Representative snapshot of wind field for the Project

CALMET generated meteorological data were extracted from a point within the CALMET domain and are graphically represented in **Figure 5-2** and **Figure 5-3**.

Figure 5-2 presents the annual and seasonal windroses from the CALMET data. On an annual basis, winds are varied and predominately occur from the north-northwest. In summer, winds predominantly occur from the northeast. The autumn distribution is similar to the annual distribution with varied winds predominantly from the west, west-southwest and north-northwest but with fewer winds from the northeast. In winter winds typically range from the southwest to the north-northwest. In spring, the winds from the northeast are most dominant.

Overall, the windroses generated in the CALMET modelling reflect the expected wind distribution patterns of the area as determined based on the available measured data and the expected terrain effects on the prevailing winds. **Figure 5-3** includes graphs of the temperature, wind speed, mixing

height and stability classification over the modelling period and show sensible trends considered to be representative of the area.

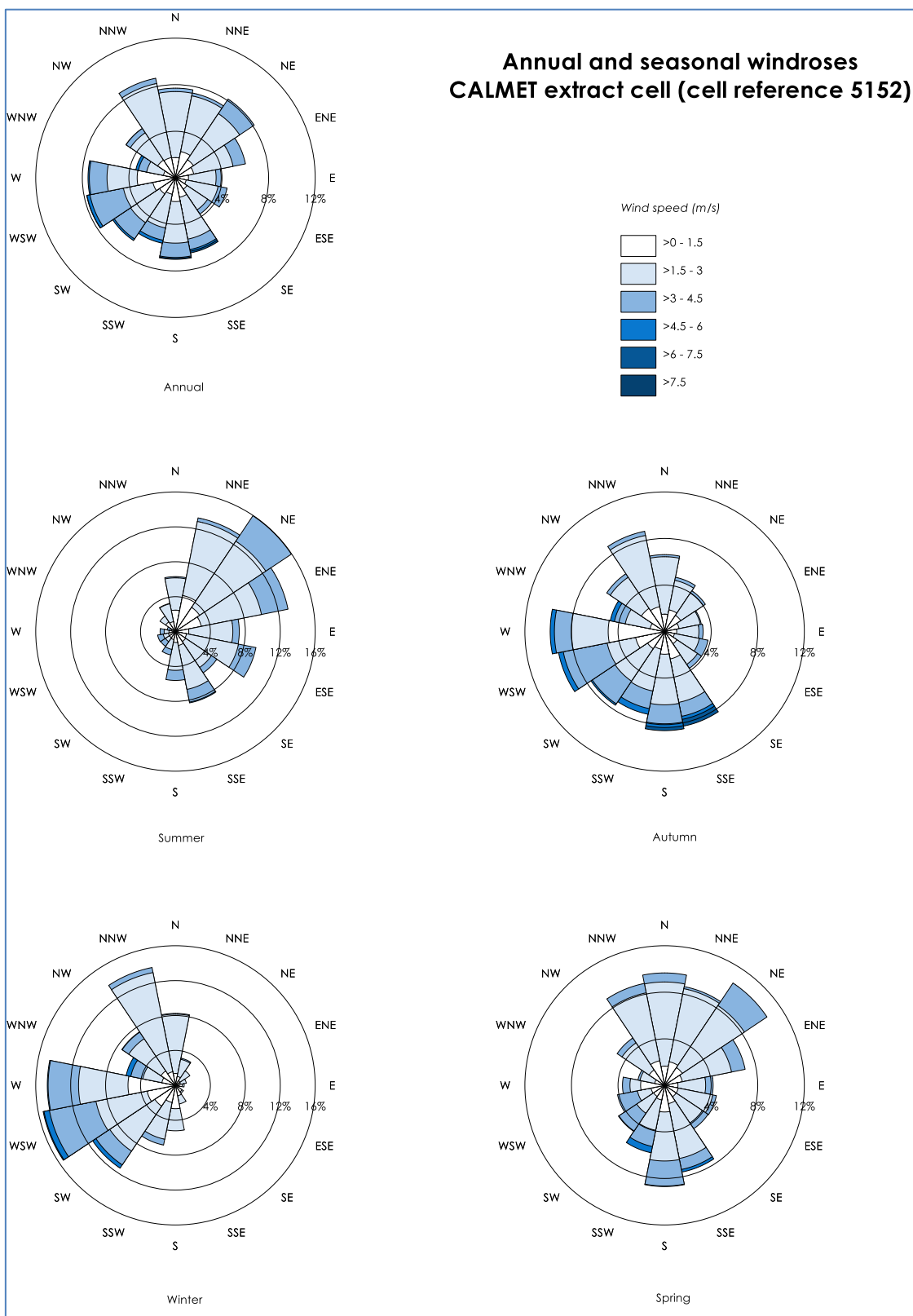


Figure 5-2: Annual and seasonal windroses from CALMET (cell ref 5152)

