ARTC

BOTANY RAIL DUPLICATION

TECHNICAL REPORT

Technical Report 3 –
Air Quality Impact Assessment

Botany Rail Duplication - Environmental Impact Statement

Technical Report 3 – Air Quality Impact Assessment

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Author, Reviewer and Approver details

Prepared by:	Nicholas Spurrett	Date: 27/09/2019	Signature:	Nick Spurrett
Technical review by:	Evan Smith	Date: 27/09/2019	Signature:	E Smith
Project team review	Karen Yale	Date: 27/09/2019	Signature:	Kyale
Approved by:	David Foldi	Date: 27/09/2019	Signature:	Dhm

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Australian Rail Track Corporation, Gateway to Sydney Joint Venture (G2S JV)

Document owner

G2S JV Gateway to Sydney Joint Venture
WSP Australia Pty Limited and GHD Pty Ltd

ABN: 55 836 411 311
Project Office
Level 27 Ernst & Young Centre
680 George Street
Sydney NSW 2000
GPO Box 5394
Sydney NSW 2001
Australia
Tel: +61 2 9272 5100
Fax: +61 2 9272 5101

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Glossary and abbreviations

ARTC	Australian Rail Track Corporation (the proponent)
AQIA	Air Quality Impact Assessment
Ausplume	A software implementation of the Gaussian plume dispersion model based on the Victorian Environment Protection Authority's Plume Calculation Procedure (EPAV 1985).
AWS	Automated Weather System
Ballast	Material such as crushed rock or stone used to provide a foundation for a railway track. Ballast usually provides the bed on which railway sleepers are laid, transmits the load from train movements and restrains the track from movement.
BoM	Bureau of Meteorology
Botany Line	A dedicated freight rail line (operated by ARTC) that forms part of the Metropolitan Freight Network. The line extends from near Marrickville Station to Port Botany.
CALMET	CALMET is a meteorological model which includes a diagnostic wind find generator containing objective analysis and parameterized treatments of slope flows, kinematic terrain effects, terrain blocking effects, and a divergence minimization procedure, and a micro-meteorological model for overland and overwater boundary layers.
CALPUFF	CALPUFF is a non-steady-state Lagrangian Gaussian puff model contain modules for complex terrain effects, overwater transport, coastal interaction effects, building downwash, wet and dry removal, and simple chemical transformation.
CO	Carbon monoxide
construction ancillary facilities	Temporary facilities during construction that include, but are not limited to, construction work areas, sediment basins, temporary water treatment plants, pre-cast yards and material stockpiles, laydown areas, parking, maintenance workshops and offices, and construction compounds.
construction compound	An area used as the base for construction activities, usually for the storage of plant, equipment and materials, and/or construction site offices and worker facilities.
Council, the	Bayside Council
detailed design	The stage of design where project elements are design in detail, suitable for construction.
EIS, the	Botany Rail Duplication environmental impact statement
embankment	A raised area of earth or other materials used to carry a rail line in certain areas.
existing rail corridor	The corridor within which the existing rail infrastructure is located. In the study area, the existing rail corridor is the Botany Line.
formation	The earthworks/material on which the ballast, sleepers and tracks are laid.

heavy vehicles	A heavy vehicle is classified as a Class 3 vehicle (a two-axle truck) or larger, in accordance with the Austroads Vehicle Classification System.
HC	Hydrocarbons
impact	Influence or effect exerted by a project or other activity on the natural, built and community environment.
Incremental concentration	Concentrations of pollutants generated by the project
LGA	local government area
Metropolitan Freight Network	A network of dedicated railway lines for freight in Sydney, linking NSW's rural and interstate rail networks with Port Botany. The Metropolitan Freight Network is managed by ARTC.
NO	Nitrogen monoxide
NO_2	Nitrogen Dioxide
Notch	A trains throttle position
Pasquill-Gifford	Stability classification used in atmospheric dispersion models to define the turbulent state of the atmosphere.
$PM_{2.5}$	Particulate matter (airborne dust) with a size of 2.5 micrograms.
PM_{10}	Particulate matter (airborne dust) with a size of 10 micrograms.
possession	A period of time during which a rail line is closed to train operations to permit work to be carried out on or near the line.
project site, the	The area that would be directly affected by construction. It includes the location of operational project infrastructure, the area that would be directly disturbed by the movement of construction plant and machinery, and the location of the storage areas/compounds etc., that would be used to construct that infrastructure.
project, the	The construction and operation of the Botany Rail Duplication
Secretary's environmental assessment requirements (SEARs)	Requirements and specifications for an environmental assessment prepared by the Secretary of the Department of Planning and Environment under section 115Y of the *Environmental Planning and Assessment Act 1979* (NSW).
SO_2	Sulfur dioxide
State significant infrastructure	Major transport and services infrastructure considered to have State significance as a result of size, economic value or potential impacts.

study area, the	The study area is defined as the wider area including and surrounding the project site, with the potential to be directly or indirectly affected by the project (e.g. by noise and vibration, visual or traffic impacts). The actual size and extent of the study area varies according to the nature and requirements of each assessment and the relative potential for impacts but which is sufficient to allow for a complete assessment of the proposed project impacts to be undertaken.
TAPM	TAPM is an air pollution model that predicts three-dimensional meteorology and air pollution concentrations.
Total impact concentrations	Concentrations of pollutants generated by the project plus the background concentrations
TSP	Total Suspended Particles – airborne dust
$\mu g/m^3$	Microgram per metre cubed
UTM	Universal Transverse Mercator coordinate system

Executive summary

Australian Rail Track Corporation proposes to construct and operate a new second track within the existing Botany Line rail corridor between Mascot and Botany, in the Bayside local government area (LGA). The Botany Rail Duplication ('the project') would increase freight rail capacity to and from Port Botany.

The project is State Significant Infrastructure in accordance with Division 5.2 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). As State Significant Infrastructure, the project needs approval from the NSW Minister for Planning and Public Spaces.

An air quality assessment has been prepared for the construction and operation of the project to accompany the environmental impact statement. This is to support the application for approval of the project, and address the environmental assessment requirements of the Secretary of the Department of Planning and Environment (the SEARs), issued on 21 December 2018.

Construction air quality impacts were modelled and assessed for typical construction scenarios. The primary air quality concern during construction is dust. A screening level dust assessment was undertaken for proposed construction activities with consideration of the Approved Methods (EPA, 2016). Dust impacts from construction activities have been assessed based on the proposed construction area with works assumed to occur all year in any one location, however it is important to note that many construction activities are mobile, transient and intermittent and likely to take place over a shorter period than one year.

The assessment found that there may be short term 24 hour averaged PM_{10} impacts within 6 metres of general construction activities and longer term annually average $PM_{2.5}$ impacts within 7 metres of long term construction activities that occur in the same location for over a year. Implementation of mitigation and management measures to minimise dust will reduce impacts.

The operational assessment considered five scenarios corresponding to the existing 2019 scenario and future build and no build for years 2024 and 2034. Operational air quality impacts are not anticipated for any pollutants. Operational air quality impacts from the Project were not deemed to be significant.

1. Introduction

1.1 Overview

1.1.1 Background

Australian Rail Track Corporation (ARTC) proposes to construct and operate a new second track within the existing Botany Line rail corridor between Mascot and Botany, in the Bayside local government area (LGA). The Botany Rail Duplication ('the project') would increase freight rail capacity to and from Port Botany. The location of the project is shown in Figure 1.1.

The project is State Significant Infrastructure in accordance with Division 5.2 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). As State Significant Infrastructure, the project needs approval from the NSW Minister for Planning and Public Spaces.

This report has been prepared to accompany the environmental impact statement (EIS) to support the application for approval of the project, and address the Secretary of the Department of Planning and Environment's environmental assessment requirements (the SEARs), issued on 21 December 2018.

1.1.2 Overview of the project

The project would involve:

- Track duplication – constructing a new track predominantly within the rail corridor for a distance of about three kilometres.
- Track realignment (slewing) and upgrading – moving some sections of track sideways (slewing) and upgrading some sections of track to improve the alignment of both tracks and minimise impacts to adjoining land uses.
- New crossovers – constructing new rail crossovers to maintain and improve access at two locations (totalling four new crossovers).
- Bridge works – constructing new bridge structures at Mill Stream, Southern Cross Drive, O'Riordan Street and Robey Street (adjacent to the existing bridges), and re-constructing the existing bridge structures at Robey Street and O'Riordan Street.
- Embankment/retaining structures – construction of a new embankment and retaining structures adjacent to Qantas Drive between Robey and O'Riordan streets and a new embankment between the Mill Stream and Botany Road bridges.

Further information on the key elements of the project is provided in the EIS.

Ancillary work would include bi-directional signalling upgrades, drainage work and protecting/relocating utilities.

Subject to approval of the project, construction is planned to start at the end of 2020, and is expected to take about three years for the main construction works to be undertaken. Construction is expected to be completed in late 2023 with commissioning activities undertaken in early 2024.

It is anticipated that some features of the project would be constructed while the existing rail line continues to operate. Other features of the project would need to be constructed during programmed weekend rail possession periods when rail services along the line cease to operate.

The project would operate as part of the existing Botany Line and would continue to be managed by ARTC. ARTC is not responsible for the operation of rolling stock. Train services are currently, and would continue to be, provided by a variety of operators. Following the completion of works, the existing functionality of surrounding infrastructure would be restored.

Key features of the project are shown on Figure 1.2.

Figure 1.1 Botany Rail Duplication location

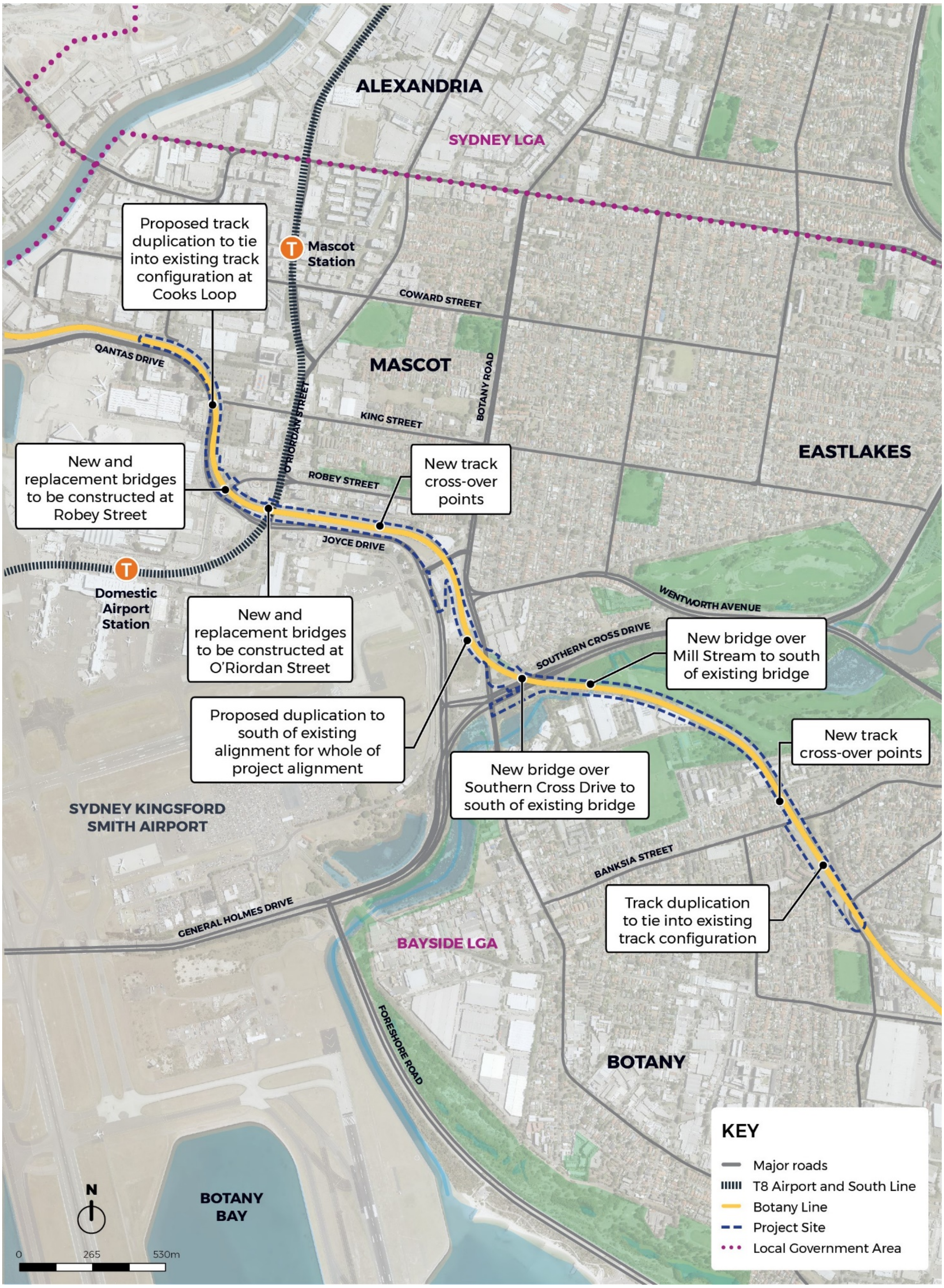


Figure 1.2 Botany Rail Duplication project overview

1.2 Purpose and scope of this report

The purpose of this report is to assess the potential air quality impacts from the operation and construction of the project. This air quality impact assessment addresses the relevant SEARs for the EIS, as outlined in Table 2.1, The report:

- describes the existing environment with respect to air quality
- assesses the impacts of constructing and operating the project on air quality
- recommends measures to mitigate the impacts identified.

1.3 Structure of this report

The structure of the report is outlined below.

- Section 1 Introduction – provides an introduction to the report.
- Section 2 Legislative and policy context – describes the legislative and policy context for the assessment, and relevant guidelines.
- Section 3 Methodology – describes the methodology for the assessment.
- Section 4 Existing environment – describes the existing environment as relevant to the assessment.
- Section 5 Construction impacts – presents a summary of the construction and operational pollutant impact assessment results.
- Section 6 Operational impacts – presents a summary of the construction and operational pollutant impact assessment results
- Section 7 Management of impacts – provides an overview of the proposed air quality mitigation measures undertaken during the project.
- Section 8 Conclusion – presents a summary of the air quality findings and sets out the principal conclusions for the assessment.

1.4 Assumptions

This air quality assessment relied upon the following assumptions:

- Emissions from construction activities are undertaken based on an overview of the proposed construction methodology (provided in EIS Chapter 7) and were characterised using generic emission factors published in the Western Regional Air Partnership Fugitive Dust Handbook (WRAP) (Countess Environmental, 2006).
- Maximum hourly and daily train movements (assuming one operational locomotive per train) for the modelled scenarios (years 2019, 2024 and 2034) were provided by ARTC.
- Locomotive emission rates sourced from the Diesel Locomotive Fuel Efficiency and Emissions Testing: Prepared for NSW EPA (ABMARC, 2016) and National Pollutant Inventory (NPI) emission factors. Locomotive alternator power output for operation at each notch was sourced from a diesel locomotive emissions report prepared by Lilley (1996).
- Notch settings (throttle position) are based on locomotive speed profiles. Table 6.2 shows locomotive speed along the track provided by ARTC.
- Operational characteristics and likely operational scenarios of the loop are supplied by ARTC (operation of project is discussed further in Botany Rail Duplication EIS Chapter 6).
- Modelling assumptions are provided in section 5 of this report. Emissions inventory assumptions for the construction and operation assessment are provided in section 5 and section 6 respectively.

2. Legislative and policy context

This section summarises the legislation, guidelines and/or policies driving the approach to the assessment.

2.1 Relevant legislation, policies and guidelines

2.1.1 *Protection of the Environment Operations Act 1997*

The *Protection of the Environment Operations (POEO) Act 1997* provides the statutory framework for managing pollution in NSW, including the procedures for issuing licences for environmental protection on aspects such as waste, air, water and noise pollution control. Companies and property owners are legally bound to control emissions from construction sites under the POEO Act. Activities undertaken onsite must not contribute to environmental degradation, and pollution and air emissions must not exceed the standards.

The criteria outlined in this Act and considered in this assessment are specified in the Approved Methods (EPA, 2016).

2.1.2 *Protection of the Environment Operations (Clean Air) Regulation 2010*

The *Protection of the Environment Operations (Clean Air) Regulation 2010* (the Clean Air Regulation) provides regulatory measures to control emissions from motor vehicles, fuels, and industry. The project would be operated to ensure it complies with the Clean Air Regulation.

The criteria outlined in this Regulation and considered in this assessment are specified in the Approved Methods (EPA, 2016).

2.1.3 Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (EPA, 2016) (Approved Methods)

The Approved Methods (EPA, 2016) lists the statutory methods for modelling and assessing emissions of air pollutants from stationary sources in NSW. It considers the above-mentioned legislation and constructs pollutant assessment criteria.

The Approved Methods (EPA, 2016) is the main guidance document that has been followed for this assessment.

2.1.4 National Environment Protection (Ambient Air Quality) Measure (2015) (Air NEPM)

The Air NEPM sets national standards for the six key air pollutants to which most Australians are exposed: Carbon monoxide (CO), Ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), lead and particulates. Under the Air NEPM, all Australians have the same level of air quality protection.

The criteria and pollutants specified in this NEPM have been considered in this assessment.

2.1.5 Approved Methods for the Sampling and Analysis of Air Pollutants in NSW (DEC, 2007)

The *Approved Methods for the Sampling and Analysis of Air Pollutants in NSW* (DEC, 2007) provides the approved methodology for sampling and analysing air pollutants.

This guidance was reviewed but as sampling was not undertaken as part of this air quality assessment this guidance has not been considered further.

2.1.6 *Technical Framework – Assessment and Management of Odour from Stationary Sources in NSW (DEC, 2006)* (Technical Framework)

The Technical Framework – Assessment and Management of Odour from Stationary Sources in NSW (DEC, 2006) provides a framework to assess and manage odour from stationary sources. The Approved Methods (EPA 2016) incorporates guidance supplied in the Technical Framework. An air quality assessment conducted in accordance with the Approved Methods (EPA 2016).

As odour was not found to be significant based on train emissions (ABMARC, 2016) and the findings of the contamination assessment for this project (*Technical Report 5 – Contamination Assessment*), detailed odour management has not been incorporated into this assessment.

2.1.7 *Protocol for Environmental Management, State Environment Protection Policy (Air Quality Management) (Victorian EPA, 2007)* (PEM)

The Protocol for Environmental Management (VIC EPA, 2007) provides the requirements for assessment and management of emissions to the air environment from the mining and extractive industries. It provides an alternate method to assess total impact air quality emissions by using the 70th percentile of background concentrations. This method is considered more appropriate for the construction phase of this project based on the intermittent and changing location of air quality emissions.

This policy was followed to develop the background concentrations used in this construction assessment based upon the 70th percentile particulate concentrations.

2.1.8 *Western Regional Air Partnership Fugitive Dust Handbook (WRAP)* (Countess Environmental, 2006)

Dust emissions from construction activities have been calculated using recommended particulate emission factors for general construction operations. The derived emission rates were characterised using recommended emission factors for average conditions and worst case conditions published in the *Western Regional Air Partnership Fugitive Dust Handbook* (WRAP) (Countess Environmental, 2006).

2.2 Secretary's environmental assessment requirements

The SEARs relevant to air quality, together with a reference to where they are addressed in this report, are outlined in Table 2.1.

Table 2.1 SEARs relevant to this assessment

Requirements	Where addressed in this report
3. Assessment of Key Issues* (2) For each key issue the Proponent must:	
describe the biophysical and socio-economic environment, as far as it is relevant to that issue;	Section 4
describe the legislative and policy context, as far as it is relevant to the issue;	Section 2
identify, describe and quantify (if possible) the impacts associated with the issue, including the likelihood and consequence (including worst case scenario) of the impact (comprehensive risk assessment), and the cumulative impacts;	Section 5
demonstrate how options within the project potentially affect the impacts relevant to the issue;	Section 5
demonstrate how potential impacts have been avoided (through design, or construction or operation methodologies);	Section 5
detail how likely impacts that have not been avoided through design will be minimised, and the predicted effectiveness of these measures (against performance criteria where relevant); and	Section 7
detail how any residual impacts will be managed or offset, and the approach and effectiveness of these measures.	Section 7
10. Air Quality (1) The Proponent must undertake an air quality impact assessment (AQIA) for construction and operation (from increases in freight rail movements) of the project in accordance with the current guidelines.	Whole report
(2) The Proponent must ensure the AQIA also includes the following:	
identification of all receivers (including residential and commercial);	Section 4.2
demonstrated ability to comply with the relevant regulatory framework, specifically the Protection of the Environment Operations Act 1997 and the Protection of the Environment Operations (Clean Air) Regulation (2010)	Section 5
the identification of potential sources of air pollution (including odour sources and from the disturbance of contaminated land) during construction and operation;	Section 5 and 6
any proposed air quality monitoring; and	Section 7
a cumulative local and regional air quality impact assessment	Section 6.6

3. Methodology

This section describes the methodology used to undertake the air quality assessment.

3.1 Air quality assessment methodology

3.1.1 Construction methodology

Construction air quality impacts were modelled and assessed for typical construction scenarios (scenarios provided in section 6.2. Dust emissions from construction activities were calculated using recommended emission factors for average conditions and worst case conditions published in the *Western Regional Air Partnership Fugitive Dust Handbook (WRAP)* (Countess Environmental, 2006). Dust impacts were modelled using Ausplume and were calculated as impact vs distance graphs. A buffer zone diagram that shows areas of predicted particulate concentration exceedance was prepared based on the earthworks and disturbance footprint.

3.1.2 Operational methodology

Operational air quality impacts were modelled and assessed for five operational scenarios (scenarios provided in section 6.2). Locomotive emissions were calculated based on best available information (derivation of emissions provided in 6.3). The meteorology modelling methodology is provided in Appendix A. Operational air quality impacts were modelled using CALPUFF and were calculated for identified worst case receptors and grid. Tabulated results and contour plot were used to present the results of the operational air quality assessment.

3.1.3 Air quality assessment criteria

Assessment criteria has been taken from the Approved Methods (EPA 2016). These criteria should be met at existing or future off-site sensitive receptors. The assessment criteria are provided as total impacts, where the predicted impact of the project is added to the background levels in order to assess the pollutants impacts. To determine the level of air quality impacts, emissions from the project must be assessed against the assessment criteria as shown in Table 3.1.

The predicted concentrations from the construction and operation air quality assessment were assessed against the assessment criteria provided in Table 3.1 to determine predicted impacts.

Table 3.1 Impact assessment criteria (Approved Methods, EPA 2016)

Pollutant	Averaging period	Percentile	Assessment criteria (µg/m^3)
TSP	Annual	100th	90
PM_{10}	24 hour	100th	50
	Annual	100th	25
$PM_{2.5}$	24 hour	100th	25
	Annual	100th	8
CO	15 minute	100th	100,000
	1 hour	100th	30,000
	8 hour	100th	10,000

Pollutant	Averaging period	Percentile	Assessment criteria (µg/m^3)
NO_2	1 hour	100th	246
	Annual	100th	62
SO_2	10 minute	100th	712
	1 hour	100th	570
	24 hour	100th	228
	Annual	100th	60
Benzene	1 hour	99.9th	29

3.2 Study area

The study area was selected to encompass a large enough extent to capture all air quality impacts from the project. The model domain was selected to 22 kilometres by 22 kilometres in size centred on the project site. The study area is considered the same size as the modelling domain. Sensitive receptors were selected within the study area. The selected receptors are presented in Table 4.2.

