Sydney Metro City & Southwest:
Waterloo Over Station Development

Air Quality Impact Assessment Report

Applicable to:	Sydney Metro City & Southwest
Author:	SLR Consulting Australia
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1.0 Introduction

1.1 Purpose of this report

This report accompanies a concept State Significant Development Application (concept SSD Application) submitted to the Department of Planning and Environment (DPE) pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The concept SSD Application is made under Section 4.22 of the EP&A Act.

This report should be read in conjunction with the Nominated State Significant Precinct (SSP) Study – Waterloo, submitted to the Minister for Planning (the Minister) in July 2018. That study proposes new planning controls to facilitate the development proposed.

Sydney Metro is seeking to secure concept approval for over station development (OSD) above and adjacent to Waterloo Station including a podium and three taller buildings which include commercial, residential, and community land uses. The concept SSD Application seeks consent for a building envelope and use for residential, retail, commercial, entertainment, community and recreational purposes, maximum building height, maximum gross floor area (GFA), pedestrian and vehicular access, circulation arrangements and associated car parking and the strategies and design parameters for the future detailed design of development.

Sydney Metro proposes to procure the construction of the OSD as part of an integrated station development package, which would result in the combined delivery of the station, OSD and public domain improvements. The station and its public domain elements form part of a separate planning approval for Critical State Significant Infrastructure (CSSI) approved by DPE on 9 January 2017.

As the development is within a rail corridor, is associated with railway infrastructure and is for "commercial premises or residential accommodation" with a Capital Investment Value of more than $30 million, the project is identified as State Significant Development (SSD) pursuant to Schedule 1, 19(2)(a) of the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP).

This report has been prepared to address the Air Quality impacts and specifically respond to the Secretary's Environmental Assessment Requirements (SEARs) issued for the concept SSD Application on 29th June 2018 which states that the Environmental Impact Statement (EIS) is to address the following requirements:

Reference	SEARs Requirement	Where Addressed in Report
8	Provide an air quality assessment report for the proposal. The assessment shall address the relevant policy guidelines.	**Section 6.0**

1.2 Overview of Sydney Metro in its context

Sydney Metro is Australia's biggest public transport project. A new standalone metro railway system, this 21st century network will deliver 31 metro stations and 66 kilometres of new metro rail for Australia's biggest city — revolutionising the way Sydney travels. Services start in the first half of 2019 on Australia's first fully-automated railway.

Sydney Metro was identified in *Sydney's Rail Future*, as an integral component of the *NSW Long Term Transport Master Plan*, a plan to transform and modernise Sydney's rail network so it can grow with the city's population and meet the future needs of customers. In early 2018, *the Future Transport Strategy 2056* was released as an update to *the NSW Long Term Transport Master Plan* and *Sydney's Rail Future*. Sydney Metro City & Southwest is identified as a committed initiative in the *Future Transport Strategy 2056*.

Sydney Metro is comprised of three projects:

Sydney Metro Northwest — formerly the 36 kilometre North West Rail Link. This $8.3 billion project is now under construction and will open in the first half of 2019 with a metro train every four minutes in the peak.

Sydney Metro City & Southwest — a new 30 kilometre metro line extending the new metro network from the end of Sydney Metro Northwest at Chatswood, under Sydney Harbour, through the CBD and south west to Bankstown. It is due to open in 2024 with an ultimate capacity to run a metro train every two minutes each way through the centre of Sydney.

Sydney Metro West – a new underground railway connecting the Parramatta and Sydney central business districts. This once-in-a-century infrastructure investment will double the rail capacity of the Parramatta to Sydney CBD corridor and will establish future capacity for Sydney's fast growing west. Sydney Metro West will serve five key precincts at Westmead, Parramatta, Sydney Olympic Park, The Bays and the Sydney CBD. The project will also provide an interchange with the T1 Northern Line to allow faster connections for customers from the Central Coast and Sydney's north to Parramatta and the Sydney CBD.

Sydney's new metro, together with signalling and infrastructure upgrades across the existing Sydney suburban rail network, will increase the capacity of train services entering the Sydney CBD – from about 120 an hour currently to up to 200 services beyond 2024. That's an increase of up to 60 per cent capacity across the network to meet demand.