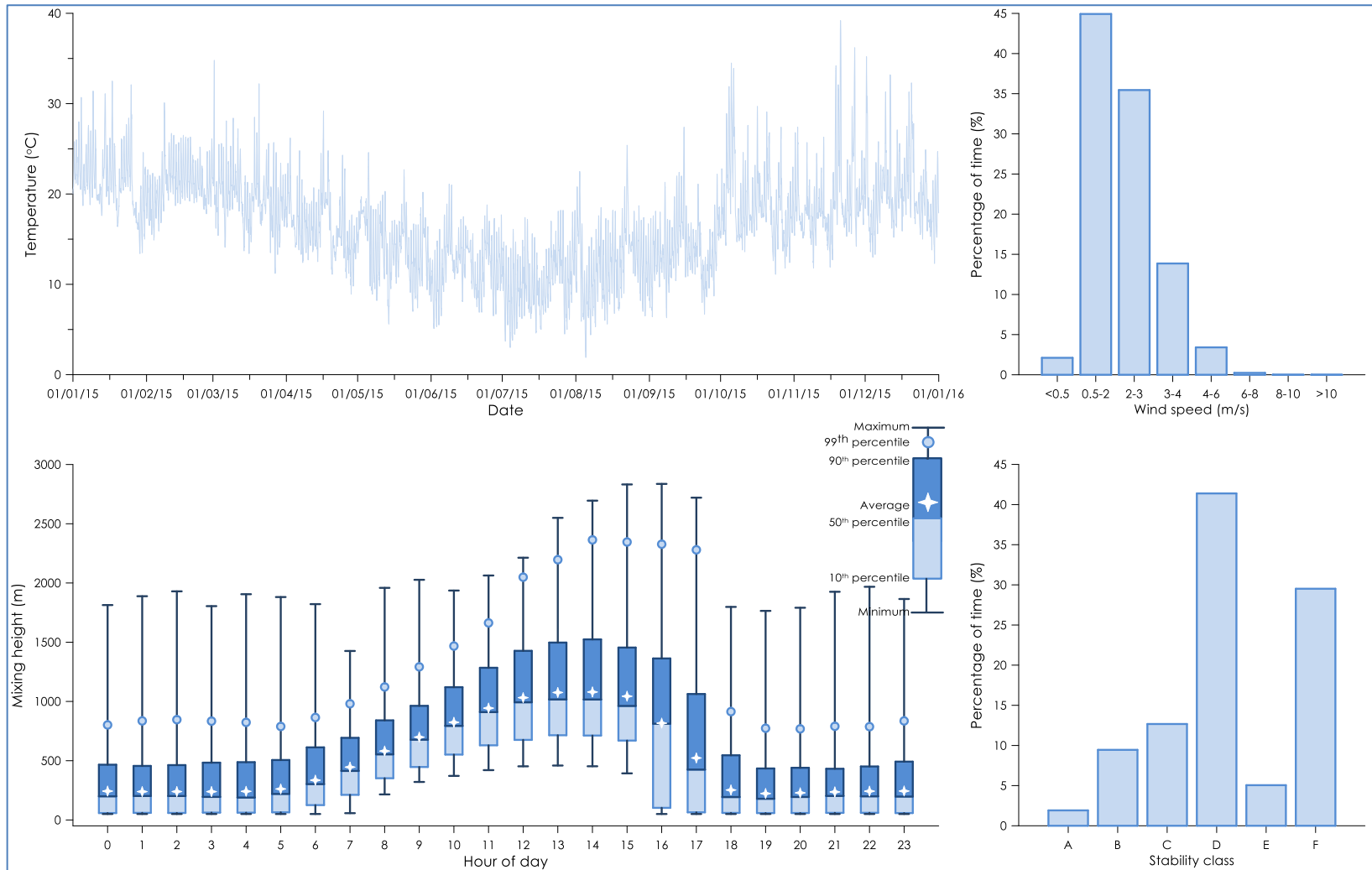


Figure 5-3: Meteorological analysis CALMET (cell ref 5152)

5.2.2 Dispersion modelling

Air dispersion modelling of the likely air emission sources identified for the Project was conducted using CALPUFF to predict potential air quality impacts in the surrounding environment.

Modelling of the key air emission sources was conducted using the emissions rates and parameters outlined in the following section and utilising the meteorological data described in the previous section.

5.3 Emission estimation

An assessment of the potential air quality impacts associated with idling and travelling buses on-site have been considered in this assessment. Estimates of potential emissions from the buses on-site have been calculated using the methodology presented in the NSW EPA document *Air Emissions Inventory for the Greater Metropolitan Region in New South Wales 2008 Calendar Year Commercial Emissions, On-Road Mobile Emissions* (NSW EPA, 2012).

Vehicles on-site are classified as heavy duty diesel buses (GVM >5 tonnes). Emissions have been estimated for the following activities:

- ✦ Hot running exhaust emissions from heavy duty diesel vehicles;
- ✦ Cold start extra exhaust emissions; and
- ✦ Non-exhaust particulate matter emissions.

Cold start extra exhaust emissions form when the vehicle is operated and when the engine has not reached optimum temperature. These emissions from vehicles are considerably higher than hot running exhaust emissions. It is noted that cold start extra exhaust emissions typically only apply for petrol or light duty diesel vehicles. However, as a conservative measure, cold start extra exhaust emissions from heavy duty diesel vehicles modelled in this assessment have been calculated for NO_x emissions by applying a cold start adjustment factor to the hot exhaust emission factors. The total exhaust emissions are the sum of the hot running and cold start extra emissions.

Emission factors for exhaust composite emissions and splitting factors characterised for residential/local roads, and non-exhaust particulate matter emissions were sourced from *Air Emissions Inventory for the Greater Metropolitan Region in New South Wales 2008 Calendar Year Commercial Emissions, On-Road Mobile Emissions* (NSW EPA, 2012).

Non-exhaust particulate matter emissions are generated by tyre, brake and road wear. Speed corrections for non-exhaust particulate matter emissions have been applied assuming an average speed of less than 40 kilometres per hour on-site.

Emissions for the Project have been based on Stage 1 operations at the site assuming that all vehicles on-site are powered by diesel fuel only. It is noted in **Section 2.2** that the capacity during Stage 2 of operations at the Project is less than the capacity proposed during Stage 1 and as such, emissions for the operation of Stage 2 are expected to be less than those during Stage 1.



A summary of the estimated hourly incoming and outgoing vehicles at the Project is provided in **Figure 5-4** below. The emissions rates for exhaust and non-exhaust particulate matter per hour varied according to the number of vehicles on-site at any one time.

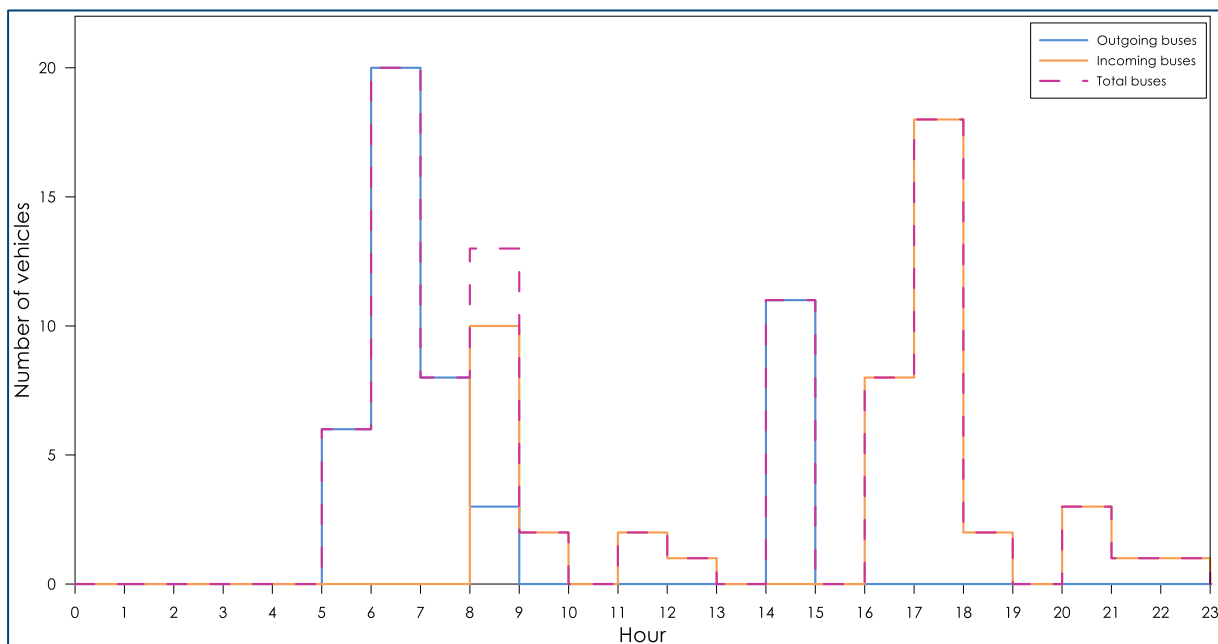


Figure 5-4: Projected departures and arrivals for the Project

Table 5-1 and **Table 5-2** below present a summary of the emission factors and emission rates used in the assessment.