3.3 Key tasks

The air quality assessment involved the following tasks:

- A desktop review of site plans, aerial photographs and topographic maps undertaken to gain an understanding of the existing environment in terms of local terrain, existing/proposed operations and sensitive receptors within the study area.
- The applicable air quality assessment criteria from the Approved Methods (EPA 2016) was outlined in section 3.1.
- A review of available background air quality in the local area was undertaken using Office of Environment and Heritage (OEH) air quality monitoring data (Randwick and Earlwood monitoring stations refer to section 4.1.2).
- Meteorological modelling was undertaken to gain understanding of the local wind climate for use as model input for conducting atmospheric dispersion modelling. A detailed methodology is provided in Appendix A.
- A construction emissions inventory was created to include emissions to air from the construction of the project (primarily particulates).
- Review of *Technical Report 5 – Contamination Assessment* (WSP 2019) was undertaken to verify management plans have been recommended during construction.
- An operational emissions inventory was created to include locomotives on the project using the report Diesel Locomotive Fuel Efficiency and Emissions Testing: Prepared for NSW EPA (ABMARC, 2016) and National Pollutant Inventory (NPI) emission factors.
- Dispersion modelling to predict construction and operational impacts at nearby receivers in the study area using regulatory approved models was undertaken.
- General mitigation measures were provided for construction and operation of the project to mitigate potential impacts which could arise as a result of the project.

4. Existing environment

This section defines the existing environment relevant to the air quality assessment.

4.1 Existing air quality

The NSW OEH operates ambient air quality monitoring stations in selected areas around NSW. The nearest station to the site is the Randwick (located 3.5 kilometres to the east of the site) and the Earlwood (located 4 kilometres to the west of the site) monitoring stations.

To assess total impact (project generated plus existing background concentrations) air quality impacts, background air quality concentrations for the same period to the model predictions are required. Determination of the modelled year (called the 'representative year') is outlined in section 4.1.1 and the review of background air quality is summarised in section 4.1.2.

4.1.1 Representative year selection

Air quality dispersion modelling using an advanced model (such as CALMET and CALPUFF used in this assessment) requires a 'representative' year to be selected and used for modelling purposes. CALPUFF recreates the meteorology of the representative year and uses it to predict future air quality impacts. Meteorological conditions vary year to year so the 'representative' year is chosen because it contains meteorological conditions that are likely to occur in future years.

An analysis of meteorological data from the nearest station in recent five years (2012 to 2016) to select a period considered most representative of 'normal' conditions is recommended by the Approved Methods (EPA 2016).

Meteorological data was taken from the nearest BoM monitoring station (Sydney Airport AMO, BoM ID: 66037) which is located approximately 2 kilometres southwest from the project site. A comprehensive analysis from hourly meteorological data in the recent five years from the station were used to determine the representative year for the project study. Probability density function graphs of the wind speed and direction over the five years at the station is provided in Appendix B.

The analysis shows that the year 2014 at Sydney Airport AMO station is the most representative year based on a review of temperature, humidity, wind speed and wind direction. The year 2014 in NSW was also identified as not being excessively wet or dry. Therefore data for 2014 has been selected as the represented year for modelling.

4.1.2 Background air quality

Pollutant average and maximum ambient concentrations for the modelled year (2014) are presented in Table 4.1.

Carbon Monoxide (CO) monitoring data is not available at either Randwick or Earlwood monitoring stations. In the absence of nearby background CO monitoring data, a total impact assessment of CO impacts cannot be undertaken (further discussion provided in section 6.5.2). For an indicative reference, the maximum 1 hour CO background from the Chullora OEH monitoring station (Chullora monitoring station is located in a similar urban environment with a rail corridor nearby, CO data taken for 2018-2019 calendar period) was 4,140 µg/m^3.

Table 4.1 Ambient air quality daily concentrations (2014)

Pollutant (in micro grams per metre cubed (µg/m^3)		Averaging period	OEH monitoring site	
			Randwick	Earlwood
NO_2	Maximum (µg/m^3)	1 hour	88.4	75.2
	Maximum (µg/m^3)	Annual	11.0	15.8
CO	Maximum (µg/m^3)	1 hour	–	–
	Maximum (µg/m^3)	8 hour	–	–
SO_2	Maximum (µg/m^3)	1 hour	68.1	–
	Maximum (µg/m^3)	24 hour	10.5	–
	Maximum (µg/m^3)	Annual	2.4	–
O_3	Average (µg/m^3)	1 hour	37.9	30.2
	Maximum (µg/m^3)	1 hour	129.4	135.2
PM_{10}	Maximum (µg/m^3)	24 hours	46.1	45.2
	Maximum (µg/m^3)	Annual	18.2	18.4
	70th percentile (µg/m^3)	24 hours	20.5	20.7
$PM_{2.5}$	Maximum (µg/m^3)	24 hour	–	22.7
	Maximum (µg/m^3)	Annual	–	7.8
	70th percentile (µg/m^3)	24 hours	–	9.2

Note: '–' denotes data not sampled at the site

4.1.3 Local emission sources

The main local sources of air pollution in the study area which contributes to the existing background concentrations include:

- vehicle emissions especially from roads with high traffic volumes such as Qantas Drive, Joyce Drive, General Holmes Drive and Southern Cross Drive. Emissions can include NOx, volatile organic compounds (VOC), CO, PM_{10} and $PM_{2.5}$
- suspended dust along roadways, from pulverized pavement materials, particles from brake linings and tyres. Dust emissions from existing rail movements along the Botany Line. Dust can include Total Suspended Particles (TSP) PM_{10} and $PM_{2.5}$
- residential emissions such as domestic products as well as fuel combustion from domestic machinery such as lawn mowers, etc. Diesel emissions from existing rail movements along the Botany Line. Emissions can include NOx, VOC, CO, TSP PM_{10} and $PM_{2.5}$

- secondary particulate emissions from freight movement (i.e. wheel and brake action, wagon turbulence in the rail corridor and windblown particulates). Secondary particulate matter pollution consists of NOx, VOC, sulphur dioxide (SO_2) and ammonia which react in the atmosphere to form secondary organic aerosols, nitrate, sulfate compounds and ozone (O_3).

4.2 Sensitive receptors

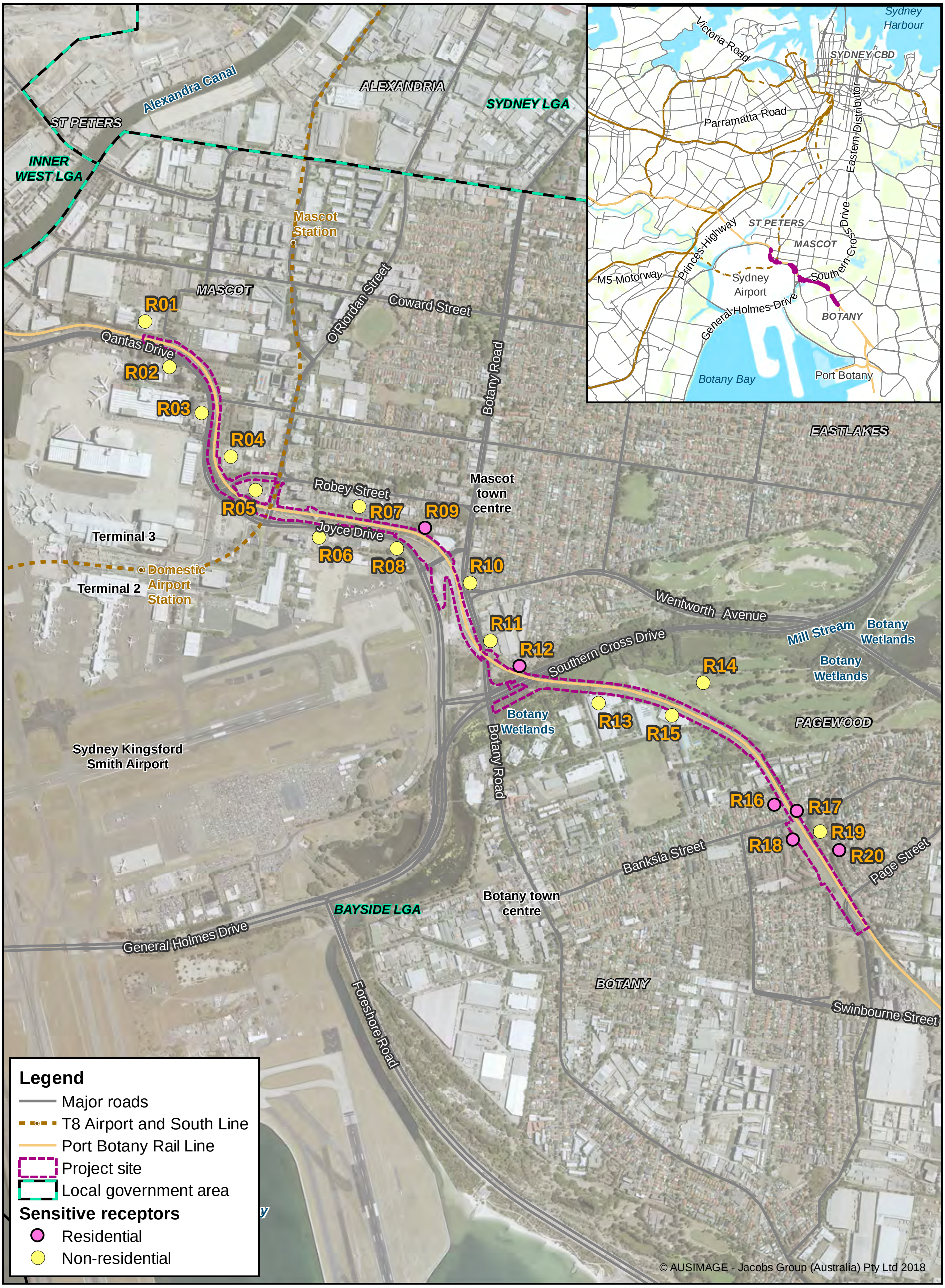
The Approved Methods (EPA 2016) defines sensitive receptors as locations where people are likely to work or reside and may include a dwelling, school, hospital, office and recreation areas.

The nearest sensitive receptors are anticipated to experience the worst case air quality impact and therefore have been selected to represent worst case scenario pollutant concentrations. If potential air quality impacts from the project comply with the impact assessment criteria at the nearest receptors, then those situated at a greater distance will also likely comply. Contour plots of predicted emissions (Appendix D) show results for all locations within the study area. Contour maps of predicted emissions show results for all locations within the study area. It is expected that the closest receptors will experience the worst-case air quality impacts.

The location of the representative sensitive receptors to the site are presented in Table 4.2 along with the coordinates and receptor type. The location of representative sensitive receptors in the study area is shown in Figure 4.1.

Table 4.2 Representative sensitive receptors locations

ID	X coordinate (m)	Y coordinate (m)	Description
R01	331897	6244614	Qantas Joy building
R02	331985	6244449	Qantas Flight Training Centre
R03	332103	6244281	Qudos Bank
R04	332209	6244122	Redspot car rentals headquarters
R05	332298	6243999	Stamford Plaza Sydney Airport
R06	332531	6243828	Krispy Kreme Mascot
R07	332676	6243941	Regional Express (Rex)
R08	332814	6243788	IMO Carwash Mascot
R09	332917	6243861	Residential
R10	333080	6243662	AEA Sydney airport serviced apartments
R11	333154	6243452	Rovacraft
R12	333262	6243358	Residential
R13	333548	6243224	Sims Metal Management
R14	333929	6243299	Eastlake Golf Club Halfway House
R15	333815	6243179	Big Picture Australia PTY Ltd
R16	334190	6242854	Residential
R17	334272	6242831	Residential
R18	334258	6242727	Residential
R19	334356	6242757	Gairarine Gardens
R20	334426	6242688	Residential



0 265 530 m

Figure 4-1

Sensitive receptors location

Author: David Naiken
Date: 21/06/2019
Map no: PS113386_GIS_020_A2

5. Construction impacts

This section presents a summary of the predicted construction and operation air quality impacts assessment results.

5.1 Construction description

Construction of the project would broadly involve the following key steps:

- early and enabling works
- main construction works including track and bridge works
- finishing and rehabilitation works.

It is noted that the construction methodology including the plant and equipment usages presented in this section are indicative and would continue to be modified and refined as the design process continues. A final construction methodology and program would be developed by the construction contractor when appointed.

A high level conservative worst case construction assessment has been undertaken.

5.1.1 Pollutant emissions from construction activities

There is potential for air quality emissions to occur during the construction of the project. The principle activities which may result in emissions include:

- dust and particulate matter emissions from earth working activities
- combustion and pollutant emissions from construction vehicle and plant exhaust
- odour and pollutant emissions from disturbance of contaminated land.

Dust

Dust and particulate matter was identified as the primary emission to air during the construction of the project. Other air emissions such as combustion products (e.g. vehicle exhaust) will also be present during construction and maintenance activities. The combustion exhaust emissions from vehicles, plant and equipment are expected to be insignificant compared to existing combustion engine emissions from road and rail traffic.

Construction activities that generate dust include earthworks and the handling and transfer of earth and other material. The key features of the project that could generate dust include:

- de-vegetation, clearing and grubbing
- installation of a new track and embankment widening
- track upgrading and minor adjustments
- bridge works and demolition
- retaining wall works
- drainage system construction and relocation of underground services and pipelines
- service routes and signalling works
- finishing and rehabilitation works.

Plant, equipment and activities likely to generate dust include:

- use of earth working plant including excavators, bull dozers and front end loaders
- trucks dumping soil and aggregate
- drilling
- scraper/graders
- wheel generated dust from vehicle movements on unsealed surfaces.

Construction vehicles and exhaust emissions

Construction vehicles are expected to travel along the alignment and resulting emissions will be discontinuous, transient, and mobile. Particulate (TSP, PM_{10} and $PM_{2.5}$) emissions from the exhaust of mobile plant and stationary engines are accounted for in the emission factors for earthmoving and handling (emissions factors further discussed in section 5.1) used in the air quality assessment. Therefore, combustion vehicle exhaust emissions have not been considered further in this assessment.

Odour and pollutant emissions

There is potential for odorous and pollutant (including PFAS and asbestos) emissions to occur during the construction of the project from the disturbance of contaminated land. Previously contained contamination (covered by topsoil) may be agitated resulting in the release of contamination into the air.

A contamination assessment has been undertaken to assess the potential impacts of this contamination. The assessment identified the risk of airborne asbestos fibres being generated during construction activities associated with the excavation, movement and stockpiling of asbestos cement material (ACM) contaminated material.

PFOS and PFAS concentrations have been recorded in surface water and ground water samples located near the rail corridor. There is higher risk of these contaminants becoming airborne during constructions works in these areas. Management measures have been included in Section 7.

Further details and a complete contamination assessment including measure to manage contamination is provided in the contamination land specialist report (*Technical Report 5 – Contamination Assessment* (WSP 2019)).

5.2 Dust emission rate calculations

Dust emissions from construction activities have been calculated using recommended particulate emission factors for general construction operations. The derived emission rates were characterised using recommended emission factors for average conditions and worst case conditions published in the *Western Regional Air Partnership Fugitive Dust Handbook* (WRAP) (Countess Environmental, 2006). These emissions factors are calculated assuming standard earth moving operations.

Total suspended particles and dust deposition is usually assessed against annual criteria however, these criteria are less relevant to the project as construction works would be transient along the length of the project site and short term. The primary emission of concern during the construction phase was found to be dust as PM_{10}. As a result, for this project, air quality impacts were assessed in terms of distances at which the relevant criteria are achieved at any time.

The dust emission factors used in the construction assessment are provided in Table 5.1. The emission factors have been sourced directly from literature where applicable, however where TSP and $PM_{2.5}$ emission factors were not provided, the following assumptions were made (assumptions taken from WRAP, 2006):

- TSP/PM_{10} ratio assumed to be a factor of 2 (based on ratio for wind erosion WRAP, 2006)
- $PM_{2.5}$/PM_{10} ratio assumed to be 0.1 (based on ratio for fugitive dust from construction and demolition activities WRAP, 2006).

Table 5.1 Dust emissions factors for construction activities

Construction activity	Particulate emission factors ($g/m^2/s$)			Source
	PM_{10}	TSP	$PM_{2.5}$	
General and fixed construction activities	9.515E-06	1.903E-05	9.515E-07	WRAP – Recommended PM_{10} emission factors for construction operations Level 1 (Average conditions).
Heavy construction areas	3.633E-05	7.266E-05	3.633E-06	WRAP – Recommended PM_{10} emission factors for construction operations Level 1 (Worst case conditions).

The following assumptions have been applied to the construction emission rate calculations:

- General construction activities have been conservatively modelled as 20 metre (width) by 100 metre (length) areas along the length of the rail. The modelled area (20 by 100 metre area) is a representative area used to consider worst case construction impacts. It does not correspond with a specific location along the rail alignment. The 100 metre length is considered an appropriate interval to calculate the worst case air quality buffer distances from the project. Air quality impacts were assessed perpendicular from the alignment beginning at the centre and extending 50 metres outwards.
- The modelling approach considers a general worst case for any of the key features of the project identified in section 5.1 that could create particulate emissions, and a general buffer distance from the project site was determined to meet the criteria.
- Emission factor used assume – WRAP – Recommended PM_{10} emission factors for construction operations Level 1 (Average conditions and worst-case conditions).
  - WRAP level 1 (average conditions) was used to model general construction areas
    - General construction activities include, track upgrading and minor adjustments, retaining wall works, drainage system construction and relocation of underground services and pipelines, service routes and signalling works and finishing and rehabilitation works.
  - WRAP level 1 (worst-case emissions) was used to model heavy construction areas
    - Heavy construction activities include de-vegetation, clearing and grubbing installation of a new track and embankment widening, bridge works and demolition.
- Adequate water supplies will be available to undertake dust suppression watering.
- Level 2 watering (> 2 $L/m^2/h$) achieving a 75% reduction in dust generation was assumed to occur at all heavy construction areas. Level 1 watering (2 $L/m^2/h$) achieving a 50% reduction in dust generation was assumed to occur at all general construction areas. Level 2 watering (> 2 $L/m^2/h$) achieving a 75% reduction in dust generation was assumed to occur at all construction areas that would occur in the same location for a year or more in duration. Emission reduction factors taken from *National Pollutant Inventory Emissions Estimation Technique Manual for Mining Version 3.1, 2012*.

5.3 Construction model settings

Given the primary air quality concern during construction is dust, a screening level dust assessment was undertaken for proposed construction activities with consideration of the Approved Methods (EPA, 2016).

Dispersion modelling for construction impacts was undertaken using AUSPLUME 6.0, a Gaussian plume dispersion model developed by the EPAV to assess the impact of airborne pollutants by computationally predicting downwind concentrations for the model inputs representative of pollutant emissions at a given physical site under a range of hourly varying meteorological conditions over a period of a year or more.

AUSPLUME was chosen to model construction impacts for the project using a simple method to create concentration versus distance graphs for pollutants based on general construction activities.

Key components of the model configuration are summarised below:

- 12 month meteorological dataset was extracted at the site from the CALMET run detailed in Appendix A.
- Model runs were undertaken for 24 hour and annual averaging periods.
- Horizontal dispersion was parameterised according to equations for the sigma-theta curves.
- Surface roughness height of 0.6 metres was used, typical of mixed commercial and residential land use.
- General construction activities have been conservatively modelled as 20 metres (width) by 100 metres (length) areas along the length of the rail. The 100 metre length is considered an appropriate discretisation interval to calculate the worst case air quality buffer distances from the easement.
- Emissions source was modelled as active from 6 am to 6 pm (12 hours) each day. Some activities will occur outside this period (night time works as described in Chapter 7 of the EIS). Assumptions and results of the construction assessment have therefore been used to assess all works.
- Emission factors used assume – WRAP – Recommended PM_{10} emission factors for construction operations Level 1 (average conditions) and Level 1 (worst case conditions). Two scenarios were modelled (average and worst case) to conservatively assess particulate impacts from all construction activities.

5.3.1 Background concentrations and averaging periods for construction impacts

The Approved Methods (EPA, 2016) approach to assess potential total impact particulate emissions is to add the measured background concentration (local measurements taken from a representative site) to corresponding model predictions. Due to the length of the new rail track and the fact that construction will move along the alignment (construction of the track will not likely occur in any one location for more than a few days), another method to assess potential construction impacts has been used.

This approach for background concentrations and averaging periods outlined below is considered appropriate as construction-based dust emissions will be time and space variant and highly variable in emission load due to activity and localised weather conditions. This non-continuous emission rate associated with construction cannot be meaningfully assessed concurrently with a contemporaneous background at a site not representative of the local area.

Background concentrations approach

Background air quality monitoring was not undertaken on site as local representative data was obtained from the Randwick and Earlwood OEH stations which are located 3.5 kilometres and 4 kilometres from the site respectively. The data is considered appropriate for this study and includes the relevant time frame (12 months) needed to undertake a level 2 assessment in accordance with the Approved Methods (EPA 2016).

The 70th percentile concentration of PM_{10} and $PM_{2.5}$ at Randwick and Earlwood OEH station has been presented in Table 4.1 for consideration in the total impact assessment. The use of the Victorian Protocol for Environmental Management (PEM) (2007) method, where the maximum predicted 24-hour average project emissions are added to a 70th percentile 24-hour average background concentration of PM_{10}, was undertaken as is commonly done in Victoria and Queensland for 24 hour average criteria.

Averaging period approach

Construction air quality impacts were assessed against the applicable assessment criteria based on the duration of construction activities. It is expected that general construction activities (including de-vegetation, clearing, grubbing, installation of a new track, track upgrades and minor adjustments) that occur over the entire earthworks and disturbance footprint will only occur for a few months at any particular location. Once the construction work is completed in a particular location, the activities begin in a different location.

Consequently, general construction activities have been assessed against the 24-hour criteria only. Assessing the general construction activity impacts against an annually averaged criteria is not considered meaningful as the proposed general construction activities will not remain in any one place for a significant period of time.

Construction activities that are expected to occur in the same location for at least one year in duration have been assessed against the annual averaged criteria. These construction activities were identified as the construction of the bridges.

5.4 Predicted construction impacts

The predicted construction dust impacts are presented as incremental and total impact results. Incremental impacts are site responsible impacts that occur directly from the project. Total impacts are resulting overall net impacts from all nearby air quality emission sources on the surrounding area. Total impacts are calculated by adding the incremental site impacts to recorded background concentrations. Background concentrations account for the impact of all existing air quality emission sources and are sourced from the nearest OEH monitoring station.

The modelled scenario assumes construction works occurring along the rail corridor and the predicted worst-case PM_{10}, $PM_{2.5}$ and TSP concentrations were calculated as concentration versus distance graphs. The 70th percentile 24 hour background concentration was added to incremental 24 hour impacts to assess the total 24 hour PM_{10} and $PM_{2.5}$ impacts (as discussed in section 5.3.1).

The next sections will look at predicted Daily and Annual construction dust impacts. The Daily impacts are expressed as the worst case (100th percentile) impacts averaged over a 24 hour period. The worst case daily impacts are predicted to occur once (for one 24 hour period) in the modelled year. Lower dust impacts are predicted for all other days (remaining 364 days of the modelled year).

The Annual impacts are expressed as the impacts averaged over the entire modelled year.

The modelling scenarios are used for assessment purposes only, and do not suggest that these impacts would occur daily or annually.

5.4.1 Daily construction impacts

The daily (24 hourly averaged) model assumed average and worst case level 1 WRAP emissions factors occurred from the entire earthworks and disturbance footprint. The model calculated the predicted 24 hour PM_{10} and $PM_{2.5}$ concentrations.