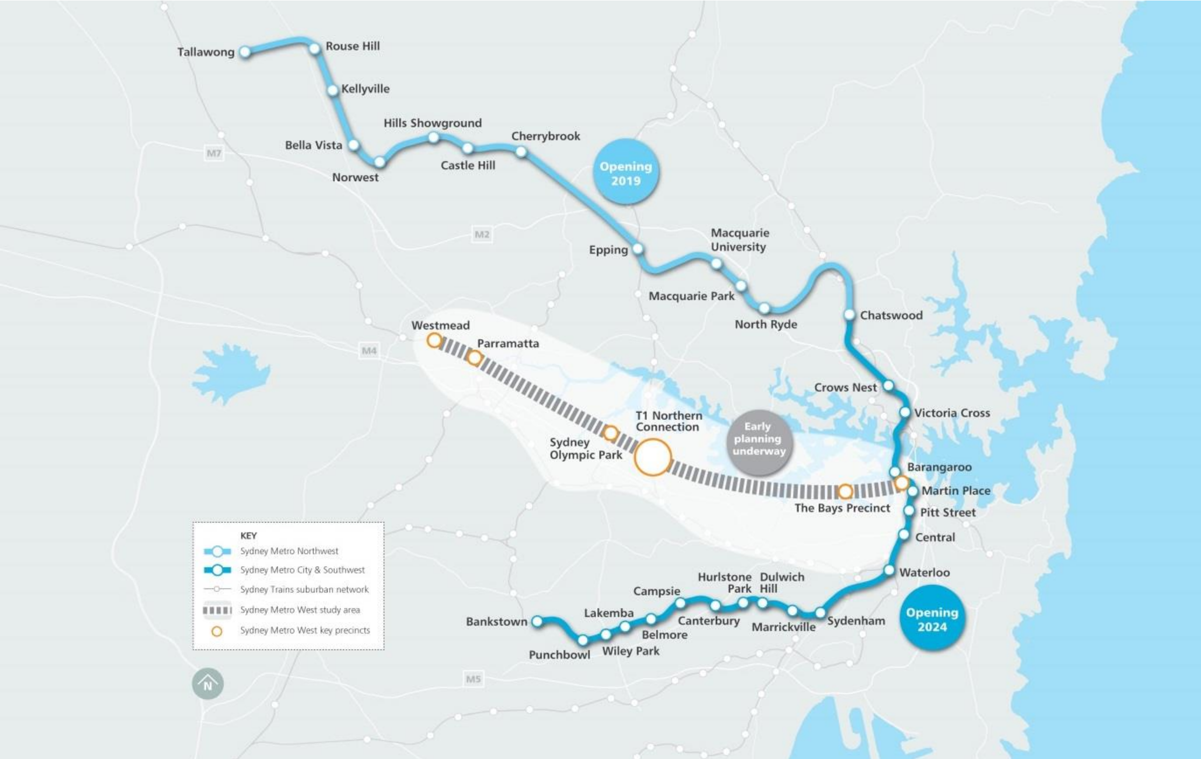

Figure 1 Sydney Metro alignment map

Sydney Metro City & Southwest includes the construction and operation of a new metro rail line from Chatswood, under Sydney Harbour through Sydney's CBD to Sydenham and on to Bankstown through the conversion of the existing line to metro standards.

The project also involves the delivery of six (6) new metro stations, including at Waterloo, together with new underground platforms at Central. Once completed, Sydney Metro will have the ultimate capacity for a train every two minutes through the CBD in each direction - a level of service never seen before in Sydney.

On 9 January 2017, the Minister approved the Sydney Metro City & Southwest - Chatswood to Sydenham application lodged by TfNSW as a CSSI project (reference SSI 15_7400).

The CSSI Approval includes all physical work required to construct the CSSI, including the demolition of existing buildings and structures on each site. Importantly, the CSSI Approval also includes provision for the construction of below and above ground structures and other components of future OSD (including building infrastructure and space for future lift cores, plant rooms, access, parking and building services, as relevant to each site). The rationale for this delivery approach, as identified within the CSSI application is to enable the OSDs to be more efficiently built and appropriately integrated into the metro station structures.

The EIS for the Chatswood to Sydenham alignment of the City & Southwest project identified that the OSD would be subject to a separate assessment process.