Table 5-1: Summary of exhaust emissions for buses

Pollutant	Composite base hot emission factor (g/km)	Composite splitting factor	Hot emission rate (g/s)	Cold start emission rate (g/s)
TSP	0.30	1.22	6.91E-06	-
PM ₁₀	0.29	1.20	6.84E-06	-
PM _{2.5}	0.28	1.17	6.64E-06	-
NO ₂	15.00	1.33	3.87E-04	7.74E-06
CO	3.05	2.26	6.25E-05	-
Benzene	0.007	0.017	2.19E-07	-
Toluene	0.003	0.007	9.62E-08	-
Xylenes	0.003	0.006	7.87E-08	-

Table 5-2: Summary of non-exhaust particulate matter emissions - combined tyre, break and road wear

Pollutant	Combined non-exhaust PM speed corrected emission factor (g/km)	Emission rate (g/s)
TSP	0.23	4.44E-06
PM ₁₀	0.15	2.82E-06
PM _{2.5}	0.08	1.46E-06

6 DISPERSION MODELLING RESULTS

This section presents the predicted impacts on air quality which may arise from air emissions generated by the Project.

The spatial distribution of the dispersion modelling predictions is presented as isopleth diagrams in **Appendix B** showing ground level concentrations. The isopleth diagrams indicate the maximum incremental predicted levels to occur at the Project site and include predicted impacts from exhaust and non-exhaust particulate matter emissions combined.

Table 6-1 below presents the maximum predicted off-site (at any location) ground level concentrations for each pollutant.

The modelling results in **Table 6-1** indicate the predicted levels are significantly below the relevant air quality criteria for the assessed pollutants.

It is noted that the maximum 24-hour background level for PM_{2.5} and PM₁₀ is already above the relevant criteria (refer to **Section 4.3**). As such, total (cumulative) 24-hour average impacts for PM_{2.5} and PM₁₀ have been addressed in **Section 6.1** below in accordance with Section 11.2 of the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (NSW EPA, 2017)*.

The Project alone increment is small and is not predicted to result in any discernible impact relative to existing levels. As such, the Project is expected to have minimal influence at the nearby assessed receptor location and would be difficult to discern beyond the existing background levels.

Table 6-1: Summary modelling predictions – ground level concentrations

Pollutant	Averaging Period	Maximum incremental offsite impact			BG	Cumulative impact	Criterion (µg/m ³)
		Exhaust emissions	Non-exhaust emissions	Total emissions			
TSP	Annual	0.04	0.003	0.05	50.4	50.4	90
PM ₁₀	Annual	0.04	0.002	0.04	14.0	14.0	25
	24 hour	0.15	0.006	0.16	56.4	56.6	50
PM _{2.5}	Annual	0.04	0.001	0.04	6.3	6.34	8
	24 hour	0.15	0.003	0.15	29.0	29.2	25
NO ₂	1 hour	65.17	-	65.17	82.0	147	246
	Annual	2.48	-	2.48	15.4	17.9	62
CO	1 hour	12.60	-	12.60	2,100	2,113	30,000
	Annual	2.32	-	2.32	1,560	1,562	10,000
Benzene	1 hour	0.04	-	0.04	-	-	29
Formaldehyde	1 hour	0.41	-	0.41	-	-	20
PAH	1 hour	0.07	-	0.07	-	-	0.4
Toluene	1 hour	0.02	-	0.02	-	-	360
Xylenes	1 hour	0.02	-	0.02	-	-	190

6.1 Assessment of Total (Cumulative) 24-hour average PM_{2.5} and PM₁₀ Concentrations

As shown in **Section 4.3**, the maximum measured 24-hour concentrations of PM_{2.5} and PM₁₀ have in the past exceeded or come close to the relevant criterion level on occasion.

As a result, the NSW EPA Level 1 contemporaneous assessment approach of adding maximum background levels to maximum predicted levels from the Project (**Table 6-1**) showed levels above the criterion whether or not the Project was operating.

In such situations, the NSW EPA applies a Level 2 contemporaneous assessment approach where the measured background levels are added to the day's corresponding predicted dust level from the Project.

Ambient (background) PM₁₀ concentration data corresponding with the year of modelling (2015) from the NSW DPIE monitoring site at Lindfield have been applied in this case to represent the prevailing background levels in the vicinity of the Project and at representative residential receptor locations surrounding the Project.

As noted in **Section 4.3.5.2**, the Lindfield monitor does not record measured PM_{2.5} data. To account for this, the average ratio of PM_{2.5} and PM₁₀ concentrations from the other reviewed monitoring stations during 2015 was applied to the measured 24-hour average PM₁₀ concentrations at the Lindfield monitor to estimate approximate 24-hour average PM_{2.5} concentration at the Lindfield monitoring site.

Table 6-2 provides a summary of the findings from the Level 2 assessment at the receptor location for both PM_{2.5} and PM₁₀. The results in **Table 6-2** indicate that the Project does not increase the number of days above the 24-hour average criterion at the assessed receptor for PM_{2.5} and PM₁₀. Based on this result it can be inferred that the Project does not increase the number of days above the 24-hour average PM_{2.5} and PM₁₀ criterion at any other potential receptor locations surrounding the Project.

Detailed tables of the contemporaneous assessment results are provided in **Appendix C**.

Table 6-2: NSW EPA contemporaneous assessment - maximum number of additional days above 24-hour average criterion

Receptor ID	PM _{2.5}	PM ₁₀
R1	0	0

7 SUMMARY AND CONCLUSIONS

This report has assessed the potential for air quality impacts associated with the operation of the proposed Bus Depot at 15 Jubilee Avenue Warriewood.

Air dispersion modelling using the CALPUFF model was applied in this assessment using air emission factors provided in the *Air Emissions Inventory for the Greater Metropolitan Region in New South Wales 2008 Calendar Year Commercial Emissions, On-Road Mobile Emissions (NSW EPA, 2012)* to predict the likely air quality impacts associated with exhaust and non-exhaust particulate matter emissions which may occur due to idling buses at the Project site.

The dispersion modelling results indicate that the potential emissions from the Project would not lead to unacceptable impacts in the area surrounding the Project site.

The modelling results demonstrate the predicted incremental levels would be significantly lower than the applicable NSW air quality criteria for the relevant pollutants and that it is unlikely to result in any discernible cumulative impact relative to existing levels.

Overall, the assessment demonstrates that the Project can operate without exceeding the applicable air quality criteria for both health and odour impacts, and hence it is concluded that there would not be any air quality impacts upon the surrounding environment due to the operation of the Project.