Impacts from the project are shown graphically in Figure 5.1 to Figure 5.4. These graphs show the impacts from the project (a blue line) and total impacts comprising project plus background impacts (a red line). The assessment criteria is shown using a black horizontal line. The graphs show two dust suppression water scenarios:

- The predicted daily PM_{10} and $PM_{2.5}$ concentrations during worst case construction activities with level 2 watering are shown on Figure 5.1 and Figure 5.2.
- The predicted daily PM_{10} and $PM_{2.5}$ concentrations during general construction activities with level 1 watering are shown on Figure 5.3 and Figure 5.4.

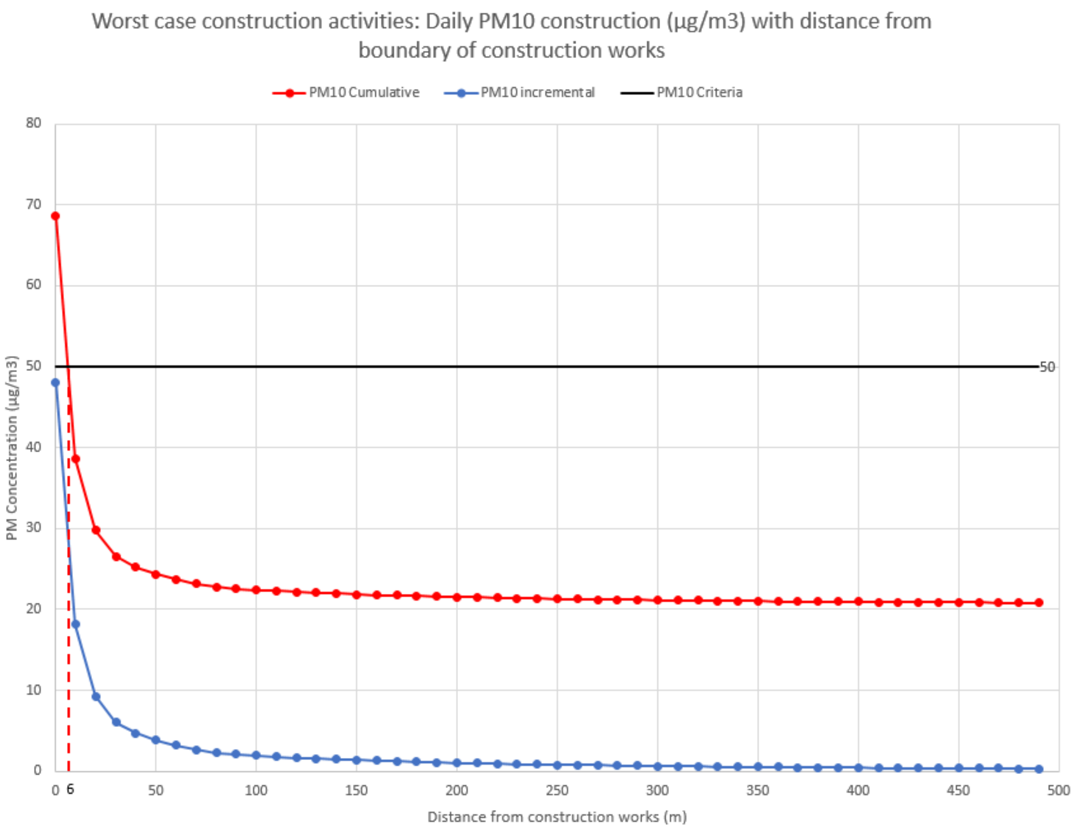


Figure 5.1 Worst case daily PM_{10} concentrations with distance from boundary of construction area (incremental and total)

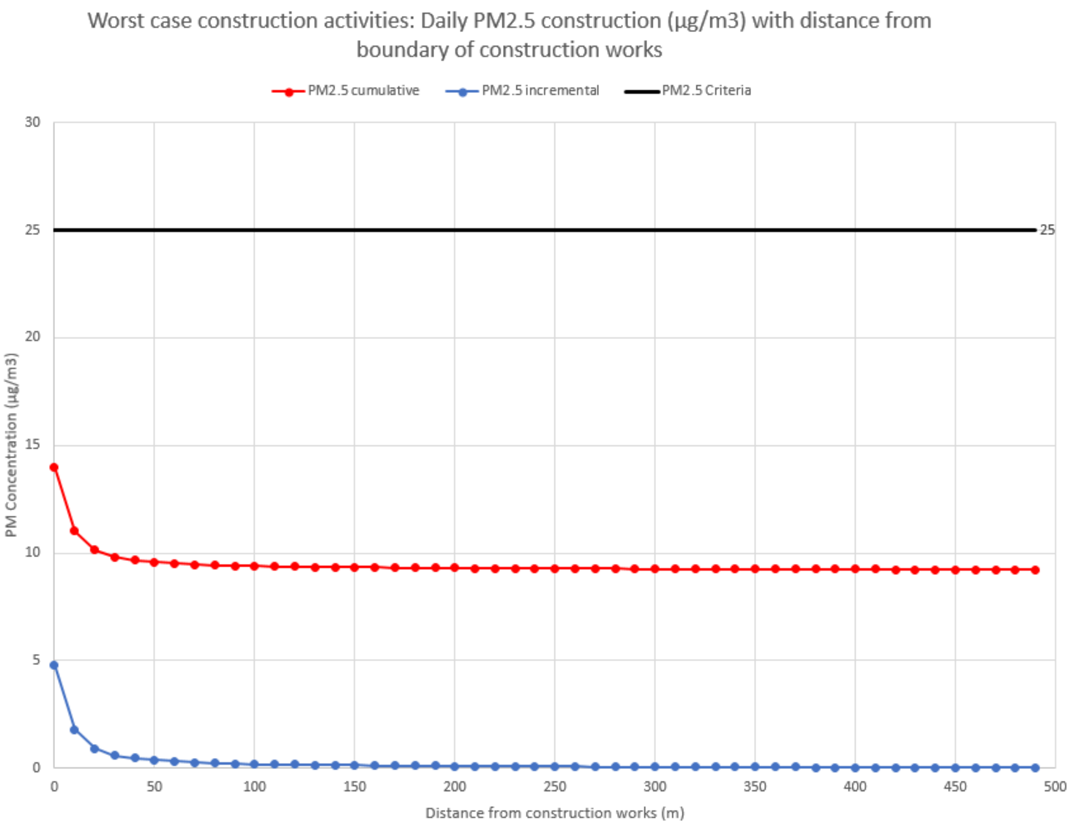


Figure 5.2 Worst case daily $PM_{2.5}$ concentrations with distance from boundary of construction area (incremental and total)

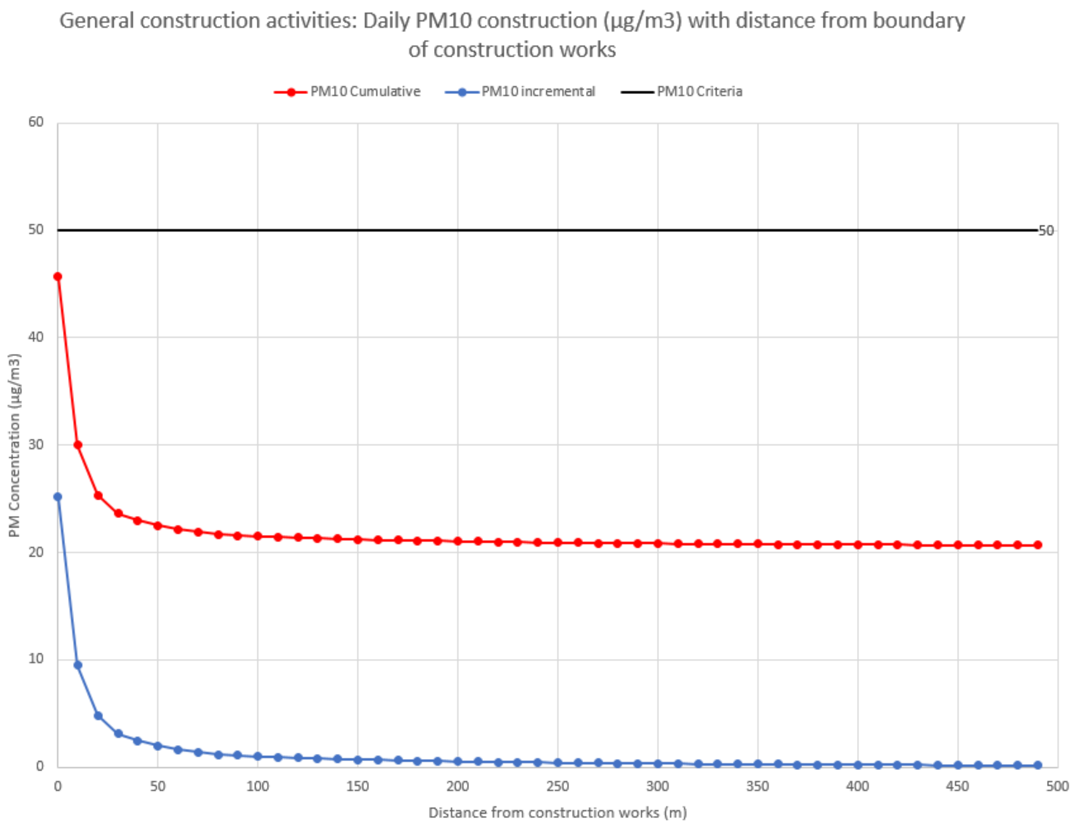


Figure 5.3 General daily PM_{10} concentrations with distance from boundary of construction area (incremental and total)

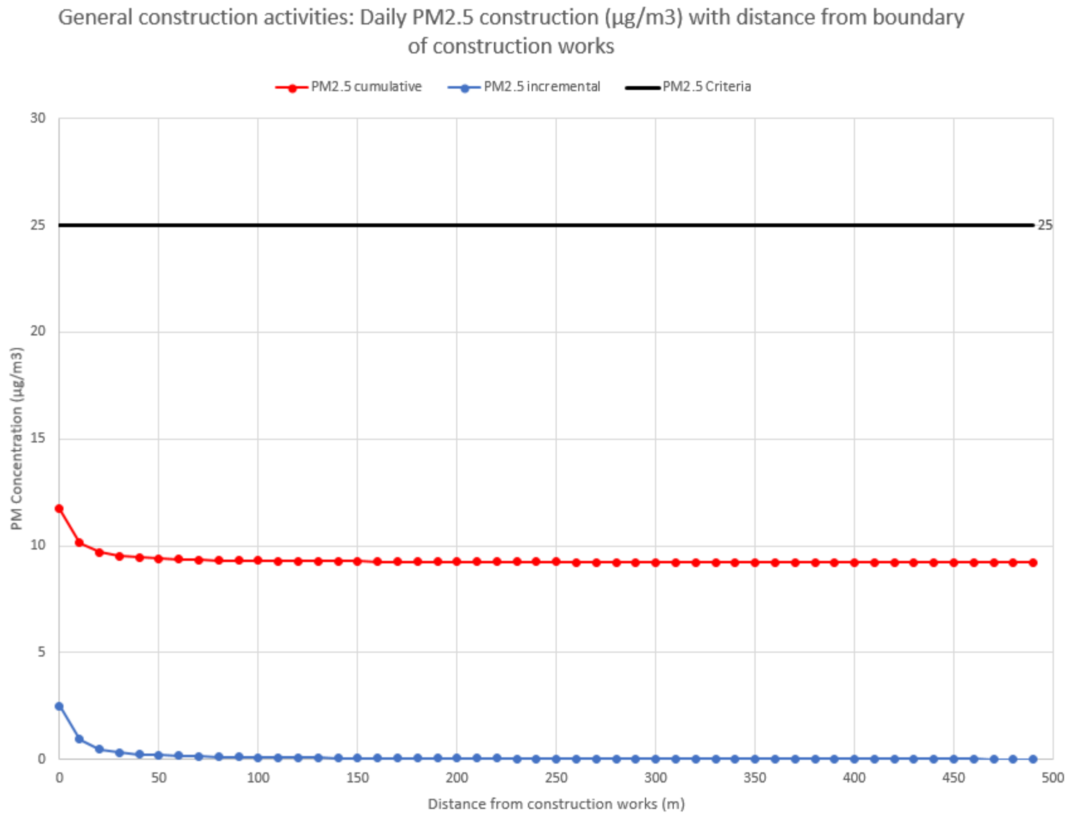


Figure 5.4 General daily $PM_{2.5}$ concentrations with distance from boundary of construction area (incremental and total)

The results of the daily assessment indicate the following:

- These graphs show that project and total impacts decrease proportionally with distance away from the site.
- Incremental impacts (impacts due to the project shown by the blue line) are relatively low compared with the assessment criteria and background concentrations. There are significant 24 hour background particulate concentrations:
  - the background PM_{10} accounts for 41% of the assessment criteria
  - the background $PM_{2.5}$ accounts for 37% of the assessment criteria.
- Worst case construction works with level 2 watering: (greater than 2 $L/m^2/h$)
  - the daily PM_{10} criteria is met at 6 metres from the site boundary of the construction works
  - the daily $PM_{2.5}$ criteria is met at the site boundary of the construction works (no off site impacts are predicted).
- Average construction works with level 1 watering (2 $L/m^2/h$)
  - the daily PM_{10} criteria is met at the site boundary of the construction works (no off site impacts are predicted)
  - the daily $PM_{2.5}$ criteria is met at the site boundary of the construction works (no off site impacts are predicted).

Incremental impacts are shown using a blue line and total impacts are shown using a red line. The assessment criteria is shown using a black horizontal line. Incremental impacts decrease proportionally with distance away from the site.

Total PM_{10} was the only pollutant the daily model predicted to exceed the assessment criteria off site. A buffer diagram was prepared to show which areas are predicted to exceed the particulate assessment criteria. A buffer diagram for PM_{10} during worst case construction with level 2 watering is shown in Figure 5.5. The buffer diagram was constructed with a 6 metre buffer zone from the proposed earthworks and disturbance footprint. All receptors within the 6 metre buffer zone are predicted to experience exceedances of the 24 hour PM_{10} criteria if worst case construction works is undertaken nearby.

Two areas of potential impact to receptors are identified in the top right (Area A) and bottom left (Area B) corners of Figure 5.5. In Area A, the 6 metre buffer zone extends on to residential properties located at 142 Banksia Street and 235 Bay Street to the east of the construction works and commercial premises (by approximately 6 metres) located at 96A Bay Street and residential properties located at 23 Myrtle Street to the west of the construction works.

In Area B, the buffer zone extends on to commercial premises at 1010-1016 Botany Road, 1008 Botany Road to the northeast of the construction works.

If construction dust is identified through visual observations and received complaints to be an issue, additional mitigation and management measure should be applied to any worst case construction works undertaken in those areas.

Additional mitigation and management measures may include:

- increase levels of mitigation such as watering
- reduce or stop work activities if visible plumes of dust are observed to blow in the direction of the residential and commercial receptors. This mitigation measure should be implemented on a case by case basis under the discretion of the site supervisor. The supervisor should take additional care to monitor (though visual inspection) activities which may be a source of elevated dust such as heavy earthworks and use of unpaved roads.

DATA SOURCE: Aerial Imagery © AUSIMAGE - Jacobs Group (Australia) Pty Ltd 2018, © Department of Finance, Services & Innovation 2018. © Water NSW - DPI-Water, 2018.

DESIGN LOT CODE

DESIGN MODEL FILES(S) USED FOR DOCUMENTATION OF THIS DRAWING - REV 3 (20190114)

PLOT DATE / TIME 20/06/2019 1:44:24 PM — PLOT BY DN

CLIENT: ARTC

BOTANY RAIL DUPLICATION

A3

Figure 5.5 Predicted Daily PM10 buffer distance (worst case construction with level 2 watering)
Air Quality Assessment

REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
A1	20/06/2019	Air Quality Assessment		

SCALES ON A1 SIZE DRAWING: 0 100 200 m, 1:10,000

CO-ORDINATE SYSTEM: MGA ZONE 56
HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY: WSP, GHD

DRG No.

TITLE	NAME	DATE
DRAWN	D.NAIKEN	20/06/2019
DRG CHECK	K YALE	20/06/2019

PREPARED FOR

RMS REGISTRATION No.

PART

ISSUE STATUS	EDMS No.	SHEET No.	ISSUE
FOR INFORMATION			A1

Document Path: U:\Projects\PS113386_ARTC_Port_Botany\5_Shared\GIS\54_Production\Maps\PS113386_GIS_054_A1.mxd

5.4.2 Annual construction impacts

It is understood that the location of earthworks and dust generating construction works will move throughout the project site as each segment of the project is completed. Therefore it is unlikely that dust generating construction works will be active in the same location for the entire duration of the construction program. Consequently, assessing the construction dust against an annually averaged criteria is not meaningful as the model assumes construction works occur at every location for the entire project leading to the model significantly over predicting potential annually averaged particulate concentrations.

To provide a conservative assessment however, annual incremental and total TSP, PM_{10} and $PM_{2.5}$ impacts for general construction activities with level 2 watering are shown in Figure 5.6, Figure 5.7 and Figure 5.8. This comprehensively assesses potential worst case air quality impacts for all long term (construction activities that occur for over a year in the same location) construction activities.

The results indicate the following:

- There are significant annual background particulate concentrations from existing sources of particulates in the area. The background PM_{10} accounts for 73% of the assessment criteria and the background $PM_{2.5}$ accounts for 98% of the assessment criteria
- General construction works with level 2 watering:
  - The annual TSP criteria is met at the site boundary of the construction works (no off site impacts are predicted).
  - The annual PM_{10} criteria is met at the site boundary of the construction works (no off site impacts are predicted).
  - The annual $PM_{2.5}$ criteria is met at 7 metres from the site boundary of the construction works.

The assessment identified the potential for elevated annually averaged $PM_{2.5}$ concentrations to occur within 7 meters of dust generating construction works if the works occur in the same location for an entire year. The $PM_{2.5}$ exceedance is attributed to high background $PM_{2.5}$ concentrations (98 per cent of assessment criteria) and relatively low incremental site specific impacts.

If dust is identified through visual observations and complaints indicate that this is an issue at any long term construction area (bridges), additional mitigation and management measure should be applied to all construction works undertaken in those areas.

Additional mitigation and management measures may include:

- increase levels of mitigation such as watering (details provided in Table 7.1)
- reduce or stop work activities if visible plumes of dust are observed to blow in the direction of the residential and commercial receptors.

Annual $PM_{2.5}$ impacts are not anticipated at any location as long term construction activities (bridge demolition and construction) are not expected to result in continual dust generation for an entire year.

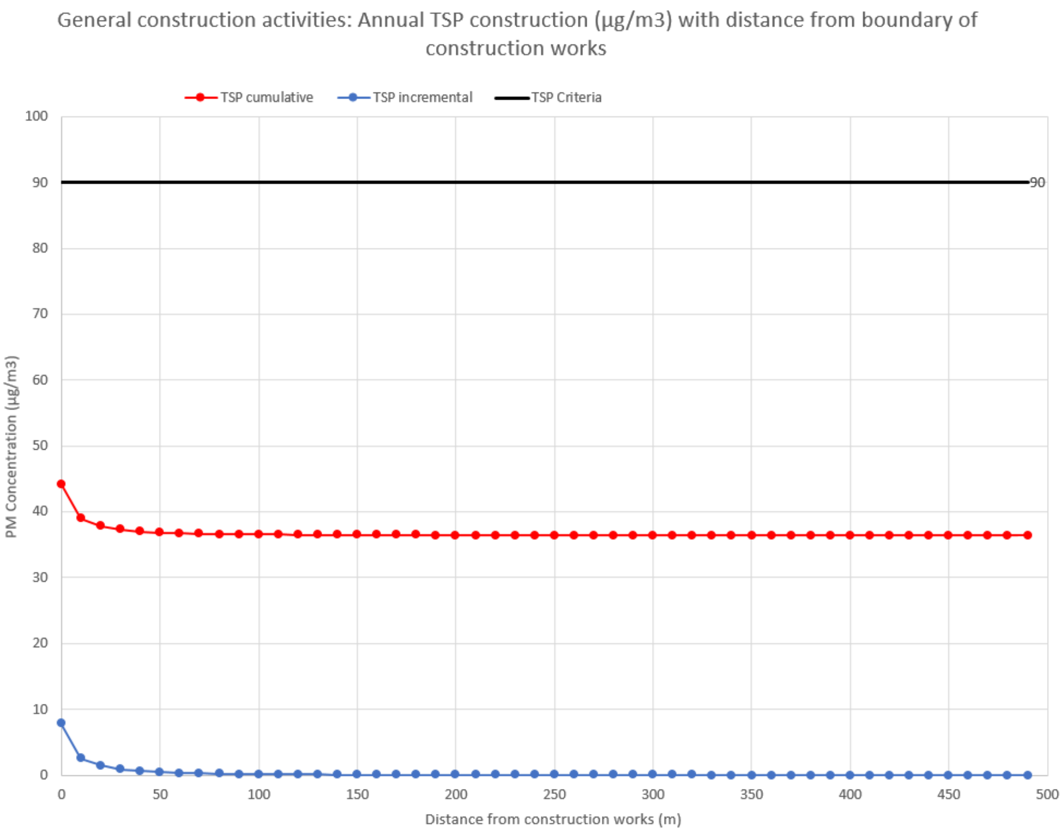


Figure 5.6 General annual TSP concentration with distance from boundary of construction area (incremental and total)

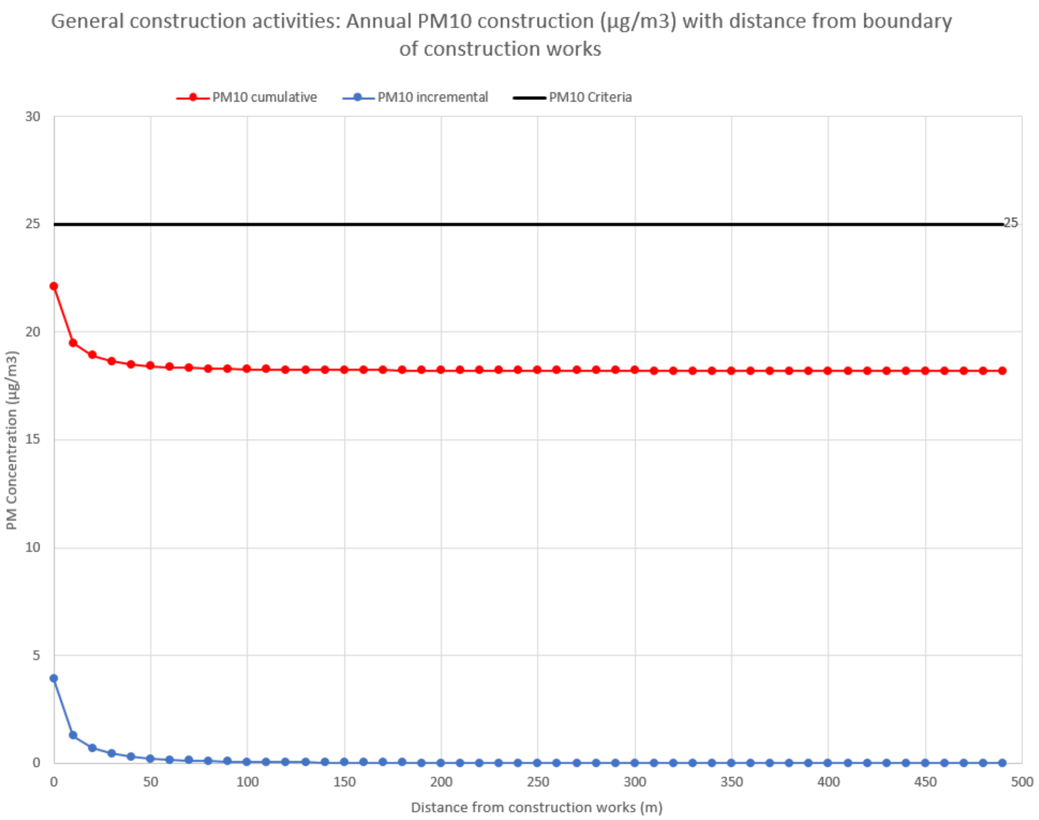


Figure 5.7 General annual PM_{10} concentration with distance from boundary of construction area (incremental and total)

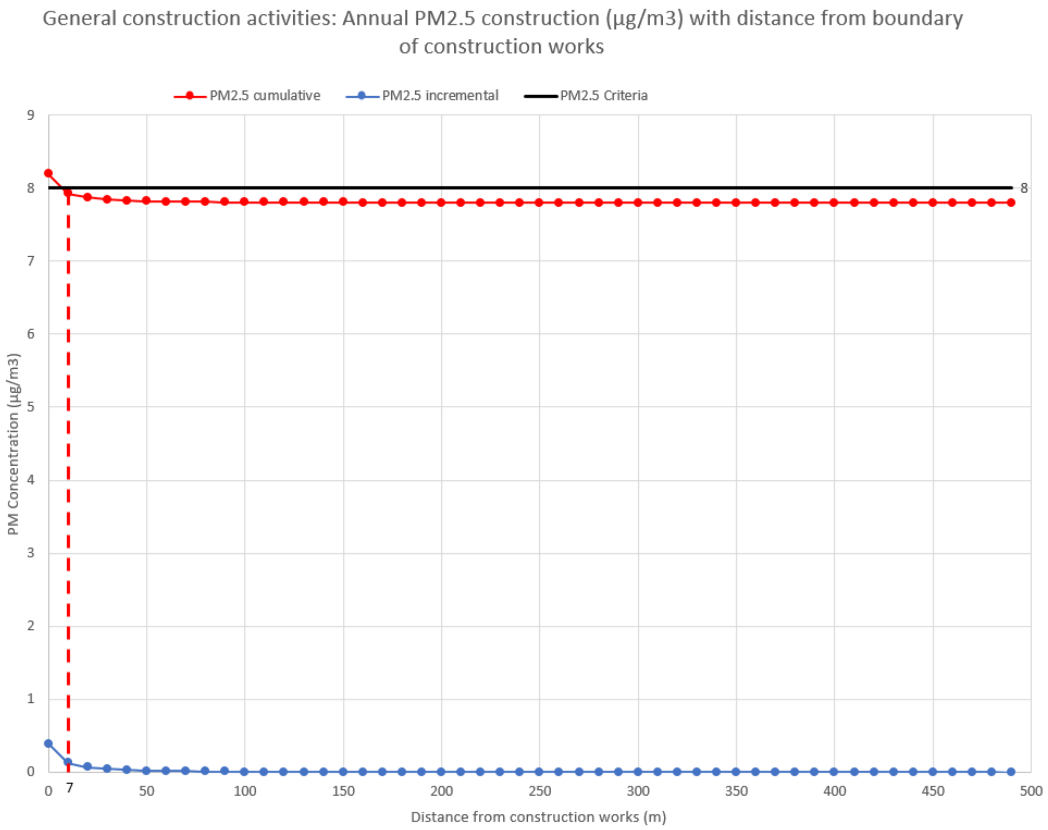


Figure 5.8 General annual $PM_{2.5}$ concentration with distance from boundary of construction area (incremental and total)

5.4.3 Impact from contaminated land

Assuming the mitigation and management measures presented in the contamination report (*Technical Report 5 – Contamination Assessment* (WSP 2019)) are incorporated into the Environment Management Plan (EMP), adverse air quality impacts from contaminated land are not expected.

5.4.4 Summary of key findings

It is acknowledged that some sensitive receptors are located within 6 metres from the project site and could experience short term elevated PM_{10} concentrations. It is expected that the location and intensity of construction works undertaken will vary significantly, depending on the daily activities, as the project is undertaken. Subsequently only short term criteria exceedances are expected. The assessment criteria taken from Air NEPM and Approved Methods were designed to protect human health and well-being. By complying with these assessment criteria, the construction phase of the project should meet air quality obligations under the POEO Act 1997 and the Clean Air Regulation 2010 as discussed in Section 2.1.1 and 2.1.2.

Implementation of the mitigation measures provided in section 7 would further minimise elevated PM_{10} concentrations and reduce potential impacts. Further detail related to air quality and human health is provided in *Technical Report 13 – Health Impact Assessment*.

Key findings of the construction impact assessment are:

- the primary emissions of concern during the construction phase was found to be dust as PM_{10} assessed over a 24 hour averaging period and $PM_{2.5}$ assessed over an annual averaging period
- there are significant background particulate concentrations. Background 24 hour concentrations account for 41% of the PM_{10} criteria and 37 per cent of the $PM_{2.5}$ criteria. Background annual concentrations account for 73 per cent of the PM_{10} criteria and 98 per cent of the $PM_{2.5}$ criteria
- daily PM_{10} and $PM_{2.5}$ criteria are met at 6 metres from and on the boundary of the construction works respectively

- annual TSP and PM_{10} criteria are met on the boundary of construction works. Annual $PM_{2.5}$ criteria is met at 7 metres from construction works. The annual $PM_{2.5}$ exceedance is attributed to high background concentrations.

5.5 Cumulative impacts

A number of other projects are anticipated to be constructed at the same time and similar location as the project such as the Sydney Gateway road project.

Potential cumulative impacts may include an exacerbation of dust impacts (PM10 and PM2.5). As the impacts from the construction of the project are predicted to be transitory and confined to an area of 7 metres from the boundary of the project site, the cumulative impacts would be minimal unless an additional source of dust (to this project) was generated close to receptors.

The potential for cumulative impacts would be mitigated through implementation of the mitigation measures proposed in section 7 of this report.

6. Operational impacts

The primary source of air quality emissions from the operation of the project are produced from locomotive movements along the track. There is potential for dust emissions and odour and pollutant emissions from the disturbance of contaminated land during maintenance activities including minor earthworks, plant movements and vegetation clearing.

6.1 Emissions from operation

6.1.1 Particulate matter

Emissions of particulate matter from freight trains are predominantly associated with the following:

- combustion-related particle emissions of diesel locomotives
- wheel and brake actions on rail lines
- entrainment of surface particles in the rail corridor.

However, the particulate matter emissions from wheel and brake actions, as well as entrainment of surface particles emissions are deemed minor (Parsons Brinckerhoff, 2012). They are sufficiently small such that they can be treated as insignificant and therefore have not been included in the dispersion modelling. Combustion related particle emissions were the only particulate source considered in this assessment.

It is expected that all maintenance works undertaken will involve little or minor dust generating activities, be infrequent and short in duration. Dust generation from maintenance works is considered insignificant and not further assessed in this report.

6.1.2 Gaseous emissions from rail movements

Gaseous emissions associated with the operation of the project are combustion engines products from diesel freight and passenger locomotives movements along the track. Combustion engines produce emissions that predominantly comprise of the following pollutants:

- nitrogen dioxide (NO_2)
- carbon monoxide (CO)
- hydrocarbons (HC)
- sulfur dioxide (SO_2)
- particulate matter with diameter less than 10 microns (PM_{10}) and less than 2.5 microns ($PM_{2.5}$).

The quantity of the above pollutants emitted by locomotive operation depends on the following locomotive operational parameters:

- locomotive type
- locomotive speed
- locomotive notch
- locomotive movement (pass bys) frequency.

6.1.3 Odour and pollutant emissions

There is potential for odour and pollutant emissions from contaminated areas to occur during the operation of the project. The contamination report (*Technical Report 5 – Contamination Assessment* (WSP 2019)) noted that the design of the rail embankment proposes management of contaminations risk via encapsulation instead of remediation (removal of contaminated soil). Consequently there is likely to be an ongoing liability and a requirement for ongoing management of potential contamination risk during operation of the upgraded rail line.

The requirement for management and/or monitoring of potential contamination risks during operation will be dependent on the final design of construction elements.

Consequently, the likely air quality impacts are dependent on how the contaminated areas are treated during the construction of the project. This is not currently known.

Additionally the contamination report (*Technical Report 5 – Contamination Assessment* (WSP 2019)) provides mitigation and management measures to be implemented during the operation of the project to manage the containment of contaminated soils and soil erosion and sedimentation.

Assuming the appropriate mitigation and management measures are implemented, adverse air quality impacts from contaminated land are not expected.

6.2 Operational scenarios

To account for all present and future operational possibilities, the following operational scenarios provided by ARTC have been considered (scenario number provided in brackets):

- existing (2019) (S1)
- at opening no build (2024) (S2)
- at opening build (2024) (S3)
- 10 year future no build (2034) (S4)
- 10 year future build (2034) (S5).

The 'no build' scenarios incorporated the existing track alignment, existing track features such as crossovers, bridges and level crossings, and existing operational features such as train speeds.

The 'build' scenarios incorporated the proposed design of the project which includes all new works, bridges, proposed track modifications, and changes to civil structures such as cuttings and embankments. This scenario also includes the proposed operational changes such as increased train speeds and volumes.

These scenarios were used in the air quality modelling for the year of opening and the 10-year design year, for both 'no build' and 'build' operational scenarios.

The following sections outline the locomotive parameters for each of the above operational scenarios.

6.3 Locomotive emission rates

Adopted locomotive emission rates were based on a recent investigation titled *Diesel Locomotive Fuel Efficiency and Emissions Testing: Prepared for NSW EPA* (ABMARC, 2016). The study examined the fuel efficiency and emission performance of two classes of locomotive that are commonly used in NSW freight operations. Average fuel efficiency and emission performance was available for NO_X, CO, Hydrocarbons (HC) and particulate matter.

The Approved Methods (EPA, 2016) does not provide an assessment criteria for total HC. HC emissions for the purpose of this study are assumed to be benzene in order to be assessed against an appropriate impact assessment criteria. Benzene would only make up a fraction of total hydrocarbon emissions. Consequently, HC emissions were speciated into benzene emissions based on emission factors presented in the *National Pollutant Inventory emission estimation technique manual for combustion engines Version 3* (2008).

It is expected that most freight trains on the existing rail line and duplication would consist of locomotives like the NR Class locomotive (NR121) and 93 class locomotives (9317). Data for a 93 class locomotive (9317) was adopted to model train pass by emission rates and is a conservative scenario.

The locomotive alternator power output for operation at each notch was sourced from a diesel locomotive emissions report prepared by Lilley (1996). The emission of SO_2 was calculated based on a sulfur fuel content of 5000 ppm using an emission factor from the National Pollutant Inventory emission estimation technique manual for combustion engines Version 3 (2008). $PM_{2.5}$ emissions were estimated as 0.97 times the PM_{10} emission as recommended in Emission Factors for Locomotives (US EPA, 2009). The adopted locomotive emission rates are presented in Table 6.1 in grams per hour (g/hr).

Table 6.1 Locomotive pollutant emission rates

Operating notch	Alternator output (kW)	Pollutant					
		NO_X (g/hr)	CO (g/hr)	HC (as Benzene) (g/hr)	SO_2 (g/hr)	PM_{10} (g/hr)	$PM_{2.5}$ (g/hr)
Idle	6	317	42	0	7	6	6
1	180	3,762	193	2	221	40	38
2	335	5,695	302	2	410	54	52
3	750	14,775	1,020	5	919	143	138
4	920	16,652	2,291	6	1127	147	143
5	1,390	19,182	2,016	7	1703	167	162
6	2,000	25,200	1,940	9	2450	200	194
7	2,630	32,612	2,051	10	3222	237	230
8	2,940	29,400	3,146	11	3602	235	228

6.3.1 Locomotive speed

Locomotive speed profiles showing the typical speed of locomotives travelling though the study area were provided by ARTC. Locomotive maximum and minimum speeds are presented in Table 6.2 in kilometres per hour (km/h).

Table 6.2 Locomotive maximum and minimum speeds

Scenario	Train Speed (km/h)	
	max	min
2019 Existing (S1)	30	10
2024 At opening no build (S2)	30	10
2024 At opening build (S3)	45	30
2034 Future no build (S4)	30	10
2034 Future build (S5)	45	30

6.3.2 Locomotive notch

Locomotive notch setting (throttle position) can fluctuate significantly based on various factors including train speed and terrain incline or decline. The locomotive notch setting (throttle position) corresponds to the engine power output and is used to control the speed of the locomotive. Notch 1 is the slowest speed (lowest power output) and notch 8 is the fastest speed (highest power output). If the locomotive operator increases the notch setting (from 2 to 3), the locomotive engine increase power output and the locomotive will accelerate. Conversely, if the operator decreases the notch setting (from 3 to 2), the locomotive will deaccelerate. Estimated notch settings for each operational scenario are presented in Table 6.3.

Table 6.3 Locomotive notch setting

Scenario	Notch setting	
	max	min
2019 Existing (S1)	3	2
2024 At opening no build (S2)	3	2
2024 At opening build (S3)	4	3
2034 Future no build (S4)	3	2
2034 Future build (S5)	4	3

6.3.3 Locomotive movements

Train movement (pass by) quantities have been provided by ARTC. trains to and from Port Botany for daytime and night-time periods are presented in Table 6.4. It is acknowledged that the actual train movements will be heavily dependent on demand so peak (maximum expected) train movements have been provided and used to predict worst case impacts.

A summary of peak and daily average train pass bys per hour are presented in Table 6.5. These are assumed for modelling to have one operational locomotive per train.

Table 6.4 Detailed train movements

Scenario	Train movements			
	Daytime (7 am–10 pm)		Night-time (10 pm–7 am)	
	To Port Botany	From Port Botany	To Port Botany	From Port Botany
2019 Existing (S1) (total)	40			
2024 At opening no build (S2)	24	24	14	14
2024 At opening build (S3)	24	24	14	14
2034 Future no build (S4)	28	28	17	17
2034 Future build (S5)	35	35	21	21

Table 6.5 Summarised train movements

Scenario	Maximum train pass bys in the time period		
	Peak 1 hour period (train per hour)	Average 24 hour period (train per day)	Average 24 hour equivalent (train per hour)
2019 Existing (S1)	4[1]	40	1.7
2024 At opening no build (S2)	7	76	3.2
2024 At opening build (S3)	7	76	3.2
2034 Future no build (S4)	7	90	3.8
2034 Future build (S5)	12	112	4.7

(1) 2019 Existing Peak 1 hour train movements estimated based on a similar ratio as other scenarios.

6.3.4 Locomotive movement emissions

The total pollutant emissions from locomotive movements for each scenario averaged over 1 hour and 24 hour periods are presented in Table 6.6 (assuming one operational locomotive per train). These are the pollutant emissions that are expected to occur from locomotives travelling along the track.

Locomotive emissions were calculated assuming worst case notch (throttle position) and speed that resulted in the highest emissions. Locomotives were assumed to travel at that worst case speed/notch for the entire length of track. Worst case emissions occurred when locomotives travel at their slowest speed. The existing and no build scenarios assumed all locomotives travelled at 10 km/h (notch 2) and the build scenarios assumed locomotives travelled at 30 km/h (notch 3).

The emission rates provided in Table 6.6 were included in the dispersion model to predict the air quality impacts presented in section 6.5.

Table 6.6 Scenario emissions rates

Scenario	Pollutant emissions rate (g/s)					
	NO_X	CO	Benzene	SO_2	PM_{10}	$PM_{2.5}$
Peak 1 hour emissions						
2019 Existing (S1)	2.2	0.12	0.00074	0.16	0.021	0.020
2024 At opening no build (S2)	3.9	0.21	0.0013	0.28	0.036	0.035
2024 At opening build (S3)	3.4	0.23	0.0011	0.21	0.032	0.031
2034 Future no build (S4)	3.9	0.21	0.0013	0.28	0.036	0.035
2034 Future build (S5)	5.7	0.40	0.0019	0.36	0.055	0.054
24 hour average emissions						
2019 Existing (S1)	0.92	0.049	0.00031	0.066	0.0087	0.0084
2024 At opening no build (S2)	1.8	0.093	0.00059	0.13	0.017	0.016
2024 At opening build (S3)	1.5	0.10	0.00051	0.09	0.015	0.014
2034 Future no build (S4)	2.1	0.11	0.00070	0.15	0.020	0.019
2034 Future build (S5)	2.2	0.15	0.00075	0.14	0.022	0.021

6.4 Operational model settings

Atmospheric dispersion modelling was carried out using the CALPUFF version 6 dispersion model. CALPUFF is a non-steady-state, Gaussian puff dispersion model. It is accepted for use by the OEH and NSW EPA for application in environments where wind patterns and plume dispersion is strongly influenced by complex terrain, the land-sea interface or where there is a high frequency of stable calm night-time conditions. CALPUFF was chosen to model the project locomotives along the alignment simultaneously as described below.

All model settings were selected based on the recommendations provided in the Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods (EPA, 2016) for the Modelling and Assessments of Air Pollutants in NSW, Australia (2011).

For this assessment, the CALPUFF dispersion model was used to predict ground-level concentrations of pollutants from the project. The grid size used in the CALPUFF model was equivalent to the CALMET domain. The same grid resolution of 200 metre used for the CALMET model run was used in CALPUFF.

Chemical transformations were not modelled within CALPUFF, however as discussed in more detail below, the formation of NO2 from NOx from combustion has been assessed using Method 2 in the Approved Methods (EPA, 2016). Method 2 limits the conversion of NOx into NO2 based on ambient ozone concentrations taking into consideration of NO reacting with ozone in the atmosphere to form NO2. Background ozone data was sourced from the OEH station at Randwick for the year 2014. Additional assumptions relevant to the operational air dispersion modelling include:

- locomotive movements were modelled as a series of volume sources (line volume) along the length of the rail track duplication. A total of 172 volume sources were used to model locomotive movements emissions along the rail track. Volume sources were sized at 10 metres by 10 metres with a vertical dimension of 6 metres
- emissions rates have been modelled as constant (24 hours per day, 7 days per weeks).

6.4.1 Pollutant averaging period

Locomotive emissions from all scenarios (refer to section 6.2) were assessed to account for all existing and future operational scenarios. The worst case 1 hour and 24 hour emissions from each scenario were modelled.

Worst case 1 hour emissions were used to assess pollutant 10 minute, 15 minute, 1 hour and 8 hour averaged criteria. Worst case 24 hour emissions were used to assess pollutant 24 hour and annually averaged criteria.

The Approved Methods (EPA, 2016) include a criteria for SO_2 and CO using an averaging period of 10 and 15 minutes respectively. Due to modelling constraints, the CALPUFF model calculates concentrations at 1 hour averaged intervals. Therefore, the 10 minute SO_2 and 15 minute CO averaged concentrations have been calculated from the 1 hour averaged concentration using the peak to mean ratio shown in the equation below:

$$C_t = C_{60} \times \left(\frac{60}{t}\right)^{0.2}$$

Where;

C_t = Concentration of pollutant over averaging time t

C_{60} = Concentration of pollutant over a 60 minute averaging time

t = desired averaging time of pollutant in minutes

6.4.2 Operational background concentrations

Total pollutant concentrations have been calculated using the 100th percentile background pollutant data from the Randwick and Earlwood OEH monitoring stations as per guidance provided in the Approved Methods (EPA 2016).

6.5 Predicted operational impacts

The following sections present the predicted pollutant impacts. Results tables are presented below and contour plot are provided in Appendix D.

Predicted operational impacts for each pollutant are provided in the sections below and show the predicted concentrations compared to the assessment criteria.

The results of the operational impact assessment consider the incremental (project generated) or total impact (project generated plus existing background air quality) emissions.

6.5.1 Predicted NO_2 concentrations

NO2 concentrations were predicted as incremental and total annual and 1 hour 100th percentile concentrations. 1 hour NO2 incremental and total concentrations were calculated using Method 2 from the Approved Methods (EPA, 2016). Hourly background NO2 and O3 data was sourced from the Randwick OEH monitoring station and matched with obtained predicted hourly NOx concentrations. Annual NO2 concentrations were calculated using Method 1 from the Approved Methods (EPA, 2016).

Predicted NO2 concentrations and the assessment criteria are presented in Table 6.7. No incremental or total exceedances of the criteria are predicted.

Table 6.7 Predicted increment and total NO_2 concentrations

Receptor	Predicted NO_2 concentrations (µg/m³)																			
	Incremental										Total									
Averaging period	1 hour					Annual					1 hour					Annual				
Situation	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Criteria	246					62					246					62				
R01	89	100	97	100	113	1	2	2	3	3	106	117	114	117	130	12	13	13	14	14
R02	70	86	84	86	106	3	6	5	7	8	89	103	101	103	115	14	17	16	18	19
R03	89	105	97	105	133	4	7	6	8	9	105	124	114	124	159	15	18	17	19	20
R04	78	102	95	102	129	4	8	7	10	11	100	114	106	114	144	15	19	18	21	22
R05	88	119	109	119	153	4	7	7	9	10	100	125	114	125	162	15	18	18	20	21
R06	87	117	107	117	150	4	8	7	9	10	92	119	109	119	153	15	19	18	20	21
R07	85	103	96	103	130	3	5	4	6	6	102	127	117	127	164	14	16	15	17	17
R08	81	106	98	106	134	5	9	7	10	11	94	106	103	106	134	16	20	18	21	22
R09	91	110	108	110	128	3	7	6	8	8	108	129	118	129	166	14	18	17	19	19
R10	85	113	104	113	145	4	8	7	9	10	105	125	114	125	163	15	19	18	20	21
R11	85	114	105	114	146	4	8	7	10	11	101	114	108	114	146	15	19	18	21	22
R12	87	117	107	117	150	5	9	8	11	11	104	117	113	117	150	16	20	19	22	22
R13	92	123	121	123	143	8	16	14	19	20	111	131	129	131	155	19	27	25	30	31
R14	101	114	111	114	122	3	7	6	8	8	110	123	121	123	138	14	18	17	19	19
R15	100	125	123	125	163	10	20	17	24	25	119	138	132	138	163	21	31	28	35	36

Receptor	Predicted NO_2 concentrations (µg/m^3)																			
	Incremental										Total									
R16	88	99	95	99	123	5	10	9	12	13	105	116	112	116	135	16	21	20	23	24
R17	78	95	93	95	112	9	18	15	21	23	114	120	119	120	127	20	29	26	32	34
R18	68	92	91	92	121	5	9	7	10	11	89	106	104	106	129	16	20	18	21	22
R19	69	76	74	76	98	3	7	6	8	8	105	114	113	114	121	14	18	17	19	19
R20	66	74	70	74	98	2	3	3	4	4	96	103	101	103	127	13	14	14	15	15

6.5.2 Predicted CO concentrations

The predicted incremental 15 minute, 1 hour and 8 hour 100th percentile CO concentrations are presented in Table 6.8. In the absence of background monitoring data at either the Randwick or Earlwood OEH station, no total impact assessment has been undertaken however predicted incremental results are orders of magnitude below the criteria.

For an indicative reference, the maximum 1 hour CO background from Chullora OEH monitoring station (Chullora monitoring station is located in a similar urban environment with a rail corridor nearby, CO data taken for 2018–2019 calendar period) was 4,140 µg/m3. The Chullora background concentration accounts for 13.8% of the assessment criteria. The highest predicted incremental 1 hour concentration at any receptor is 97 µg/m3, this accounts for 0.3% of the assessment criteria.