8 REFERENCES

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Climate statistics for Australian locations, Bureau of Meteorology website. Accessed August 2020. <<http://www.bom.gov.au/climate/averages>>

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"Current air quality in New South Wales", a technical paper supporting the Clean Air Forum 2010, Department of Environment, Climate Change and Water NSW, August 2010.

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"Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales", January 2017

NSW DPIE (2019a)

"Dustwatch Report November 2019", prepared by NSW Department of Planning Industry & Environment (DPIE), November 2018.

NSW DPIE (2019b)

"Dustwatch Report December 2019", prepared by NSW Department of Planning Industry & Environment (DPIE), November 2018.

TRC (2011)

"Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia", Prepared for the NSW Office of Environment and Heritage by TRC Environmental Corporation.



Appendix A

Selection of Meteorological Year



Selection of meteorological year

A statistical analysis of the of last five years of available meteorological data from the nearest BoM weather station with suitable available data, Terry Hills AWS, is presented in **Table A-1**.

The analysis of the five years indicates that 2016 is closest to the average for wind speed, 2015 is closest to the average for wind direction, 2018 is closest to the average for temperature, and 2016 is closest to the average for relative humidity followed by 2012.

A score weighting analysis was performed to consider the deviation from the average for each of the five years of meteorological data in **Table A-1**. The score value is based on the weighting of the different parameters as considered most relevant for the purposes of air dispersion modelling and assessment. The best score is achieved for 2015 and determined to be most representative for the purposes of air dispersion modelling.

Table A-1: Long term analysis results for Terry Hills AWS

Year	Wind speed	Wind direction	Temperature	Relative humidity	Score
2015	0.44	0.13	0.20	0.57	2.20
2016	0.38	0.30	0.16	0.21	2.35
2017	0.54	0.22	0.16	0.35	2.46
2018	0.52	0.18	0.11	0.61	2.50
2019	0.49	0.14	0.15	0.50	2.20

Figure A-1 shows the frequency distributions for wind speed, wind direction, temperature and relative humidity for the 2015 year compared with the mean and range of the combined 2015 to 2019 data set. The 2015 year data appear to be well aligned with the mean data.

Therefore, based on this analysis it was determined that 2015 is generally representative of the long-term trends compared to other years and is thus suitable for the purpose of modelling.

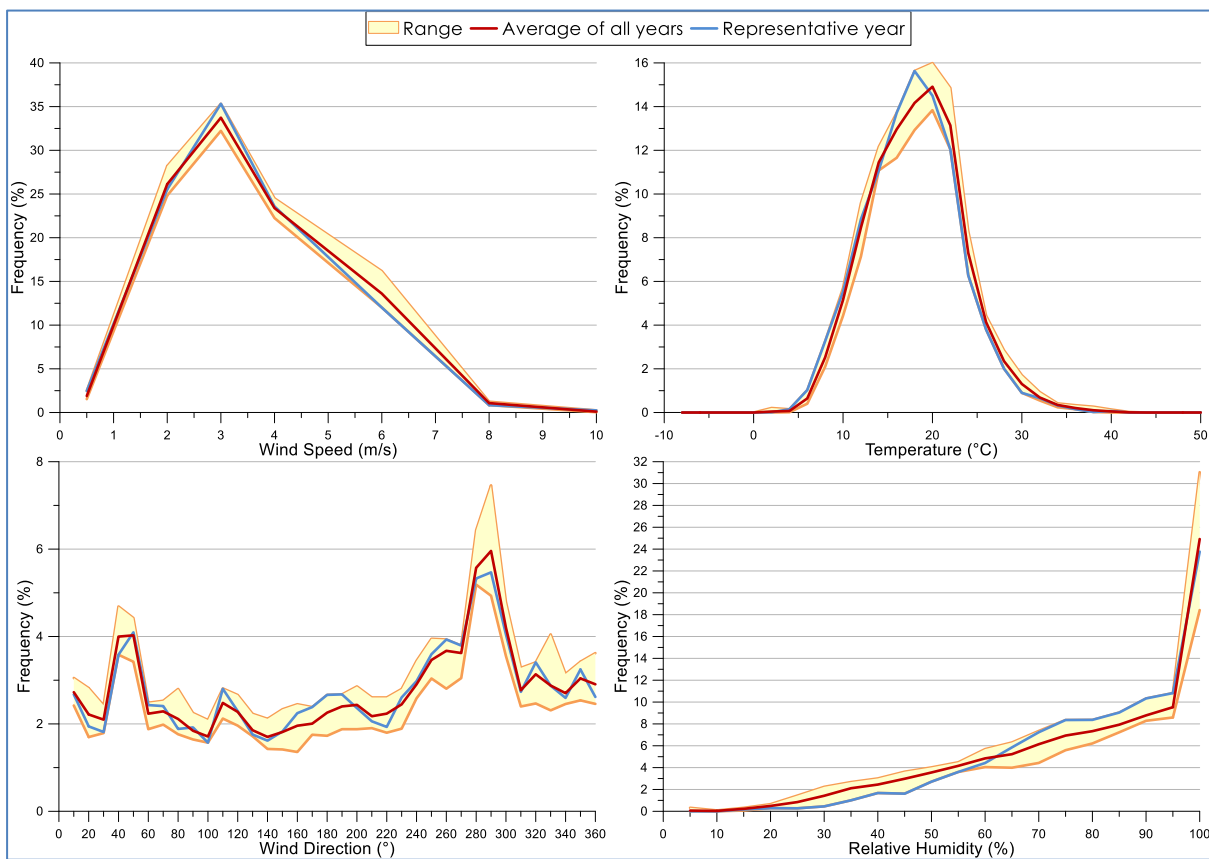


Figure A-1: Frequency distributions for wind speed, wind direction, temperature and relative humidity