Adding this conservative indicative background concentration to all incremental CO concentration presented in Table 6.8 would result in all total concentrations significantly below the assessment criteria (30,000 µg/m3).

No incremental or total exceedances of the criteria are predicted. A contour plot of the maximum incremental 1 hour CO impact during the worst case scenario (S5) is presented on Appendix D, Figure D.1.

Table 6.8 Predicted CO concentrations

Receptor	Incremental CO concentrations (µg/m³)														
Averaging period	**15 minutes**					**1 hour**					**8 hours**				
Situation	**S1**	**S2**	**S3**	**S4**	**S5**	**S1**	**S2**	**S3**	**S4**	**S5**	**S1**	**S2**	**S3**	**S4**	**S5**
Criteria (µg/m³)	**100,000**					**30,000**					**10,000**				
R01	15	27	30	27	52	12	20	23	20	39	2	4	5	4	8
R02	17	30	34	30	58	13	23	26	23	44	3	6	6	6	11
R03	29	51	58	51	99	22	39	44	39	75	5	9	10	9	17
R04	25	44	50	44	85	19	33	38	33	65	5	9	11	9	18
R05	34	60	67	60	116	26	45	51	45	88	7	13	14	13	24
R06	29	50	56	50	97	22	38	43	38	73	5	9	10	9	17
R07	30	53	60	53	103	23	40	45	40	78	5	8	9	8	15
R08	23	41	46	41	80	18	31	35	31	60	4	8	9	8	15
R09	31	54	61	54	105	23	41	46	41	80	5	9	10	9	18
R10	31	54	61	54	105	24	41	46	41	80	6	10	11	10	19
R11	31	55	62	55	107	24	42	47	42	81	6	11	12	11	21
R12	34	60	68	60	117	26	46	52	46	86.0	7	12	14	12	24
R13	32	56	63	56	108	24	42	48	42	82	5	9	11	9	18
R14	25	43	48	43	83	19	33	37	33	63	5	9	10	9	17
R15	38	66	75	66	128	29	50	57	50	97	7	13	15	13	25
R16	27	48	54	48	92	21	36	41	36	70	5	9	10	9	17

Receptor	Incremental CO concentrations (µg/m³)														
R17	27	48	54	48	93	21	36	41	36	70	7	12	13	12	22
R18	23	40	46	40	78	17	31	35	31	59	4	7	8	7	14
R19	23	40	45	40	78	17	31	34	31	59	4	7	8	7	14
R20	22	39	44	39	76	17	30	33	30	58	3	5	5	5	9

6.5.3 Predicted HC (as benzene) concentrations

The predicted incremental 1 hour 99.9th percentile HC concentration (as benzene) and assessment criteria is presented in Table 6.9.

No incremental exceedances of the criteria are predicted. A contour plot of predicted incremental HC (as benzene) concentrations during the worst case scenario (S5) is provided on Appendix D, Figure D.2.

Background HC concentrations (as benzene) are not recorded at any OEH station. Consequently no total impact HC (as benzene) assessment was undertaken. The predicted incremental results are orders of magnitude below the criteria, therefore no total HC (as benzene) criteria exceedances are anticipated.

Table 6.9 Predicted incremental HC (as benzene) concentrations

Receptor	HC (as Benzene) concentration (µg/m^3)				
Averaging period	**1 hour**				
Situation	**S1**	**S2**	**S3**	**S4**	**S5**
Criteria (µg/m^3)	**29**				
R01	0.04	0.07	0.06	0.07	0.10
R02	0.05	0.09	0.08	0.09	0.13
R03	0.08	0.14	0.12	0.14	0.20
R04	0.08	0.14	0.12	0.14	0.20
R05	0.11	0.20	0.17	0.20	0.30
R06	0.06	0.11	0.10	0.11	0.17
R07	0.09	0.15	0.13	0.15	0.22
R08	0.06	0.10	0.09	0.10	0.15
R09	0.08	0.14	0.12	0.14	0.20
R10	0.10	0.18	0.16	0.18	0.27
R11	0.08	0.14	0.12	0.14	0.21
R12	0.10	0.17	0.15	0.17	0.25
R13	0.11	0.19	0.17	0.19	0.28
R14	0.08	0.14	0.12	0.14	0.21
R15	0.11	0.20	0.17	0.20	0.30
R16	0.07	0.12	0.10	0.12	0.17

Receptor	HC (as Benzene) concentration (µg/m^3)				
R17	0.09	0.16	0.14	0.16	0.24
R18	0.06	0.10	0.08	0.10	0.15
R19	0.06	0.10	0.09	0.10	0.15
R20	0.04	0.08	0.07	0.08	0.12
Maximum in study area (100th percentile)	0.18	0.32	0.27	0.32	0.47

6.5.4 Predicted SO_2 concentrations

The predicted incremental 100th percentile SO_2 concentrations and assessment criteria for each averaging period are presented in Table 6.10. No incremental criteria exceedances are predicted. A contour plot of predicted incremental 1 hour SO_2 concentrations during the worst case scenario (S5) is provided on Appendix D, Figure D.3.

Table 6.10 Predicted incremental SO_2 concentrations

Receptor	SO_2 incremental concentrations																			
Averaging period	**10 minutes**					**1 hour**					**24 hour**					**Annual**				
Situation	**S1**	**S2**	**S3**	**S4**	**S5**	**S1**	**S2**	**S3**	**S4**	**S5**	**S1**	**S2**	**S3**	**S4**	**S5**	**S1**	**S2**	**S3**	**S4**	**S5**
Criteria	**712**					**570**					**228**					**60**				
R01	23	39	29	39	51	16	28	21	28	35	1	1	1	1	1	0	0	0	0	0
R02	26	45	33	45	57	18	31	23	31	40	1	2	1	2	2	0	0	0	1	0
R03	43	75	56	75	97	30	53	39	53	67	1	2	2	3	2	0	0	0	1	1
R04	37	65	48	65	83	26	45	34	45	58	1	2	2	3	3	0	1	0	1	1
R05	51	88	66	88	113	35	62	46	62	79	2	3	2	4	3	0	1	0	1	1
R06	42	74	55	74	94	30	52	38	52	66	1	2	1	2	2	0	1	0	1	1
R07	45	78	58	78	100	31	55	41	55	70	1	2	2	2	2	0	0	0	0	0
R08	35	61	45	61	78	24	42	32	42	54	1	2	1	2	2	0	1	0	1	1
R09	46	80	60	80	103	32	56	42	56	72	1	2	2	3	3	0	0	0	1	1
R10	46	80	60	80	103	32	56	42	56	72	1	2	2	3	3	0	1	0	1	1
R11	47	81	61	81	104	33	57	42	57	73	1	3	2	3	3	0	1	0	1	1
R12	51	89	66	89	114	36	62	46	62	80	2	3	2	4	3	0	1	0	1	1
R13	47	83	61	83	106	33	58	43	58	74	2	3	3	4	4	1	1	1	1	1
R14	36	63	47	63	81	25	44	33	44	57	1	2	1	2	2	0	0	0	1	1
R15	56	98	73	98	125	39	68	51	68	87	2	4	3	5	5	1	1	1	2	2
R16	40	70	52	70	90	28	49	37	49	63	1	2	2	3	2	0	1	1	1	1

Receptor	SO_2 incremental concentrations																			
R17	41	71	53	71	91	28	49	37	49	63	2	3	3	4	4	1	1	1	2	1
R18	34	60	44	60	76	24	42	31	42	53	1	2	2	3	2	0	1	0	1	1
R19	34	59	44	59	76	24	42	31	42	53	1	2	1	2	2	0	0	0	1	1
R20	33	58	43	58	74	23	40	30	40	52	1	1	1	1	1	0	0	0	0	0

The predicted total 100th percentile SO_2 concentrations and assessment criteria for each averaging period are presented in Table 6.11. Maximum background SO_2 concentrations were obtained from the Randwick OEH monitoring station for all averaging periods. No total criteria exceedances are predicted.

Table 6.11 Predicted total SO_2 concentrations

Receptor	**SO_2 total concentrations**														
Averaging period	**1 hour**					**24 hour**					**Annual**				
Situation	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S2**	**S3**	**S4**	**S5**
Criteria	**570**					**228**					**60**				
R01	84	96	89	96	103	11	12	11	12	12	2	3	3	3	3
R02	86	99	91	99	108	11	12	12	12	12	3	3	3	3	3
R03	98	121	107	121	136	12	13	12	13	13	3	3	3	3	3
R04	94	114	102	114	126	12	13	12	13	13	3	3	3	3	3
R05	104	130	114	130	147	12	14	13	14	14	3	3	3	3	3
R06	98	120	107	120	134	11	12	12	13	13	3	3	3	3	3
R07	100	123	109	123	138	12	13	12	13	13	3	3	3	3	3
R08	92	110	100	110	122	11	12	12	13	12	3	3	3	3	3
R09	100	124	110	124	140	12	13	12	13	13	3	3	3	3	3
R10	100	124	110	124	140	12	13	12	13	13	3	3	3	3	3
R11	101	125	110	125	141	12	13	13	14	14	3	3	3	3	3
R12	104	130	114	130	148	12	14	13	14	14	3	3	3	3	3
R13	101	126	111	126	142	12	14	13	15	14	3	4	3	4	4
R14	94	112	101	112	125	12	12	12	13	13	3	3	3	3	3
R15	107	136	119	136	156	13	15	14	16	15	3	4	3	4	4
R16	96	117	105	117	131	12	13	12	13	13	3	3	3	3	3

Receptor	SO_2 total concentrations														
R17	96	118	105	118	131	12	14	13	15	14	3	4	3	4	4
R18	92	110	99	110	121	12	13	12	13	13	3	3	3	3	3
R19	92	110	99	110	121	11	12	12	12	12	3	3	3	3	3
R20	91	109	98	109	120	11	12	11	12	12	3	3	3	3	3

6.5.5 Predicted PM_{10} concentrations

The predicted 24 hour and annual 100th percentile PM_{10} concentrations are presented in Table 6.12. Background PM_{10} concentrations were sourced from the Randwick OEH monitoring station. Background 24 hour and annual PM_{10} concentrations were high. The background 24 hour concentration accounted for 92% of the 24 hour criteria and the background annual concentration accounted for 73% of the annual criteria.

No incremental or total criteria exceedances are predicted for both daily and annual averaging periods. A contour plot of the predicted incremental 24 hour PM_{10} concentrations during the worst case scenario (S5) is provided on Appendix D, Figure D.4.

Table 6.12 Predicted increment and total PM_{10} concentrations

Receptor	**Predicted PM_{10} concentrations (µg/m³)**																			
	Incremental										**Total**									
Averaging period	**24 hour**					**Annual**					**24 hour**					**Annual**				
Situation	**S1**	**S2**	**S3**	**S4**	**S5**	**S1**	**S2**	**S3**	**S4**	**S5**	**S1**	**S2**	**S3**	**S4**	**S5**	**S1**	**S2**	**S3**	**S4**	**S5**
Criteria	**50**					**25**					**50**					**25**				
R01	0.1	0.1	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.0	46	46	46	46	46	18	18	18	18	18
R02	0.1	0.2	0.2	0.2	0.3	0.0	0.1	0.1	0.1	0.1	46	46	46	46	46	18	18	18	18	18
R03	0.1	0.3	0.2	0.3	0.4	0.0	0.1	0.1	0.1	0.1	46	46	46	46	46	18	18	18	18	18
R04	0.2	0.3	0.3	0.4	0.4	0.0	0.1	0.1	0.1	0.1	46	46	46	46	47	18	18	18	18	18
R05	0.2	0.4	0.4	0.5	0.5	0.0	0.1	0.1	0.1	0.1	46	47	46	47	47	18	18	18	18	18
R06	0.1	0.2	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.1	46	46	46	46	46	18	18	18	18	18
R07	0.1	0.3	0.2	0.3	0.3	0.0	0.0	0.0	0.1	0.1	46	46	46	46	46	18	18	18	18	18
R08	0.1	0.2	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.1	46	46	46	46	46	18	18	18	18	18
R09	0.2	0.3	0.3	0.4	0.4	0.0	0.1	0.1	0.1	0.1	46	46	46	46	46	18	18	18	18	18
R10	0.2	0.3	0.3	0.4	0.4	0.0	0.1	0.1	0.1	0.1	46	46	46	46	47	18	18	18	18	18
R11	0.2	0.4	0.3	0.4	0.5	0.0	0.1	0.1	0.1	0.1	46	46	46	47	47	18	18	18	18	18
R12	0.2	0.4	0.4	0.5	0.5	0.0	0.1	0.1	0.1	0.1	46	47	46	47	47	18	18	18	18	18
R13	0.2	0.4	0.4	0.5	0.6	0.1	0.2	0.1	0.2	0.2	46	47	46	47	47	18	18	18	18	18
R14	0.1	0.3	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.1	46	46	46	46	46	18	18	18	18	18
R15	0.3	0.6	0.5	0.7	0.7	0.1	0.2	0.2	0.2	0.2	46	47	47	47	47	18	18	18	18	18

Receptor	Predicted PM_{10} concentrations (μg/m^3)																			
	Incremental										Total									
R16	0.2	0.3	0.3	0.3	0.4	0.1	0.1	0.1	0.1	0.1	46	46	46	46	46	18	18	18	18	18
R17	0.2	0.4	0.4	0.5	0.6	0.1	0.2	0.1	0.2	0.2	46	47	46	47	47	18	18	18	18	18
R18	0.1	0.3	0.2	0.3	0.4	0.0	0.1	0.1	0.1	0.1	46	46	46	46	46	18	18	18	18	18
R19	0.1	0.2	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.1	46	46	46	46	46	18	18	18	18	18
R20	0.1	0.2	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.0	46	46	46	46	46	18	18	18	18	18

6.5.6 Predicted $PM_{2.5}$ concentrations

The predicted 24 hour and annual 100th percentile $PM_{2.5}$ concentrations and assessment criteria for each averaging period are presented in Table 6.13. Background $PM_{2.5}$ concentrations were sourced from the Earlwood OEH monitoring station due to $PM_{2.5}$ not being sampled at the Randwick station. Background 24 hour and annual $PM_{2.5}$ concentrations were high. The background 24 hour concentration accounted for 91% of the 24 hour criteria and the background annual concentration accounted for 98% of the annual criteria.

No incremental or total criteria exceedances are predicted for both daily and annual averaging periods. A contour plot of the predicted incremental 24 hour PM_{10} concentrations during the worst case situation (S5) is provided on Appendix D, Figure D.5.

Table 6.13 Predicted increment and total $PM_{2.5}$ concentrations

Receptor	Predicted PM_{10} concentrations (µg/m³)																			
	Incremental										Total									
Averaging period	**24 hour**					**Annual**					**24 hour**					**Annual**				
Situation	**S1**	**S2**	**S3**	**S4**	**S5**	**S1**	**S2**	**S3**	**S4**	**S5**	**S1**	**S2**	**S3**	**S4**	**S5**	**S1**	**S2**	**S3**	**S4**	**S5**
Criteria	**50**					**25**					**50**					**25**				
R01	0.1	0.1	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.0	23	23	23	23	23	7.8	7.8	7.8	7.8	7.8
R02	0.1	0.2	0.2	0.2	0.3	0.0	0.1	0.0	0.1	0.1	23	23	23	23	23	7.8	7.9	7.8	7.9	7.9
R03	0.1	0.3	0.2	0.3	0.4	0.0	0.1	0.1	0.1	0.1	23	23	23	23	23	7.8	7.9	7.9	7.9	7.9
R04	0.2	0.3	0.3	0.4	0.4	0.0	0.1	0.1	0.1	0.1	23	23	23	23	23	7.8	7.9	7.9	7.9	7.9
R05	0.2	0.4	0.3	0.5	0.5	0.0	0.1	0.1	0.1	0.1	23	23	23	23	23	7.8	7.9	7.9	7.9	7.9
R06	0.1	0.2	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.1	23	23	23	23	23	7.8	7.9	7.9	7.9	7.9
R07	0.1	0.3	0.2	0.3	0.3	0.0	0.0	0.0	0.1	0.1	23	23	23	23	23	7.8	7.8	7.8	7.9	7.9
R08	0.1	0.2	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.1	23	23	23	23	23	7.8	7.9	7.9	7.9	7.9
R09	0.2	0.3	0.3	0.3	0.4	0.0	0.1	0.1	0.1	0.1	23	23	23	23	23	7.8	7.9	7.9	7.9	7.9
R10	0.2	0.3	0.3	0.4	0.4	0.0	0.1	0.1	0.1	0.1	23	23	23	23	23	7.8	7.9	7.9	7.9	7.9
R11	0.2	0.4	0.3	0.4	0.5	0.0	0.1	0.1	0.1	0.1	23	23	23	23	23	7.8	7.9	7.9	7.9	7.9
R12	0.2	0.4	0.4	0.5	0.5	0.0	0.1	0.1	0.1	0.1	23	23	23	23	23	7.8	7.9	7.9	7.9	7.9
R13	0.2	0.4	0.4	0.5	0.6	0.1	0.1	0.1	0.2	0.2	23	23	23	23	23	7.9	7.9	7.9	8.0	8.0
R14	0.1	0.2	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.1	23	23	23	23	23	7.8	7.9	7.9	7.9	7.9
R15	0.3	0.6	0.5	0.7	0.7	0.1	0.2	0.2	0.2	0.2	23	23	23	23	23	7.9	8.0	8.0	8.0	8.0

Receptor	Predicted PM_{10} concentrations (µg/m³)																			
	Incremental										Total									
R16	0.1	0.3	0.2	0.3	0.4	0.0	0.1	0.1	0.1	0.1	23	23	23	23	23	7.8	7.9	7.9	7.9	7.9
R17	0.2	0.4	0.4	0.5	0.6	0.1	0.2	0.1	0.2	0.2	23	23	23	23	23	7.9	8.0	7.9	8.0	8.0
R18	0.1	0.3	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.1	23	23	23	23	23	7.8	7.9	7.9	7.9	7.9
R19	0.1	0.2	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.1	23	23	23	23	23	7.8	7.9	7.9	7.9	7.9
R20	0.1	0.2	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.0	23	23	23	23	23	7.8	7.8	7.8	7.8	7.8

6.5.7 Operational impacts

The results of the operational impact assessment predict that:

- NO_2 concentrations – no incremental or total exceedances of the criteria are predicted.
- CO concentration – no incremental exceedances of the criteria are predicted. Total CO exceedances are not anticipated as discussed in Section 6.5.2.
- HC concentration (as benzene) – no incremental exceedances of the criteria are predicted. Total HC (as Benzene) exceedances are not anticipated as discussed in Section 6.5.3.
- SO_2 concentrations – no incremental or total exceedances of the criteria are predicted.
- PM_{10} concentrations – no incremental or total criteria exceedances are predicted for both daily and annual averaging periods.
- $PM_{2.5}$ concentrations – no incremental or total criteria exceedances are predicted for both daily and annual averaging periods.

6.5.8 Impact on health

No exceedances of the assessment criteria are expected as a result from the project. The assessment criteria taken from Air NEPM and Approved Methods (EPA, 2016) were designed to protect human health. Consequently, no adverse impacts on human health are expected (refer to *Technical Report 13 – Health Impact Assessment*).

Additional model results specifically requested for inclusion into the specialist health report are supplied in Appendix C. These modelling results have not been included in this air quality assessment and are not assessed against Approved Methods because the pollutants averaging periods do not correspond with air quality assessment criteria presented in the Approved Methods (EPA 2016).

6.5.9 Summary of key findings

Key findings of the operational impact assessment are:

- the air quality criteria are designed to reduce the risks to human health and the environment. The assessment predicts no exceedances of the assessment criteria for any of the assessed pollutants and therefore not predicted to have adverse air quality impacts in the surrounding areas
- particulate (PM_{10} and $PM_{2.5}$) background concentrations are below the criteria. Background 24 hour concentrations account for 92 per cent of the PM_{10} criteria and background annual concentrations account for 73 per cent of the PM_{10} criteria. Background 24 hour concentrations account for 91% of the $PM_{2.5}$ criteria and background annual concentrations account for 98 per cent of the $PM_{2.5}$ criteria
- all other pollutants are below assessment criteria
- general mitigation measures for operation of the project to help reduce any additional impacts are discussed in section 7 of this report. Further detail related to air quality and health is provided in *Technical Report 13 – Health Impact Assessment*.

6.6 Cumulative impacts

Ambient (background) air pollutant concentrations recorded at the Randwick and Earlwood OEH stations include emissions from all regional sources. Cumulative assessment of all existing regional sources of air pollution are accounted for by including the ambient air quality concentrations measured at the Randwick and Earlwood OEH stations and adding them to incremental site impacts as undertaken in section 6.4.

Future sources of air quality emissions include:

- Sydney Gateway road project
- WestConnex New M5
- WestConnex M4-M5
- F6 Extension stage 1
- Banksmeadow Waste transfer Terminal
- Airport East and Airport North road projects.

It is acknowledged that the operation of the above mentioned projects have the potential to increase air quality pollutant emissions within the study area. It deemed unlikely that future total air quality criteria exceedances will occur due to the project in combination with other projects due to the following reasons:

- Incremental impacts due to the operation of the project account for a relatively small portion of the assessment criteria and localised around the location of the rail duplication (see predicted results and contour plots in section 6.5 and Appendix D).
- The above mentioned projects would complete their own air quality impact assessments that would also identify mitigation measures to reduce the likelihood of any future air quality criteria exceedances. The combination of management measures from all projects would minimise cumulative impacts across the study area.

7. Management of impacts

This section provides mitigation and management measure to be undertaken during the project.

7.1 Approach

As described in the EIS Chapter 6 (Project features and operation) and Chapter 7 (Construction), design development and construction planning has focused on avoiding and/or minimising the potential for environmental impacts during all key phases of the process. Measures taken to avoid or minimise impacts which relate to air quality include:

- where possible, the construction access points and construction traffic routes would be directed away from sensitive areas and would consider these land uses when defining the use and operation of specific compounds.

The construction assessment identified the potential for elevated 24 hourly averaged particulate matter (PM_{10}) within 6 metres of any earthworks undertaken on the construction site. The operational assessment predicted no incremental or total pollutant criteria exceedances would occur.

Even with the approach to avoid and minimise impacts, there is still the potential for residual impacts to occur from the project. This section outlines mitigation measures to be implemented during construction and operation of the project to minimise air quality emissions and resulting impacts. Implementation of the mitigation measures mentioned in Table 7.1 should reduce the predicted air quality impacts in outlined in section 5.

Mitigation measures would be managed through the following:

- ARTC's Site environmental management plans (EMP(s) for enabling works
- project specific CEMP for main construction works
- community and stakeholder engagement plan
- ARTC's environmental management system for operation of the project.

Monitoring requirements are discussed in Section 7.2. This includes ongoing visual monitoring for construction dust and complaint based particulate sampling. Based on the findings of this assessment, no operational air quality monitoring has been recommended.

7.2 List of mitigation measures

Mitigation measures that are recommended to address potential air quality impacts are listed in Table 7.1 and would be incorporated into the relevant management plans.

Table 7.1 Mitigation measures

Stage	Impact	Measure
Construction	Minor and temporary elevated particulate matter (PM_{10}) at receptors within six metres of the construction boundary	Dust suppression will be undertaken as required, using water sprays, water carts or other media on: ▪ unpaved work areas subject to traffic or wind ▪ sand, spoil and aggregate stockpiles ▪ during the loading and unloading of dust generating materials. As a minimum, level 1 watering should be undertaken on general construction areas and level 2 watering should be undertaken on heavy construction areas. Further discussion including a description of construction work classification is provided in Section 5.2.
		Visual dust monitoring will be performed on a routine basis, and all staff will be trained to look out for visible dust leaving the worksite in the direction of sensitive receptors. If the works are creating visible dust plumes, the works will be modified or stopped until the dust hazard is reduced to an acceptable level. If complaints are received relating to dust from construction works, works will be reviewed to identify opportunities to reduce potential impacts from dust. In the instance of ongoing dust issues, or complaints, a short term dust monitoring device will be installed in the relevant area which may be adjacent to a sensitive receptor near any longer term construction area.
		Construction vehicles with potential for loss of loads (such as dust or litter) will be covered when using public roads.
		Plant and equipment will be maintained in good condition to minimise spills and air emissions that may cause nuisance.
		The size of stockpiles will be minimised where possible and located as far as practicable from sensitive receptors.
	Contaminated dust with PFAS may become airborne and disperse to receptors	Identified areas which may have elevated PFAS/PFOS concentrations are limited to small areas shown in the *Technical Report 5 – Contamination Assessment* (WSP 2019)). This report includes specific management measures. Dust management measures are considered sufficient to manage dust from areas potentially containing PFAS however high risk areas will be identified in the site induction so all personnel are aware of the importance of dust management in these areas. Dust management measures will prevent visible dust from potentially contaminated areas from leaving the construction site boundary.
	Release of odour and pollutants from disturbance of contaminated land	An unexpected finds protocol will be prepared and implemented as part of the relevant management plan. It would identify the process to follow in the event that indicators of contamination are encountered during construction (such as odours, ACM or visually contaminated materials).

Stage	Impact	Measure
Operation	Emissions	Plant and equipment used for maintenance works will be operated in accordance with manufacturer specifications and ARTC's Safety Management System and Environment Management System.
	Release of odour and pollutants from contaminated land	Ongoing management measures will be implemented for areas where contamination remains following construction. These management measures will be documented in an environmental management plan that is specific to contamination. In particular, the plan will clearly identify areas of remaining ACM impacts and detail the controls to be implemented during maintenance works likely to disturb soils. The plan will also detail the requirements for periodic inspections of ACM capping layer to ensure its integrity.

8. Conclusion

An air quality assessment has been prepared for the construction and operation of the project.

Construction air quality impacts were modelled and assessed for typical construction scenarios. Dust impacts from construction activities have been assessed based on the proposed construction area with works assumed to occur all year in any one location, however it is important to note that many construction activities are mobile, transient and intermittent and likely to take place over a shorter period than one year.

The assessment found that there may be short term 24 hour averaged PM_{10} impacts within 6 metres of general construction activities and longer term annually average $PM_{2.5}$ impacts within 7 metres of long term construction activities that occur in the same location for over a year. Implementation of mitigation and management measures to minimise dust will reduce impacts.

The operational assessment considered five scenarios corresponding to the existing 2019 scenario and future build and no build for years 2024 and 2034. The air quality criteria are designed to reduce the risks to human health and the environment. The assessment predicts no exceedances of the assessment criteria for any of the assessed pollutants and therefore not predicted to have adverse air quality impacts in the surrounding areas.

Operational air quality impacts are not anticipated for any pollutants. Operational air quality impacts from the Project were not deemed to be significant. Further detail related to air quality and health is provided in *Technical Report 13 – Health Impact Assessment*.

9. References

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- OEH NSW. (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'. Sydney: NSW Office of Environment and Heritage.
- Parsons Brinckerhoff, (2012), Northern Sydney Freight Corridor Epping to Thornleigh Third Track Project Air Quality Impact Assessment.
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- WSP (2019), *Technical Report 5 – Contamination Assessment*, prepared for Botany Rail Duplication project.

Appendix A

Meteorology modelling procedure

A1. Meteorology modelling procedure

This section outlines the methodology used to synthesize meteorology for the project site. The meteorology is used in CALPUFF to drive the dispersion model.

A1.1 Overview

Local meteorology including long term wind speed and direction, and atmospheric stability can influence how pollutants are dispersed into the local environment.

Site specific meteorology for the project was produced using a model called CALMET. The CALMET simulation produced a 3D wind field for the modelled year. Prognostic TAPM data was used alongside observations taken at one NSW Bureau of Meteorology (BoM) site as inputs into the CALMET model. Details of the procedure undertaken to produce the site specific meteorology is outlined in the following sections.

A1.2 Methodology

The characterisation of local wind patterns generally requires accurate site-representative hourly recordings of wind direction and speed over a period of at least a year.

Existing observational data is available from the Sydney airport AMO (BoM ID: 66037).

In order to produce a representative site-specific meteorological data set encompassing the meteorological data from the observational site, the following methodology was carried out:

- production of a 3D gridded dataset with the prognostic model TAPM
- utilising the TAPM 3D gridded dataset as an initial guess field for the CALMET meteorological model
- utilising data from the observation site (Sydney airport AMO) for surface level observations.

A1.2.1 Representative year selection

An analysis of meteorological data from the nearest station in the recent five years (2012 to 2016) to select a period considered most representative of ‘normal’ conditions is recommended by the Approved Methods (EPA, 2016).

Meteorological data was taken from the nearest BoM monitoring station (Sydney Airport AMO, BoM ID: 66037) which is located approximately 2 kilometres southwest from the project site. A comprehensive analysis from hourly meteorological data in the recent five years from the station were used to determine the representative year for the project study. Probability density function graphs of the wind speed and direction over the five years at the station is provided in Appendix B.

The analysis shows that the year 2014 at Sydney Airport AMO station is the most representative year based on a review of temperature, humidity, wind speed and wind direction. The year 2014 in NSW was also identified as not being excessively wet or dry.

A1.2.2 Prognostic meteorology

The TAPM prognostic (predictive) model was run to obtain a coarse meteorological 3D gridded dataset for the site for the selected year (2014). This dataset is based on synoptic (general and collated) observations, local terrain and land use information with a resolution of 1,000 meters. The TAPM model parameters are summarised in Table A.1 and are selected in accordance with the Approved Methods (EPA, 2016).

Table A.1 TAPM model parameters

Parameter	Value
Modelled period	1 December 2013 to 1 January 2015
Domain centre	UTM: 56H 332,847 mE, 6,244,687 mS Latitude = -33° 55.5’ Longitude = 151° 11.5’
Number of vertical levels	25
Number of easting grid points	25
Number of northing grid points	25
Outer grid spacing	30,000 m x 30,000 m
Number of grid levels	4
Grid level horizontal resolution	Level 2 – 10,000 m Level 3 – 3,000 m Level 4 – 1,000 m

A1.3 CALMET modelling

The US EPA Approved version of CALMET (Version 5) was used to resolve the wind field around the subject site to a 200 metres spatial resolution. The application of CALMET for this purpose is an approved modelling approach in NSW as per the Approved Methods (EPA, 2016) with model guidance documentation provided.

Upon completion of the broad scale TAPM modelling runs, a CALMET simulation was set up to run for the model period, combining the three dimensional gridded data output from the TAPM model with the site specific surface data from the Sydney Airport BoM station. This approach is consistent with guidance documentation.

All model settings were selected based on the recommendations provided in the model guidance documentation CALMET was run using the “Hybrid” mode with the TAPM data provided as an initial guess field.

The southwest corner of the CALMET domain, or the origin, was located at UTM Zone 56 coordinates 321.847 kilometre east and 6233.687 kilometre north. The CALMET domain extended 22 kilometre to the east and north.

The CALMET domain consisted of 110 grids in both the east and north directions, with a grid resolution of 0.2 kilometre.

CALMET settings were selected as per the model guidance document for “Hybrid” mode.

The TERRAD, RMAX and R variables were set to the values presented in Table A.2 based on an inspection of the terrain elevations in the immediate vicinity of the subject site, based on model guidance. The CALMET model parameters are summarised in Table A.2.

CALMET requires geophysical data including terrain elevation and land use categories. Terrain and land use data used for the CALMET modelling are presented in Figure A.1 and Figure A.2.

Table A.2 Summary of CALMET model parameters

Parameter	Value
Modelled period	1 January 2014 to 31 December 2014
Mode	Hybrid (NOOBS = 1)
UTM zone	56
Domain origin (south-west corner)	Easting: 321.847 km Northing: 6233.687 km
Domain size	110 x 110 at 0.2 km resolution (22.0 km x 22.0 km)
Number of vertical levels	11
Vertical levels (m)	20, 40, 60, 90, 120, 180, 250, 500, 1000, 2000, 3000
CALMET settings for hybrid mode Settings selected in accordance with (OEH, 2011)	TERRAD = 10.0 km RMAX1 = 10.0 km RMAX2 = 10.0 km RMIN = 0.1 km R1 = 5.0 km R2 = 5.0 km
Initial guess field	TAPM .m3d file used as an initial guess field for CALMET.
Surface data	Sydney Airport AMO E: 331.173 km N: 6242.272 km
Upper air data	No site specific upper air data is utilised. Upper air data is included within the TAPM .m3d initial guess field.
Land use and terrain data	Land use data was manually developed through assessment of aerial imagery to accurately reflect the land use in the area. High-resolution terrain data was sourced from the STRM 1-second (~30 m) database.

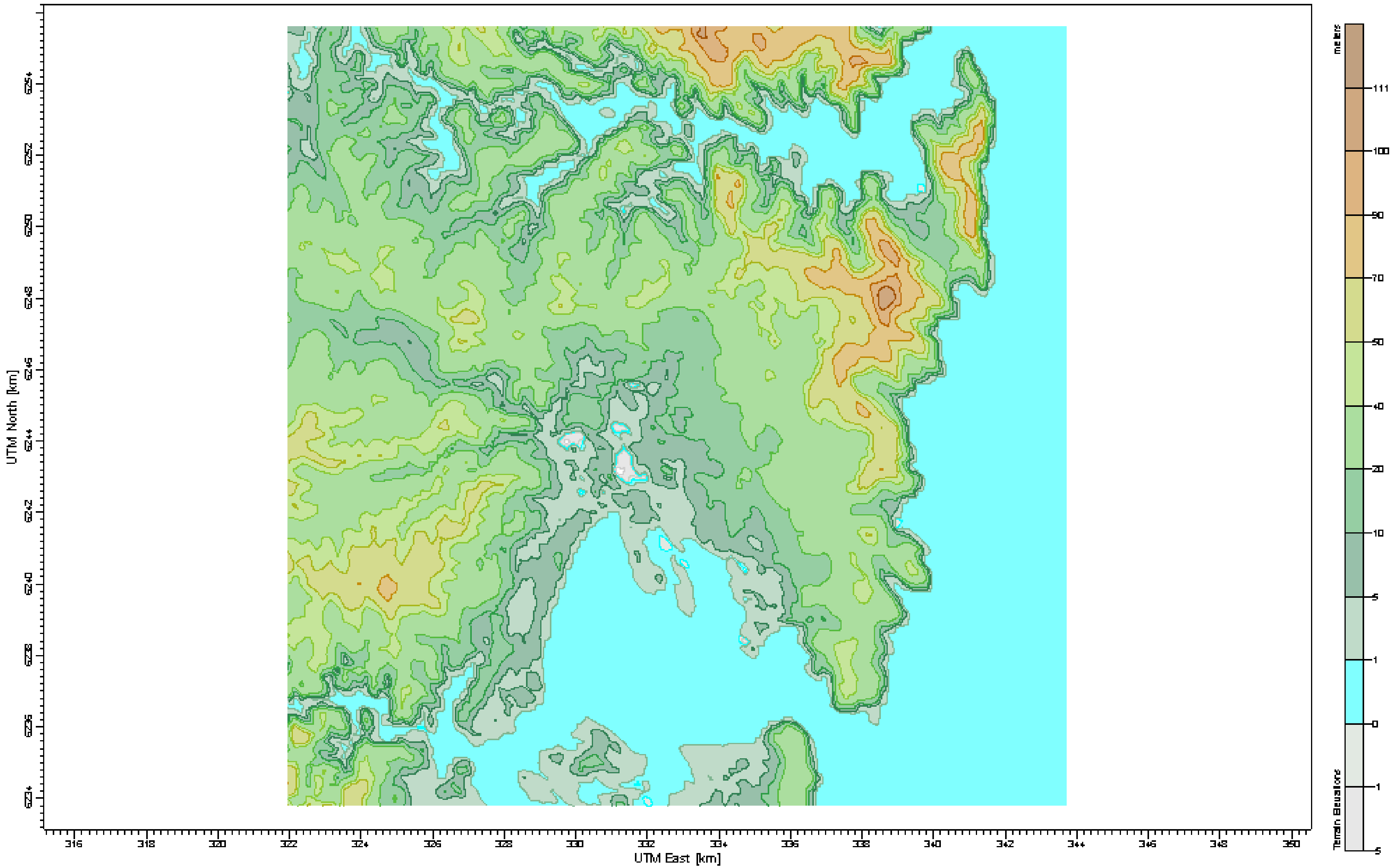


Figure A.1 Terrain data used for CALMET modelling

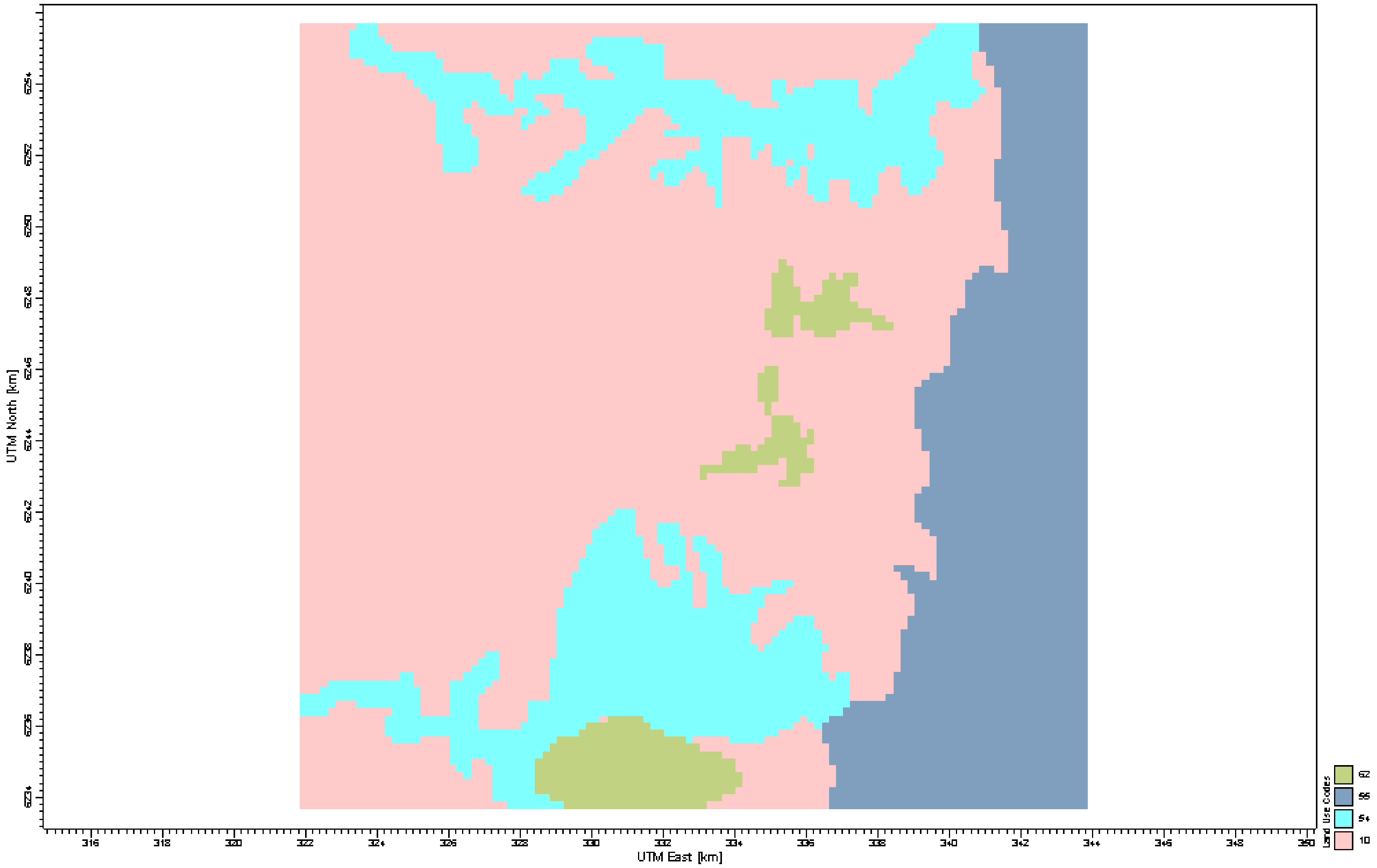


Figure A.2 Land use data used for CALMET modelling

The local meteorology largely determines the pattern of off-site air quality impact on receptors (houses, businesses and industry). The effect of wind on dispersion patterns can be examined using the wind and stability class distributions at the site from the dataset that is produced by CALMET. The winds at the site are most readily displayed by means of wind rose plots, giving the distribution of winds and the wind speeds from these directions.

The features of particular interest in this assessment are: (i) the dominant wind directions and (ii) the relative incidence of stable light wind conditions that yield minimal mixing (defines peak impacts from ground-based sources).

A1.3.1 Annual pattern in wind

The average wind rose for the entire data period taken at the project site is shown in Figure A.3 and shows the following features:

- the predominant annual average wind directions are from the northwest, northeast and south
- the majority of lower wind speeds (2–4 m/s) are from the northwest
- the average wind speed measured was 4.77 metres per second
- calms (winds speeds less than 0.5 m/s) occurred 0.19 per cent of the time.

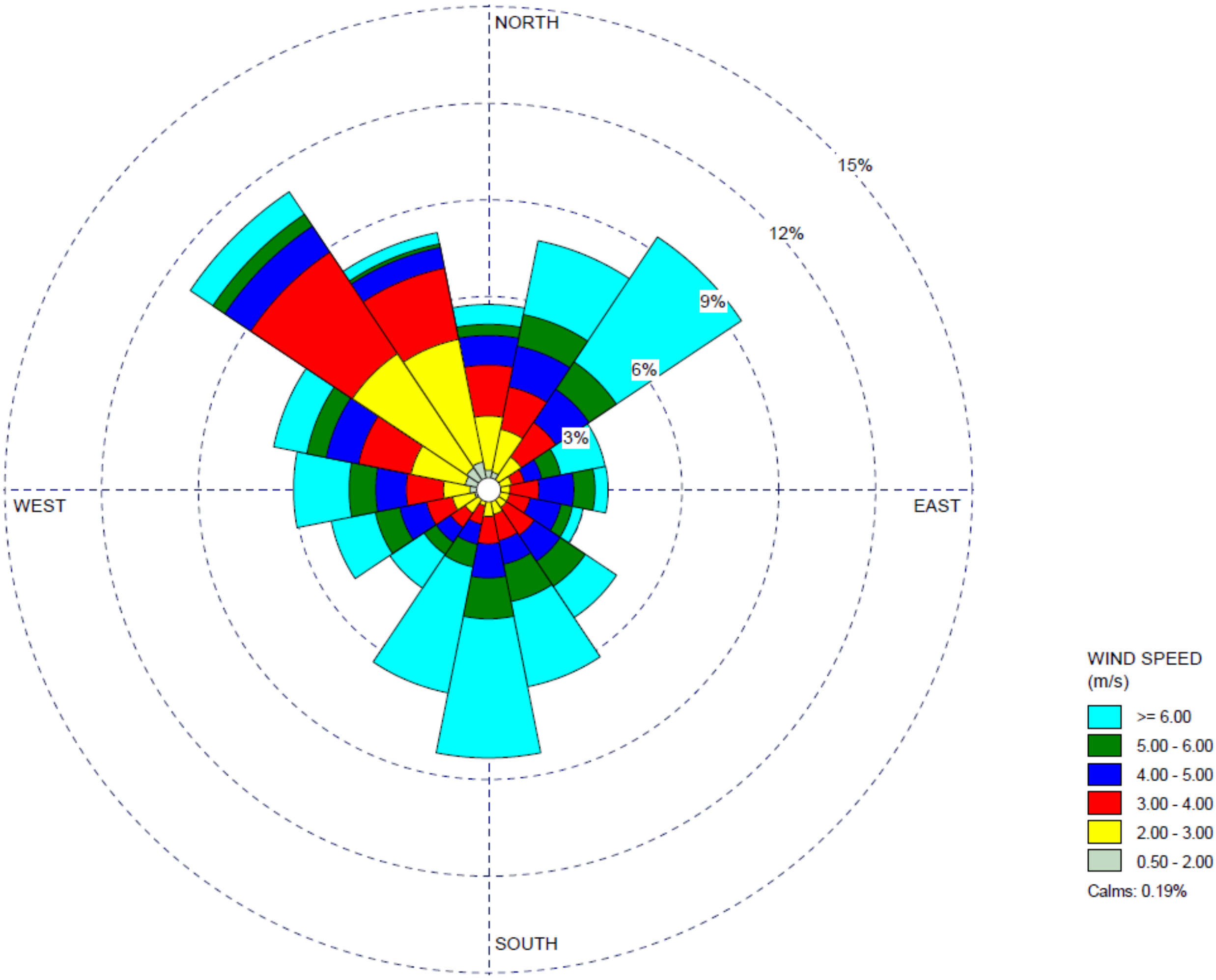
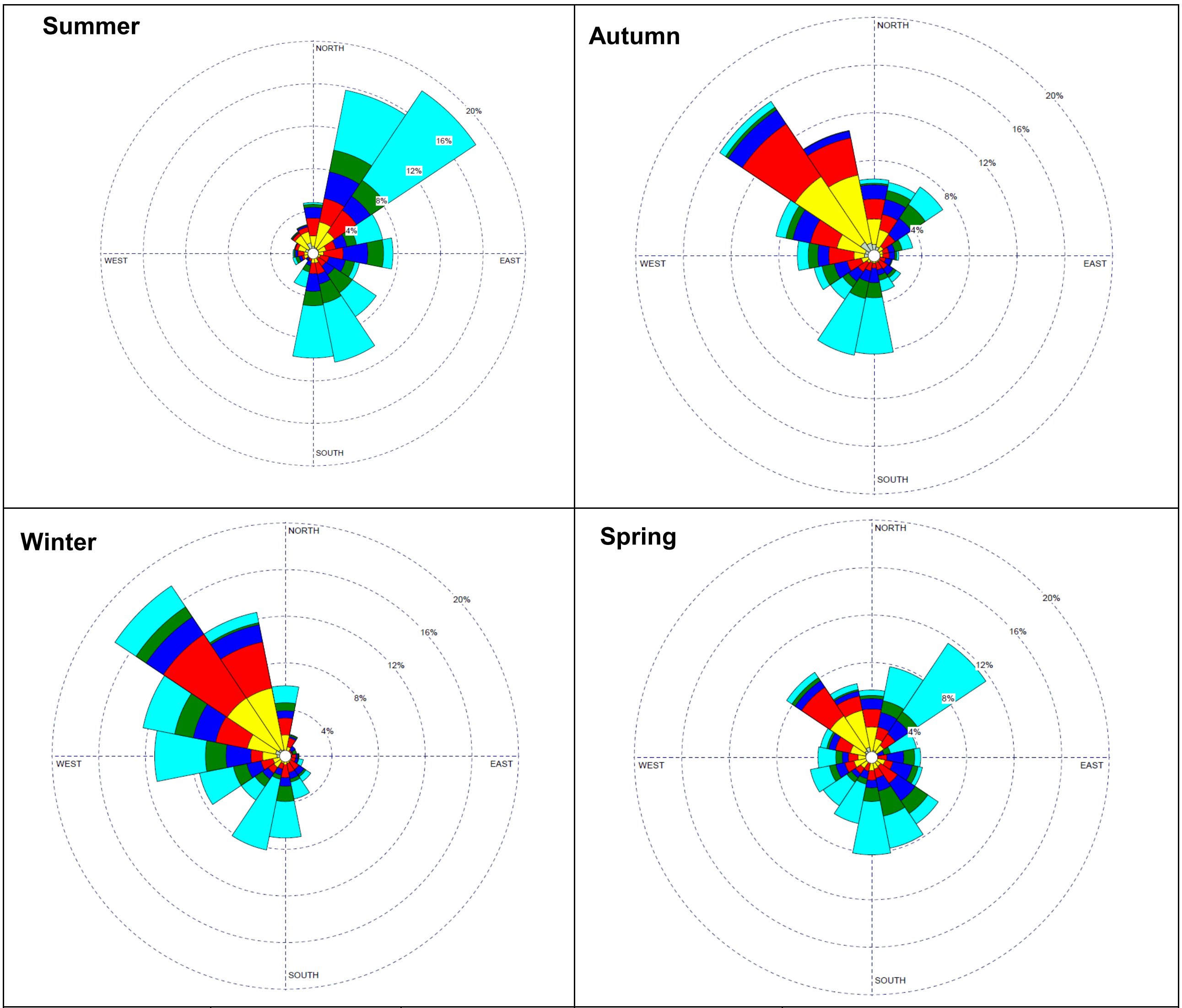


Figure A.3 Wind rose from CALMET for 2014

A1.3.2 Seasonal variation in wind pattern

The seasonal wind roses for 2014 are presented in Figure A.4 and show that:

- during summer the predominant wind direction is from the northeast and south
- during winter, north westerly and westerly winds are the most dominant
- autumn and spring are transitional periods. During these seasons both summer and winter patterns are observed. Autumn wind patterns are characteristically similar to winter, generally consisting of north westerly winds. Spring wind patterns are more similar to Summer displaying a higher percentile of northeast winds.