Appendix B
Isopleth diagrams

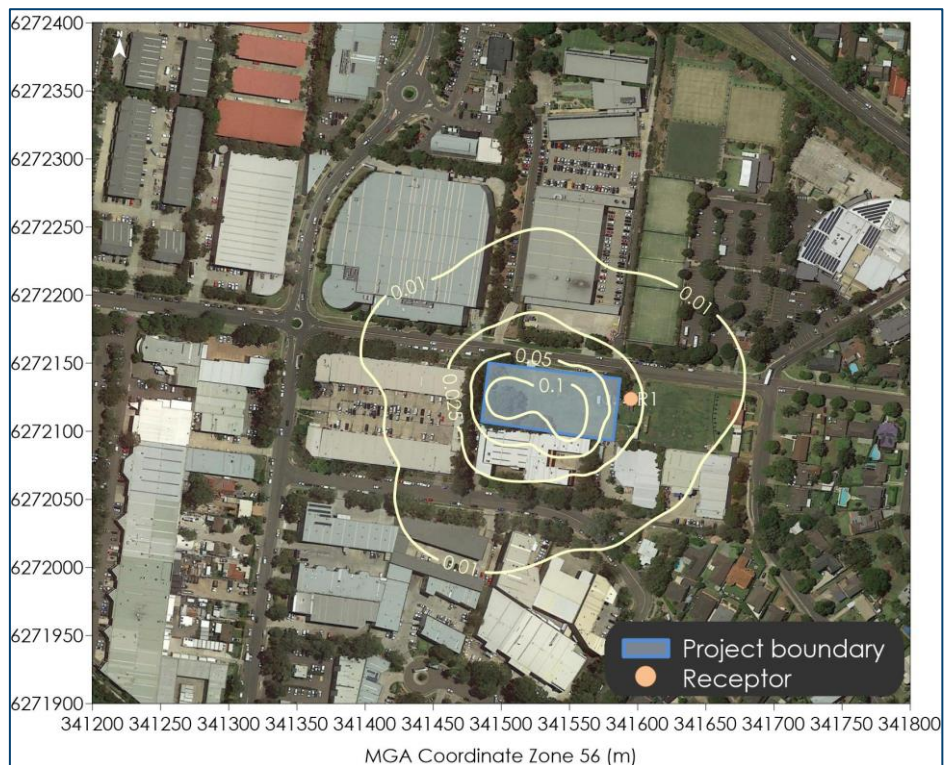


Figure B-1: Predicted incremental 24-hour average PM₁₀ concentrations (µg/m³)

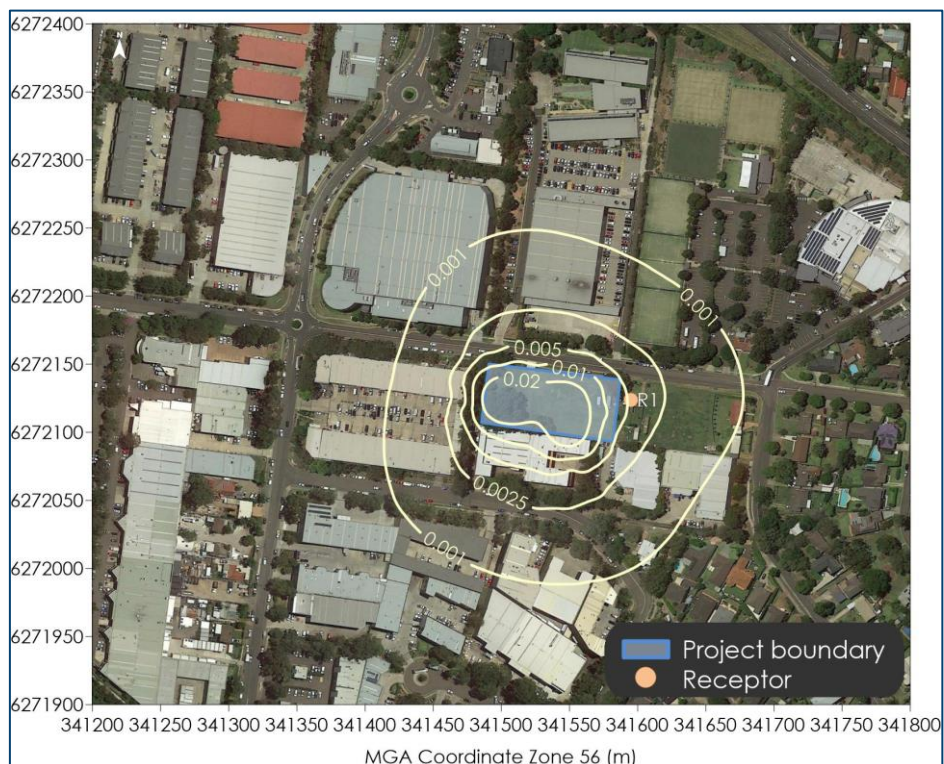


Figure B-2: Predicted incremental annual average PM₁₀ concentrations (µg/m³)



Figure B-3: Predicted incremental 24-hour average PM_{2.5} concentrations (µg/m³)

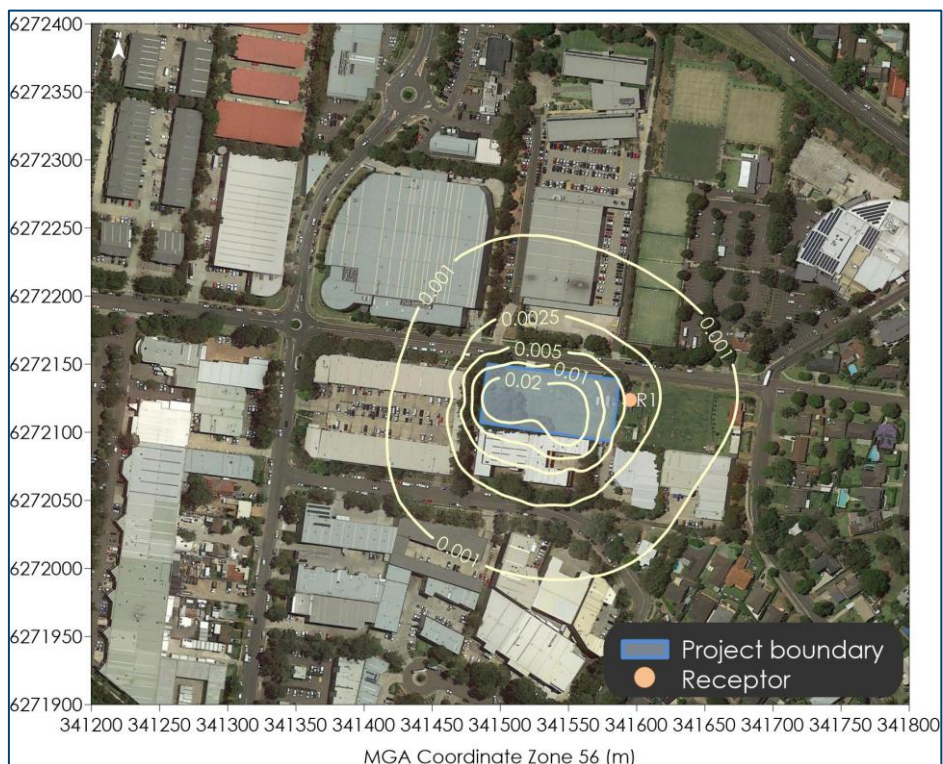


Figure B-4: Predicted incremental annual average PM_{2.5} concentrations (µg/m³)