Season	%Complete Record	Average WS (m/s)	Calms Frequency (%)
Summer	100%	5.19	0.14
Autumn	100%	4.15	0.36
Winter	100%	4.75	0.00
Spring	100%	4.99	0.27

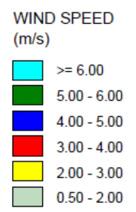


Figure A.4 Seasonal wind roses for 2014

A1.3.3 Pattern of atmospheric stability

Atmospheric stability substantially affects the capacity of a pollutant such as gas, particulate matter or odour to disperse into the surrounding atmosphere upon discharge and is a measure of the amount of turbulent energy in the atmosphere.

There are six Pasquill–Gifford classes (A-F) used to describe atmospheric stability, and these classes are grouped into three stability categories; stable (classes E-F), neutral (class D), and unstable (classes A-C). The climate parameters of wind speed, cloud cover and solar insolation are used to define the stability category as shown in Table A.3, and as these parameters vary diurnally, there is a corresponding variation in the occurrence of each stability category.

Stability is most readily displayed by means of stability rose plots, giving the frequency of winds from different directions for various stability classes A to F.

Table A.3 Stability category relationship to wind speed, and stability characteristics

Stability category	Wind speed range (m/s)[a]	Stability characteristics
A	0 – 2.8	Extremely unstable atmospheric conditions, occurring near the middle of day, with very light winds, no significant cloud.
B	2.9 – 4.8	Moderately unstable atmospheric conditions occurring during mid-morning/mid-afternoon with light winds or very light winds with significant cloud.
C	4.9 – 5.9	Slightly unstable atmospheric conditions occurring during early morning/late afternoon with moderate winds or lighter winds with significant cloud.
D	≥6	Neutral atmospheric conditions. Occur during the day or night with stronger winds. Or during periods of total cloud cover, or during the twilight period.
E	3.4 – 5.4 [b]	Slightly stable atmospheric conditions occurring during the night-time with significant cloud and/or moderate winds.
F	0 – 3.3 [b]	Moderately stable atmospheric conditions occurring during the night-time with no significant cloud and light winds.

[a] Data sourced from the Turner's Key to the P-G Stability Categories, assuming a Net Radiation Index of +4 for daytime conditions (between 10:00 am and 6:00 pm) and –2 for night-time conditions (between 6:00 pm and 10:00 am)

[b] Assumed to only occur at night, during Net Radiation Index categories of –2.

Figure A.5 shows the frequency of stability class for all hours of the model generated dataset. The following observation were made:

- neutral atmosphere conditions (class D) are the dominant stability state of the atmosphere occurring 40 per cent of the time
- stable stability (classes E and F) occurs 36 per cent of the time
- unstable atmospheres (classes A, B and C) occur about 24 per cent of the time.

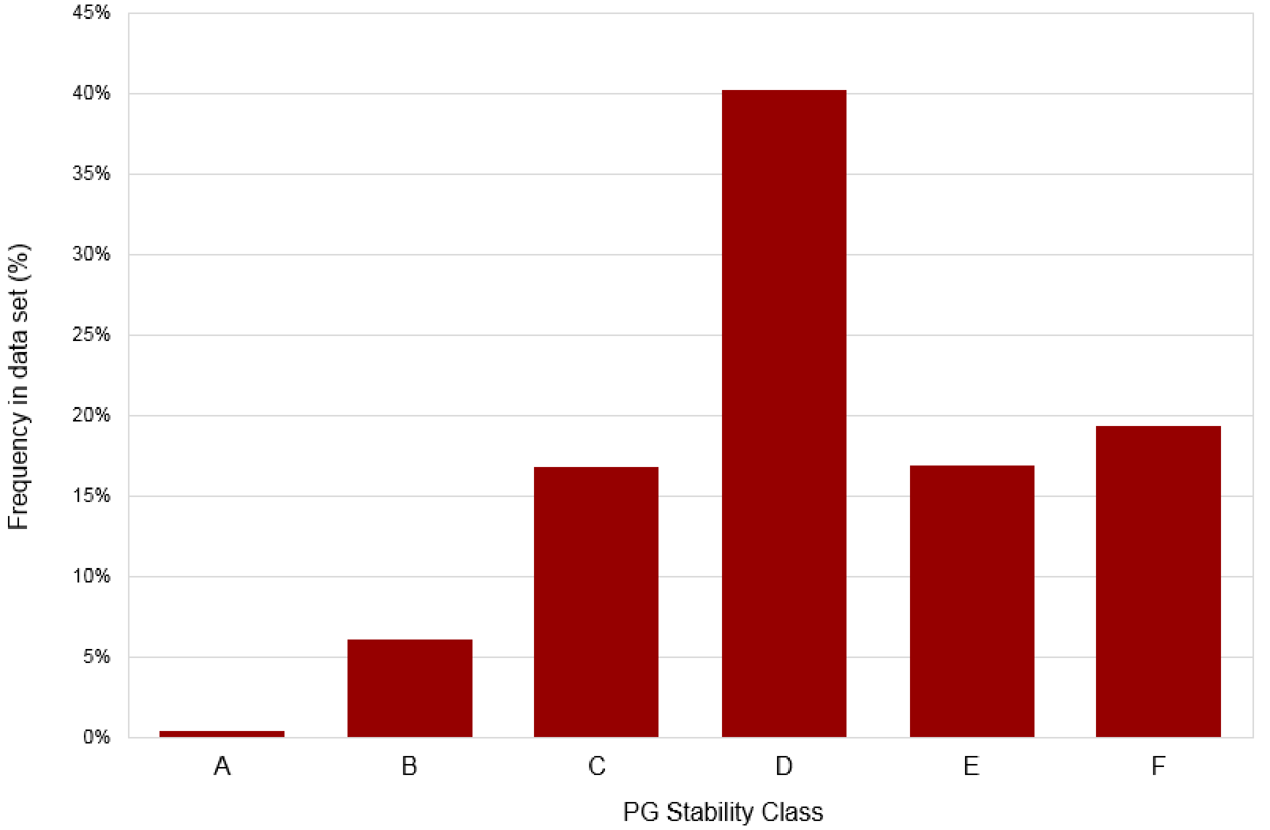
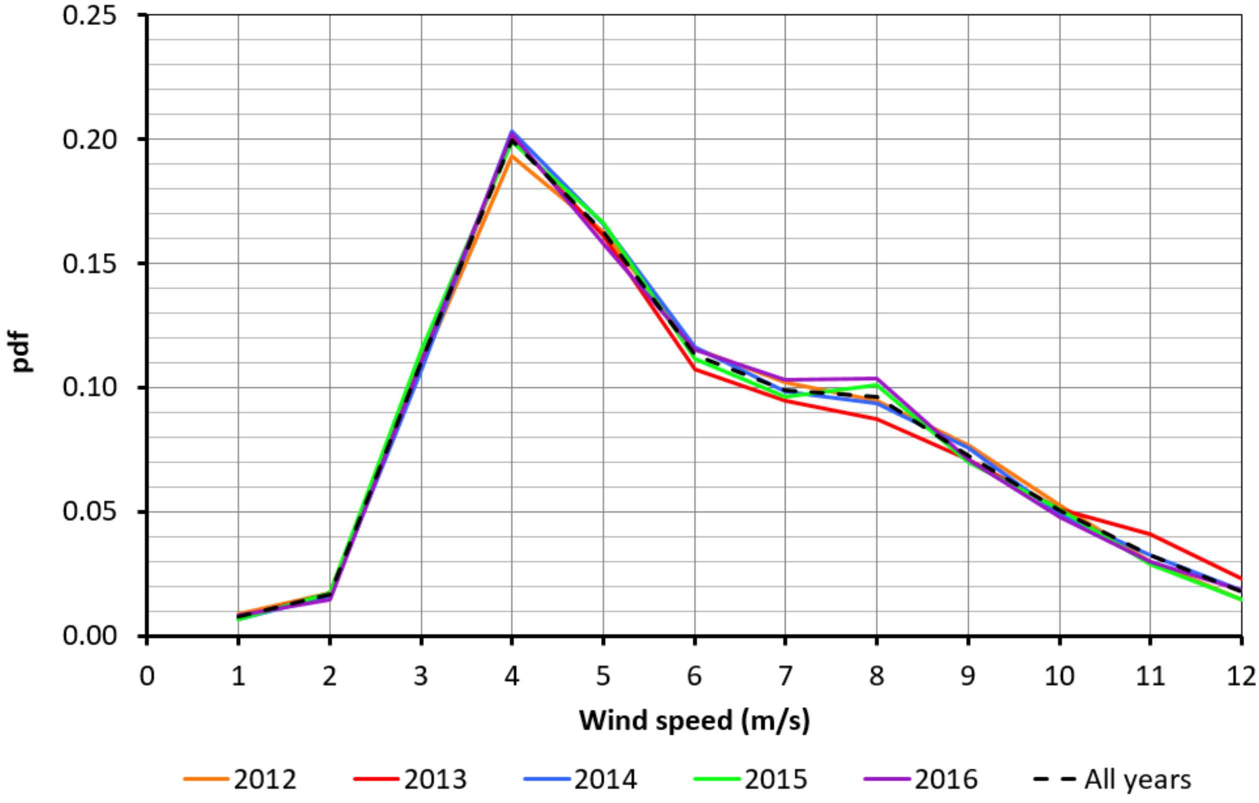
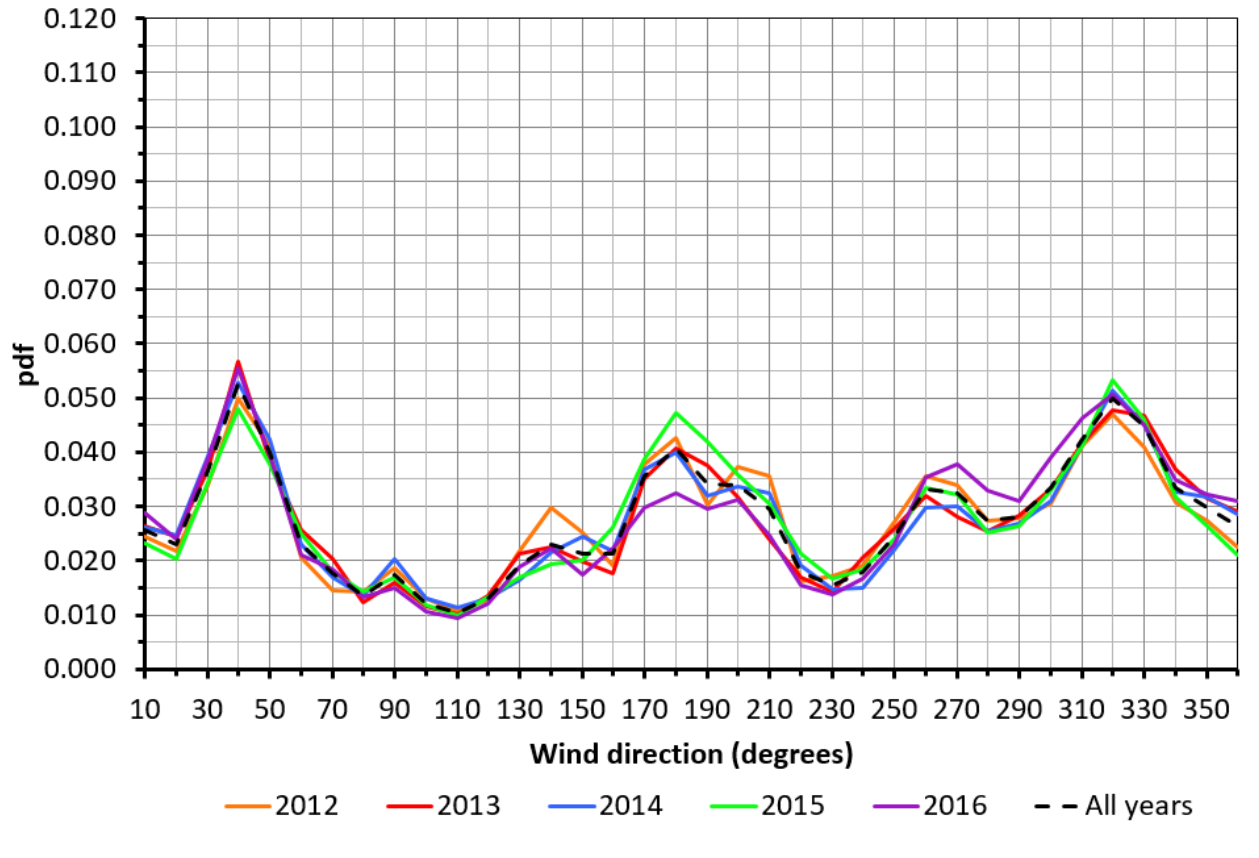


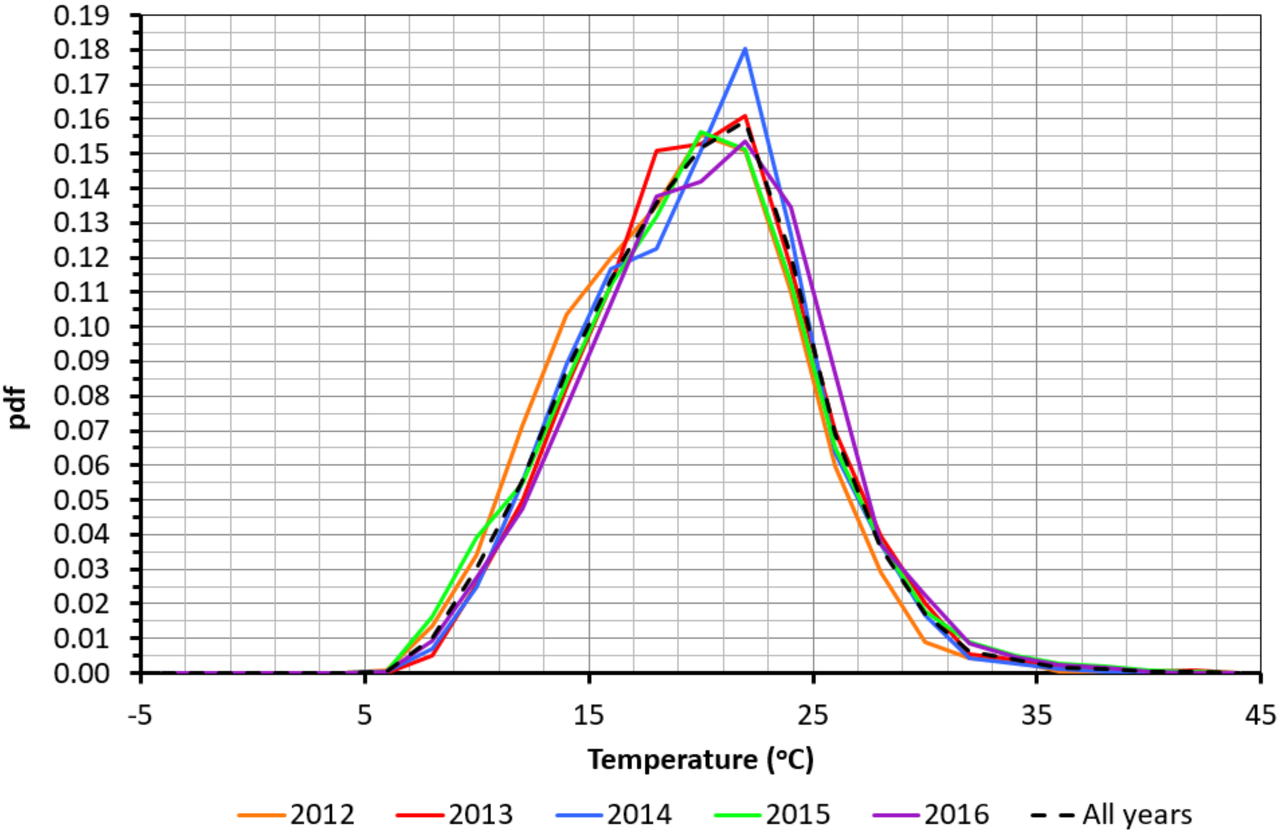
Figure A.5 Distribution of stability class for the model period

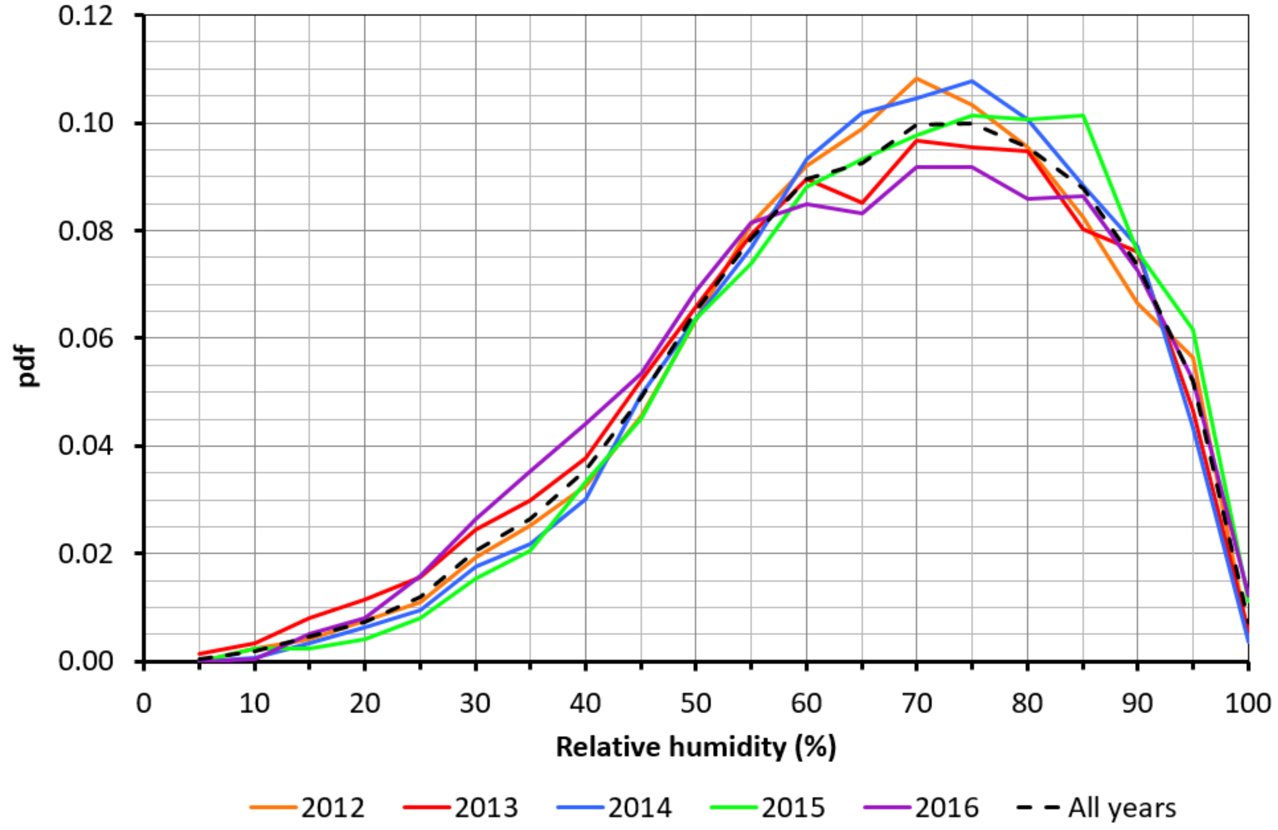
Appendix B
Probability density plots over the five years

B1. Probability density plots






pdf
Temperature (°C)
2012
2013
2014
2015
2016
All years


pdf
Relative humidity (%)
2012
2013
2014
2015
2016
All years

Appendix C

Additional modelling results for health assessment

C1. 1 hour PM_{10} concentrations

Receptor	Predicted PM_{10} concentrations (µg/m^3)									
	Incremental					Total				
Averaging period	1 hour					1 hour				
Situation	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
R01	2.1	3.6	3.2	3.6	5.5	165	167	166	167	168
R02	2.3	4.1	3.6	4.1	6.2	165	167	167	167	169
R03	3.9	6.9	6.1	6.9	10.5	167	170	169	170	173
R04	3.4	5.9	5.3	5.9	9.0	166	169	168	169	172
R05	4.6	8.1	7.1	8.1	12.3	168	171	170	171	175
R06	3.8	6.7	6.0	6.7	10.2	167	170	169	170	173
R07	4.1	7.2	6.3	7.2	10.9	167	170	169	170	174
R08	3.2	5.5	4.9	5.5	8.4	166	169	168	169	171
R09	4.2	7.3	6.5	7.3	11.1	167	170	169	170	174
R10	4.2	7.3	6.5	7.3	11.1	167	170	169	170	174
R11	4.2	7.4	6.6	7.4	11.3	167	170	170	170	174
R12	4.6	8.1	7.2	8.1	12.4	168	171	170	171	175
R13	4.3	7.5	6.7	7.5	11.5	167	171	170	171	174
R14	3.3	5.8	5.1	5.8	8.8	166	169	168	169	172
R15	5.1	8.9	7.9	8.9	13.6	168	172	171	172	177
R16	3.7	6.4	5.7	6.4	9.8	167	169	169	169	173
R17	3.7	6.5	5.7	6.5	9.8	167	169	169	169	173
R18	3.1	5.5	4.8	5.5	8.3	166	168	168	168	171
R19	3.1	5.4	4.8	5.4	8.3	166	168	168	168	171
R20	3.0	5.3	4.7	5.3	8.0	166	168	168	168	171