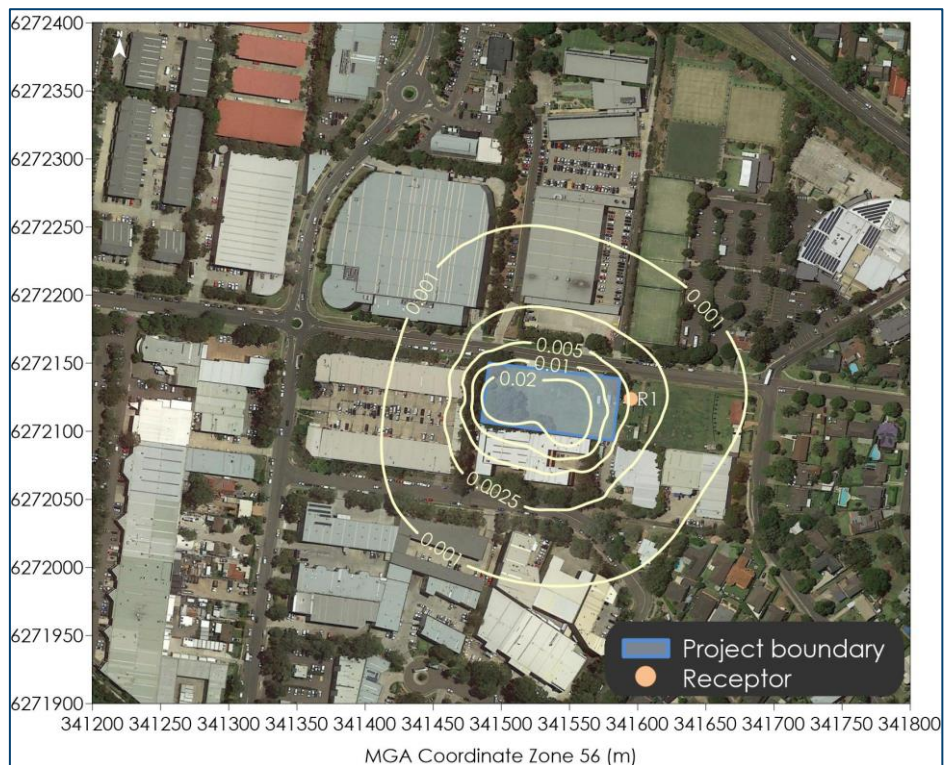


Figure B-5: Predicted incremental annual average TSP concentrations ($\mu\text{g}/\text{m}^3$)

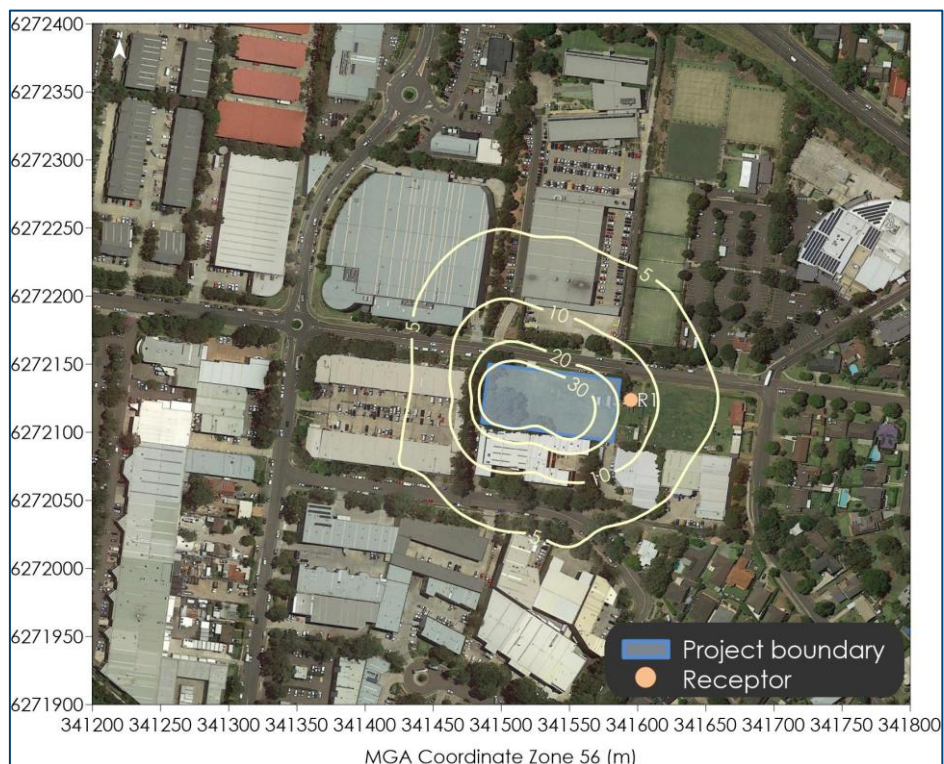


Figure B-6: Predicted incremental 1-hour average NO_2 concentrations ($\mu\text{g}/\text{m}^3$)

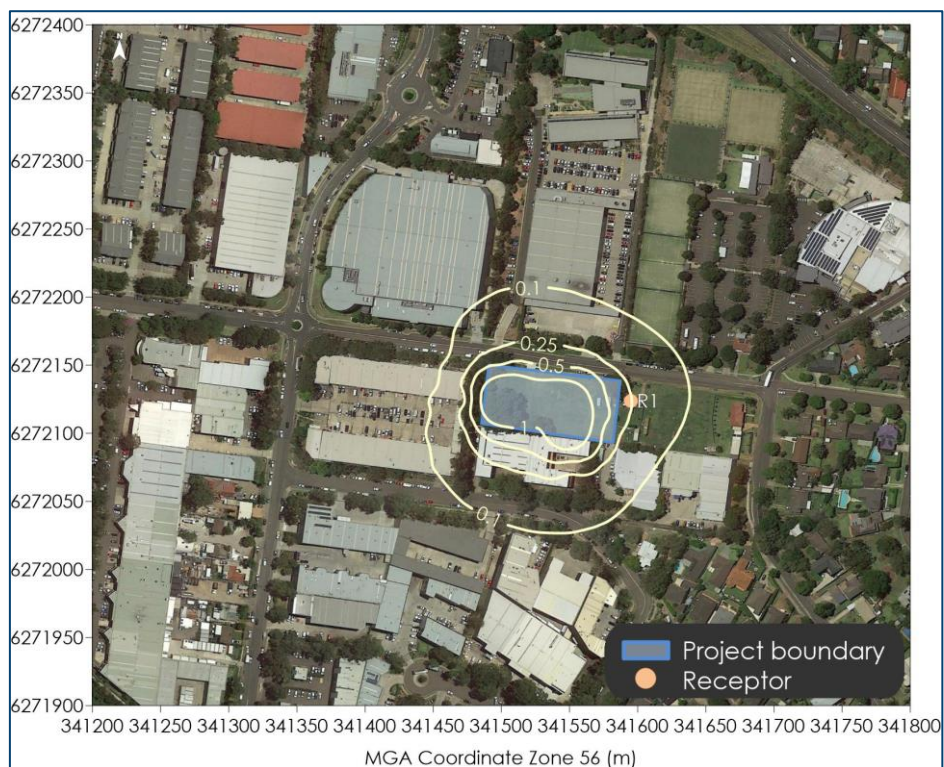


Figure B-7: Predicted incremental annual average NO₂ concentrations (µg/m³)

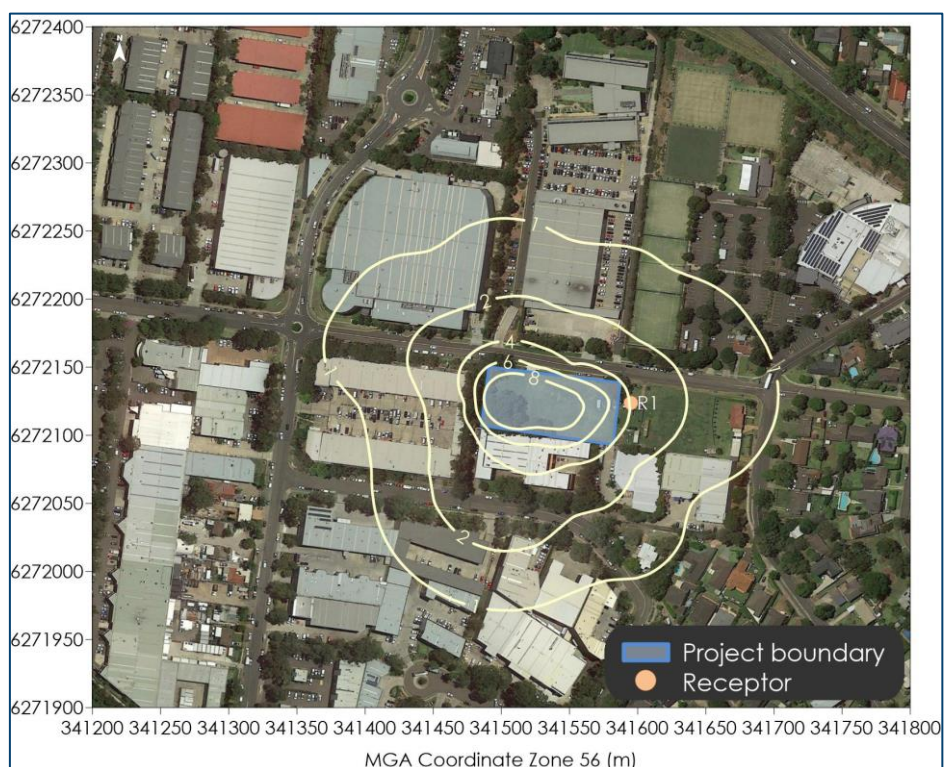


Figure B-8: Predicted incremental 1-hour average CO concentrations (µg/m³)

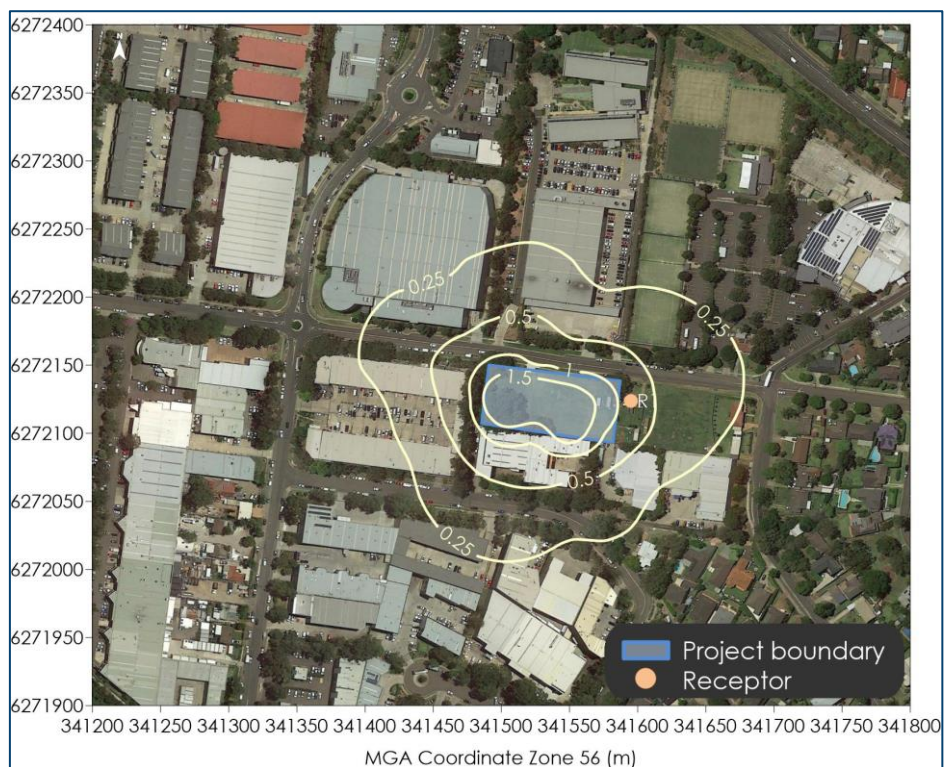


Figure B-9: Predicted incremental 8-hour average CO concentrations ($\mu\text{g}/\text{m}^3$)

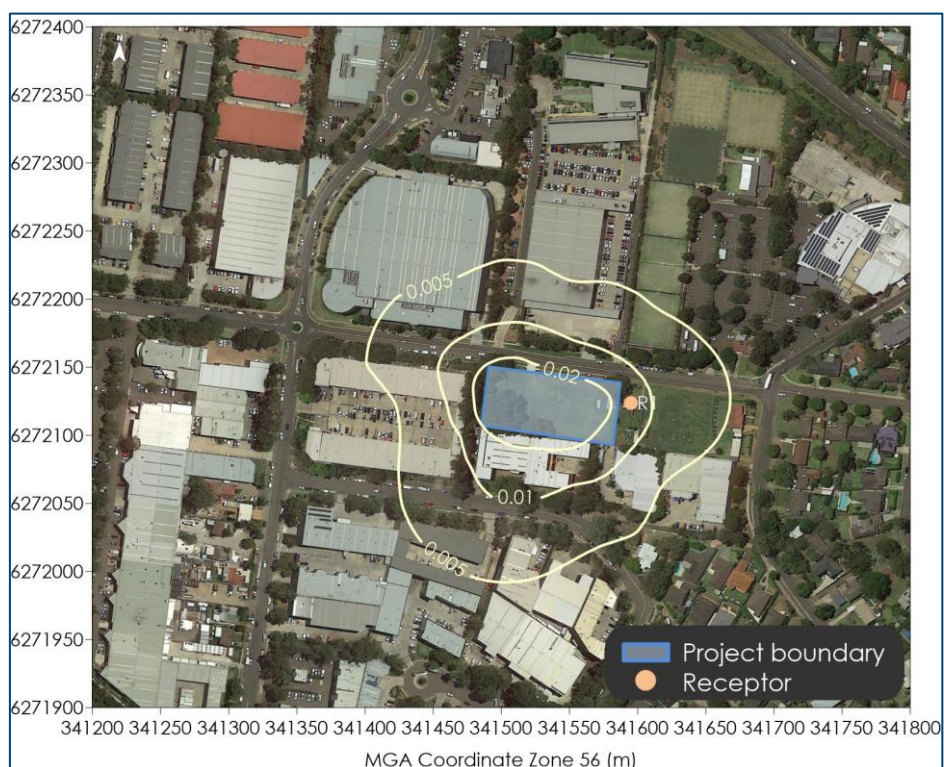


Figure B-10: Predicted incremental 1-hour average benzene concentrations ($\mu\text{g}/\text{m}^3$)