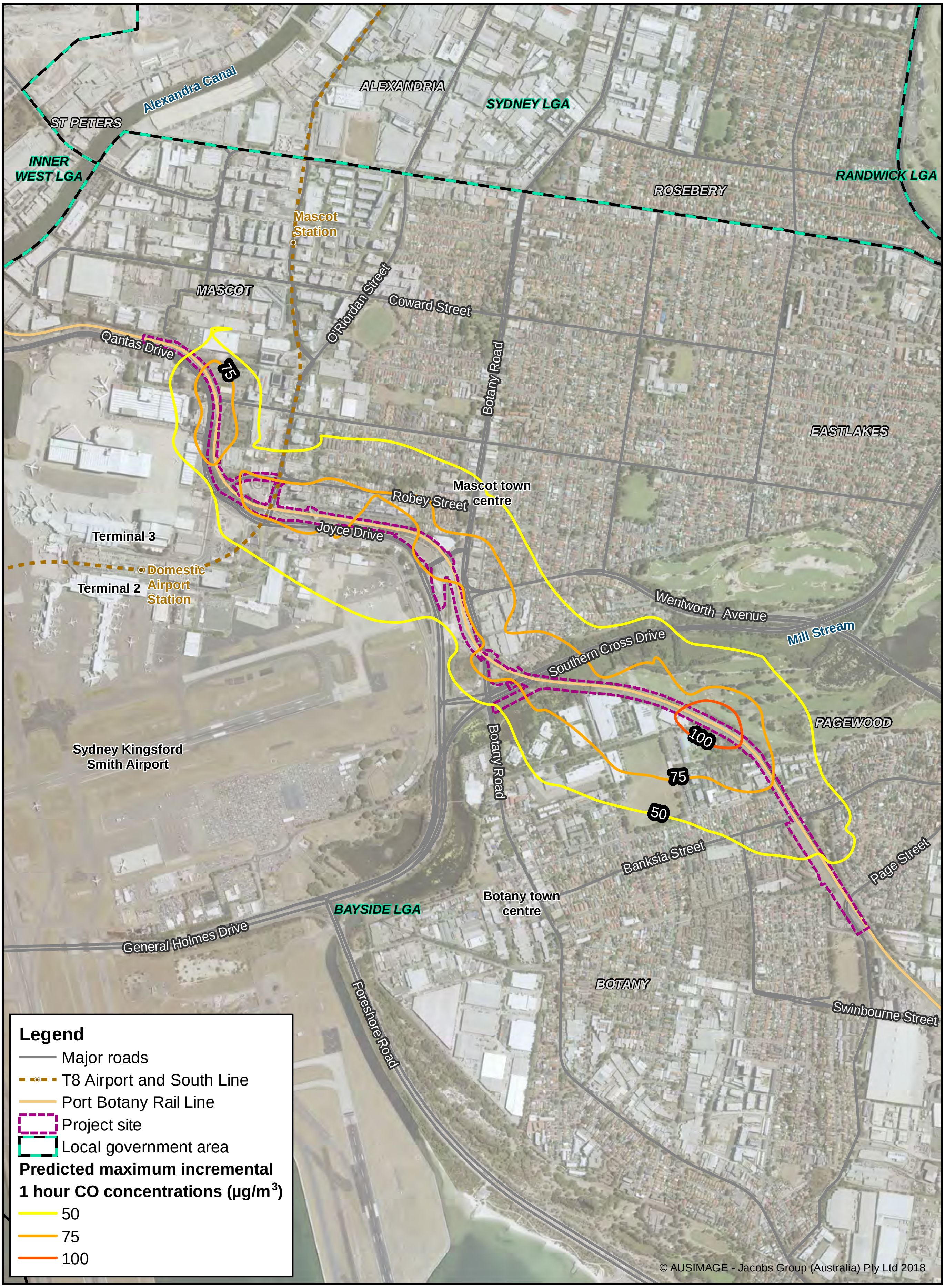
C2. 1 hour $PM_{2.5}$ concentrations

Receptor	Predicted $PM_{2.5}$ concentrations (µg/m^3)									
	Incremental					Total				
Averaging period	1 hour					1 hour				
Situation	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
R01	2.0	3.5	3.1	3.5	5.3	69	70	70	70	72
R02	2.3	3.9	3.5	3.9	6.0	69	71	70	71	73
R03	3.8	6.7	5.9	6.7	10.2	71	73	73	73	77
R04	3.3	5.8	5.1	5.8	8.8	70	73	72	73	76
R05	4.5	7.8	6.9	7.8	11.9	71	75	74	75	79
R06	3.7	6.5	5.8	6.5	9.9	71	73	73	73	77
R07	4.0	6.9	6.2	6.9	10.6	71	74	73	74	77
R08	3.1	5.4	4.8	5.4	8.2	70	72	72	72	75
R09	4.1	7.1	6.3	7.1	10.8	71	74	73	74	78
R10	4.1	7.1	6.3	7.1	10.8	71	74	73	74	78
R11	4.1	7.2	6.4	7.2	10.9	71	74	73	74	78
R12	4.5	7.9	7.0	7.9	12.0	71	75	74	75	79
R13	4.2	7.3	6.5	7.3	11.1	71	74	73	74	78
R14	3.2	5.6	5.0	5.6	8.5	70	72	72	72	75
R15	4.9	8.7	7.7	8.7	13.2	72	75	74	75	80
R16	3.6	6.2	5.5	6.2	9.5	70	73	72	73	76
R17	3.6	6.3	5.6	6.3	9.5	70	73	72	73	76
R18	3.0	5.3	4.7	5.3	8.0	70	72	71	72	75
R19	3.0	5.3	4.7	5.3	8.0	70	72	71	72	75
R20	2.9	5.1	4.6	5.1	7.8	70	72	71	72	75

C3. Annual CO concentrations

Receptor	Predicted CO concentrations (μg/m^3)				
	Incremental				
Averaging period	1 hour				
Situation	S1	S2	S3	S4	S5
R01	0.1	0.1	0.1	0.2	0.2
R02	0.2	0.3	0.4	0.4	0.5
R03	0.2	0.4	0.4	0.4	0.6
R04	0.2	0.4	0.5	0.5	0.7
R05	0.2	0.4	0.4	0.5	0.7
R06	0.2	0.4	0.5	0.5	0.7
R07	0.1	0.3	0.3	0.3	0.4
R08	0.2	0.5	0.5	0.5	0.8
R09	0.2	0.3	0.4	0.4	0.6
R10	0.2	0.4	0.5	0.5	0.7
R11	0.2	0.4	0.5	0.5	0.7
R12	0.3	0.5	0.5	0.6	0.8
R13	0.4	0.9	1.0	1.0	1.4
R14	0.2	0.4	0.4	0.4	0.6
R15	0.6	1.0	1.2	1.2	1.7
R16	0.3	0.5	0.6	0.6	0.9
R17	0.5	0.9	1.1	1.1	1.6
R18	0.2	0.5	0.5	0.5	0.8
R19	0.2	0.4	0.4	0.4	0.6
R20	0.1	0.2	0.2	0.2	0.3

Appendix D
Predicted pollutant contour plots



0 265 530 m

Figure D.1

Predicted maximum incremental 1 hour CO concentrations (µg/m³)

Author: Geeta Kumar
Date: 17/05/2019
Map no: PS113386_GIS_021_A1

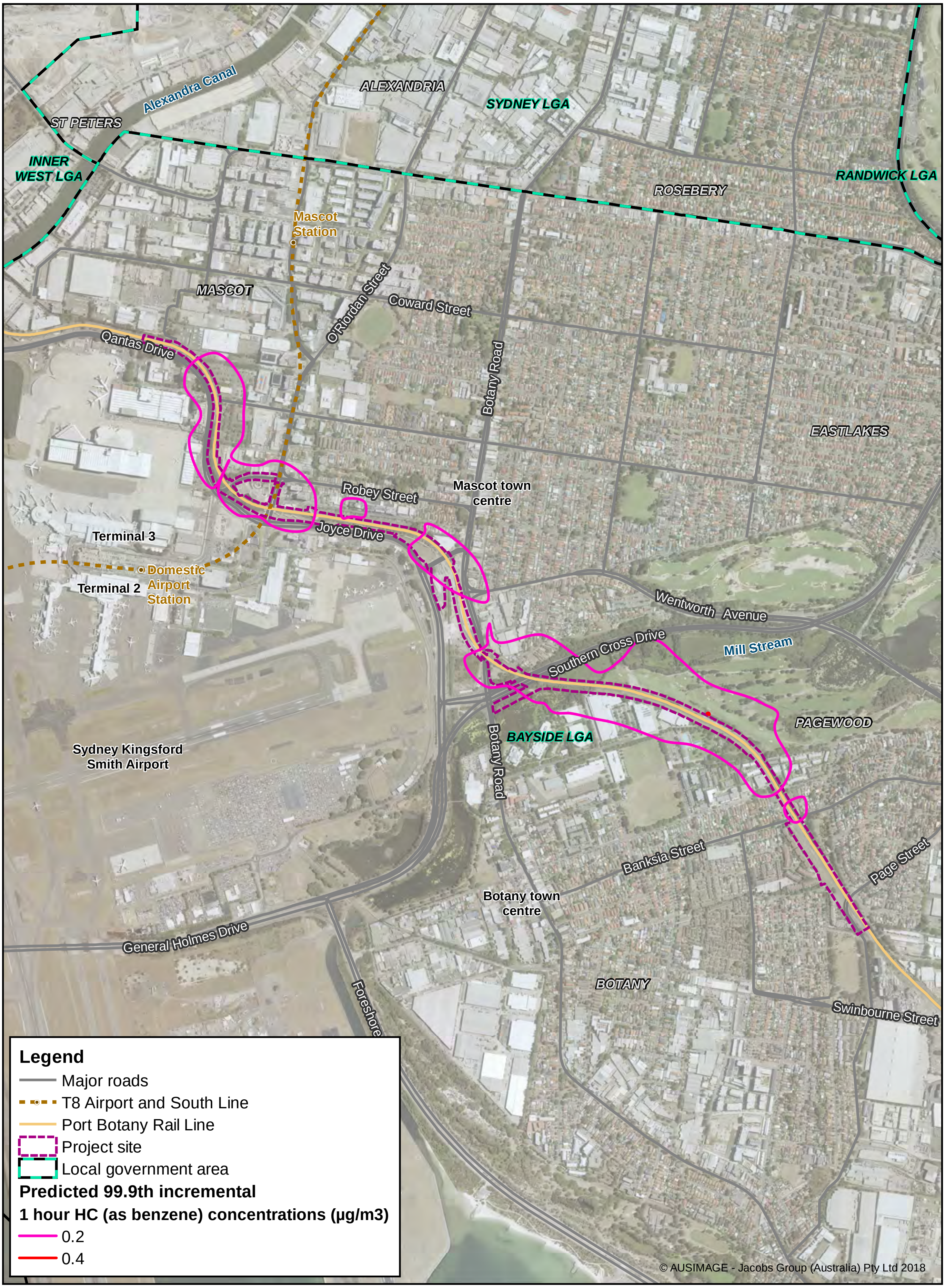


Figure D.2

Predicted 99.9th incremental 1 hour HC (as benzene) concentrations (µg/m^3)

Author: Geeta Kumar
Date: 17/05/2019
Map no: PS113386_GIS_022_A1

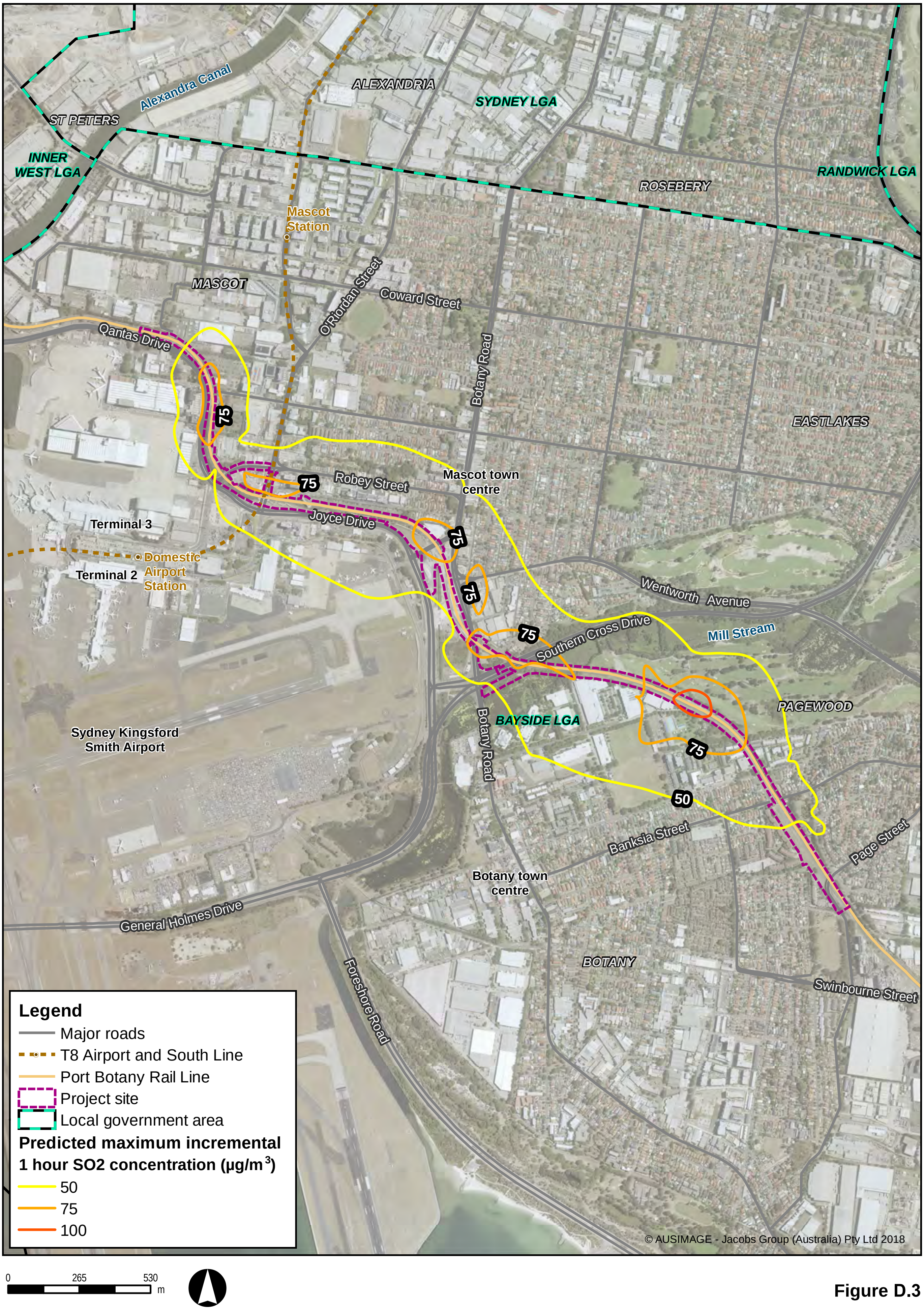


Figure D.3

Predicted maximum incremental 1 hour SO_2 concentration (µg/m^3)

Author: Geeta Kumar
Date: 17/05/2019
Map no: PS113386_GIS_023_A1

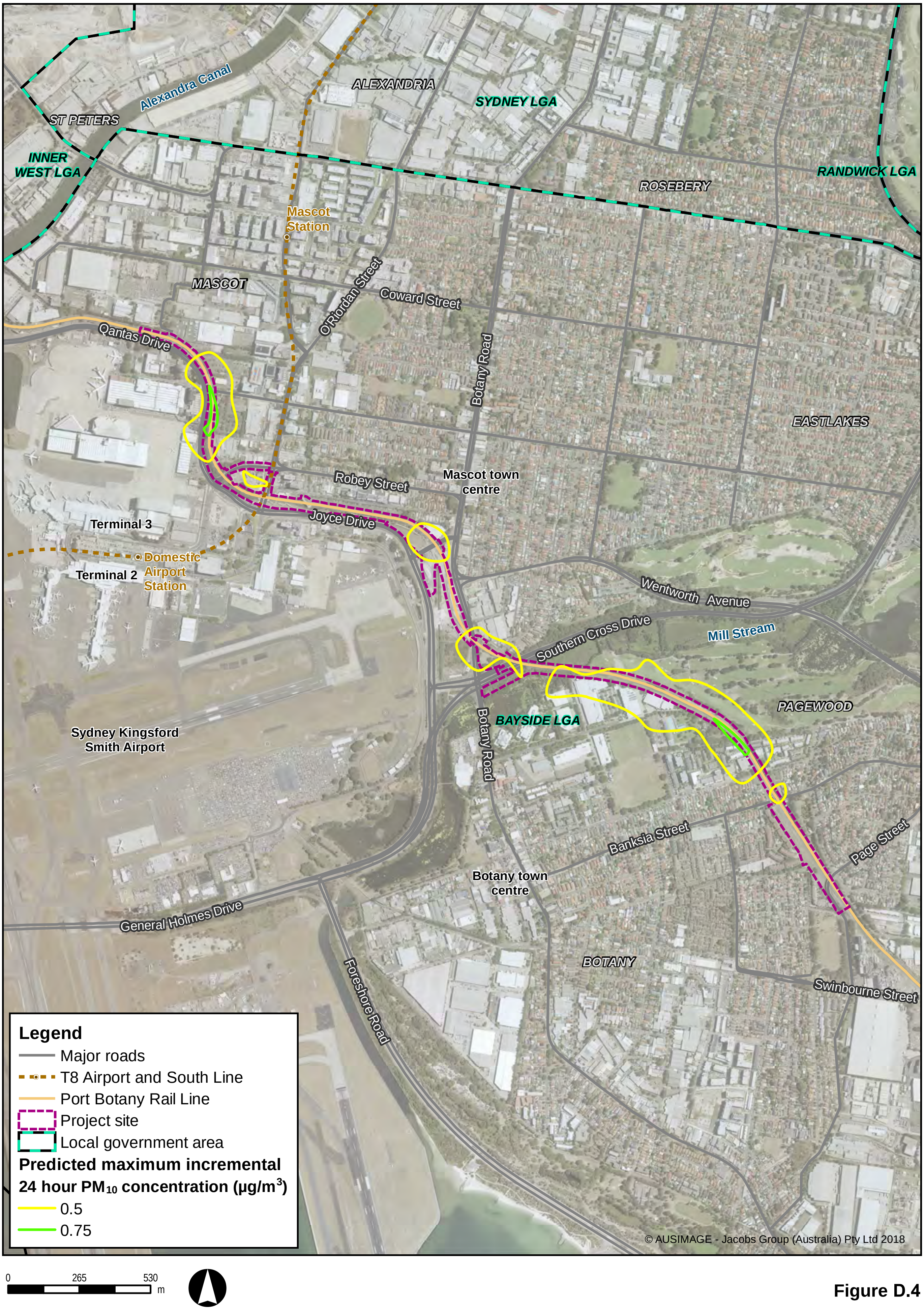


Figure D.4

Predicted maximum incremental 24 hour PM_{10} concentration ($\mu g/m^3$)

Author: Geeta Kumar
Date: 17/05/2019
Map no: PS113386_GIS_024_A1

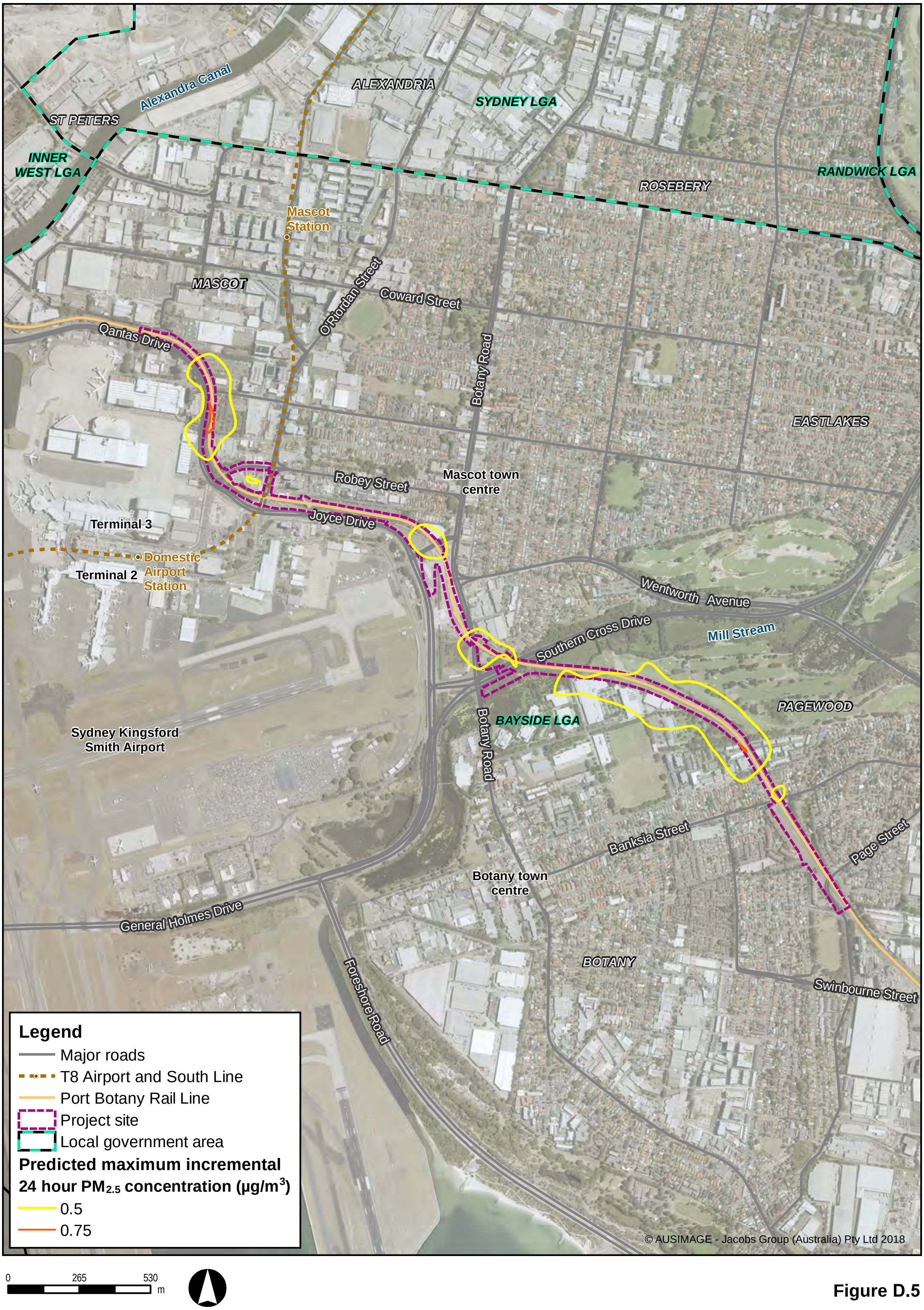


Figure D.5

Predicted maximum incremental 24 hour $PM_{2.5}$ concentration ($\mu g/m^3$)

Author: Geeta Kumar
Date: 17/05/2019
Map no: PS113386_GIS_025_A1

ARTC

G2SJV Gateway to Sydney Joint Venture
WSP Australia Pty Limited and GHD Pty Ltd

ABN: 55 836 411 311

Project Office
Level 27 Ernst & Young Centre
680 George Street
Sydney NSW 2000

GPO Box 5394
Sydney NSW 2001

Tel: +61 2 9272 5100
Fax: +61 2 9272 5101