Figure B-11: Predicted incremental 1-hour average formaldehyde concentrations ($\mu\text{g}/\text{m}^3$)



Figure B-12: Predicted incremental 1-hour average PAH concentrations ($\mu\text{g}/\text{m}^3$)

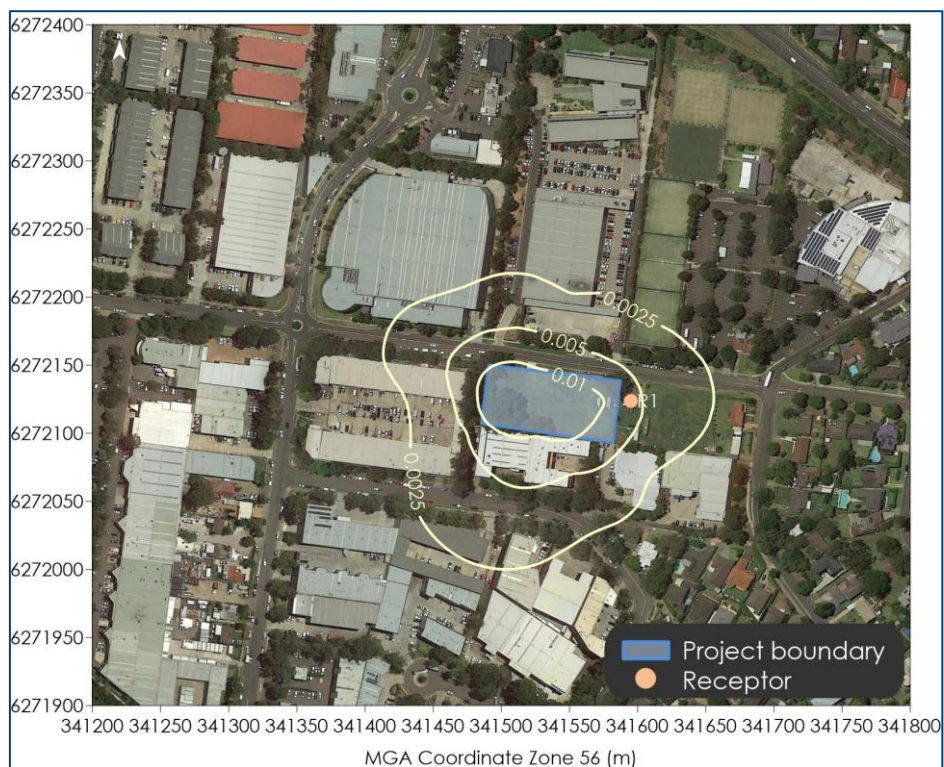


Figure B-13: Predicted incremental 1-hour average toluene concentrations ($\mu\text{g}/\text{m}^3$)



Figure B-14: Predicted incremental 1-hour average xylene concentrations ($\mu\text{g}/\text{m}^3$)

Appendix C

Further detail regarding 24-hour PM_{2.5} and PM₁₀ analysis



Further detail regarding 24-hour average PM_{2.5} and PM₁₀ analysis

The analysis below provides a cumulative 24-hour PM_{2.5} and a cumulative 24-hour PM₁₀ impact assessment in accordance with the NSW EPA Approved Methods; refer to the worked example on page 46 to 47 of the Approved Methods.

The background level is the ambient level at Lindfield monitoring station for PM_{2.5} and PM₁₀ as stated in **Section 6.1**.

The predicted increment is the predicted level to occur at the receptor due to the Project.

The total is the sum of the background level and the predicted level. The totals may have minor discrepancies due to rounding.

Tables C-1 and **C-2** assesses receptor R1 and shows the predicted maximum cumulative levels. The left half of the table examines the cumulative impact during the periods of highest background levels and the right half of the table examines the cumulative impact during the periods of highest contribution from the Project.

The **green** shading represents days ranked per the highest background level but below the criteria.

The **blue** shading represents days ranked per the highest predicted increment level but below the criteria.

The **orange** shading represents days where the measured background level is already over the criteria.

Any value above the PM_{2.5} criterion of 25µg/m³ or above the PM₁₀ criterion of 50µg/m³ is in **bold red**.



Table C-1: Cumulative 24-hour average PM_{2.5} concentration (µg/m³) – Receptor R1

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
6/05/2015	28.2	0.02	28.2				
21/08/2015	22.7	0.00	22.7	15/06/2015	7.5	0.03	7.5
26/11/2015	18.8	0.00	18.8	12/06/2015	5.8	0.03	5.8
14/12/2015	15.7	0.00	15.7	14/04/2015	8.6	0.02	8.6
10/12/2015	15.5	0.00	15.5	27/03/2015	8.4	0.02	8.4
27/11/2015	15.5	0.00	15.5	30/03/2015	4.8	0.02	4.8
17/10/2015	15.1	0.00	15.1	4/07/2015	8.9	0.02	8.9
12/12/2015	14.7	0.00	14.7	25/06/2015	6.9	0.02	6.9
2/01/2015	14.6	0.00	14.6	14/03/2015	4.4	0.02	4.4
20/12/2015	14.6	0.00	14.6	6/07/2015	4.9	0.02	4.9
11/12/2015	14.4	0.00	14.4	7/05/2015	6.1	0.02	6.1

Table C-2: Cumulative 24-hour average PM₁₀ concentration (µg/m³) – Receptor R1

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
6/05/2015	56.4	0.02	56.4				
21/08/2015	45.3	0.00	45.3	15/06/2015	14.9	0.03	14.9
26/11/2015	37.5	0.00	37.5	12/06/2015	11.6	0.03	11.6
14/12/2015	31.3	0.00	31.3	14/04/2015	17.2	0.03	17.2
10/12/2015	31.0	0.00	31.0	27/03/2015	16.8	0.03	16.8
27/11/2015	30.9	0.00	30.9	30/03/2015	9.5	0.02	9.5
17/10/2015	30.1	0.00	30.1	4/07/2015	17.8	0.02	17.8
12/12/2015	29.3	0.00	29.3	25/06/2015	13.8	0.02	13.8
2/01/2015	29.1	0.00	29.1	14/03/2015	8.7	0.02	8.7
20/12/2015	29.1	0.00	29.1	6/07/2015	9.7	0.02	9.7
11/12/2015	28.8	0.00	28.8	7/05/2015	12.1	0.02	12.1