Since the CSSI Approval was issued, Sydney Metro has lodged four modification applications to amend the CSSI Approval as outlined below:

- Modification 1 - Victoria Cross and Artarmon Substation which involves relocation of the Victoria Cross northern services building from 194-196A Miller Street to 50 McLaren Street together with inclusion of a new station entrance at this location referred to as Victoria Cross North. The modification also involves the relocation of the substation at Artarmon from Butchers Lane to 98 – 104 Reserve Road. This modification application was approved on 18 October 2017.
- Modification 2 - Central Walk which involves additional works at Central Railway Station including construction of a new eastern concourse, a new eastern entry, and upgrades to suburban platforms. This modification application was approved on 21 December 2017.
- Modification 3 - Martin Place Station which involves changes to the Sydney Metro Martin Place Station to align with the Unsolicited Proposal by Macquarie Group Limited (Macquarie) for the development of the station precinct. The proposed modification involves a larger reconfigured station layout, provision of a new unpaid concourse link and retention of the existing MLC pedestrian link and works to connect into the Sydney Metro Martin Place Station. It is noted that if the Macquarie proposal does not proceed, the original station design remains approved. This modification application was approved on 22 March 2018.
- Modification 4 - Sydenham Station and Sydney Metro Trains Facility South which incorporated Sydenham Station and precinct works, the Sydney Metro Trains Facility South, works to Sydney Water's Sydenham Pit and Drainage Pumping Station and ancillary infrastructure and track and signalling works into the approved project. This modification application was approved on 13 December 2017.

The CSSI Approval as modified allows for all works to deliver Sydney Metro between Chatswood and Sydenham Stations and also includes upgrade of Sydenham Station.

The remainder of the City & Southwest alignment (Sydenham to Bankstown) proposes the conversion of the existing heavy rail line from west of Sydenham Station to Bankstown to metro standards. This part of the project, referred to as the Sydenham to Bankstown upgrade, is the subject of a separate CSSI Application (Application No. SSI 17_8256) for which an EIS was exhibited between September and November 2017. A Response to Submissions and Preferred Infrastructure Report was submitted to DPE in June 2018 for further exhibition and assessment. This application is subject to assessment and determination by DPE, taking into consideration a further Response to Submissions Report which was submitted to DPE in September 2018.

1.3 Nominated State Significant Precinct - Waterloo

Following the decision to locate a metro station in Waterloo, the Minister determined that parts of Waterloo are of State planning significance which should be investigated for urban renewal through the SSP process. Study requirements for such investigations were issued by the Minister on 19 May 2017.

Investigation of the Precinct is being undertaken by UrbanGrowth NSW Development Corporation (UrbanGrowth NSW), in partnership with Sydney Metro and the Land and Housing Corporation (LAHC). The outcome of the SSP process will be new planning controls that will enable future development applications for renewal of the Precinct.

The Precinct includes two separate but contiguous and inter-related parts:

- The Waterloo Metro Quarter (the Metro Quarter)
- The Waterloo Estate (the Estate)

A separate SSP Study for the Metro Quarter was lodged in July 2018 in advance of the SSP Study for the Estate to provide a planning framework for the construction of OSD within the Metro Quarter. The staged submission of the Metro Quarter SSP Study also facilitates the proposed development to be delivered concurrently with the metro station, as an integrated station development.

As this concept SSD Application relies upon the planning framework proposed in the Metro Quarter SSP Study, it is anticipated that the SSP Study and the EIS for the SSD will be exhibited concurrently.

1.4 Planning relationship between Waterloo Station and the OSD

While Waterloo Station and the OSD will form an integrated station development, the planning pathways defined under the EP&A Act require separate approval for each component of the development. In this regard, the approved station works (CSSI Approval) are subject to the provisions of Part 5.1 of the EP&A Act (now referred to as Division 5.2) and the OSD component is subject to the provisions of Part 4 of the EP&A Act.

For clarity, the approved station works under the CSSI Approval included the construction of below and above ground structures necessary for delivering the station and also enabling construction of the integrated OSD. This includes but is not limited to:

- demolition of existing development
- excavation
- integrated station and OSD structure (including concourse and platforms)
- lobbies

- retail spaces within the station building
- public domain improvements associated with the station
- access arrangements including vertical transport such as escalators and lifts
- space provisioning and service elements necessary to enable the future development of the OSD, such as lift cores, plant rooms, access, parking, retail, utilities connections and building services.

The vertical extent of the approved station works above ground level is defined by the ‘transfer level’ level (which for Waterloo is defined by approximately RL 33.1 over the northern station box and RL 35.1 over the southern station box), above which would sit the OSD. An example of this delineation is illustrated in **Figure 2**.

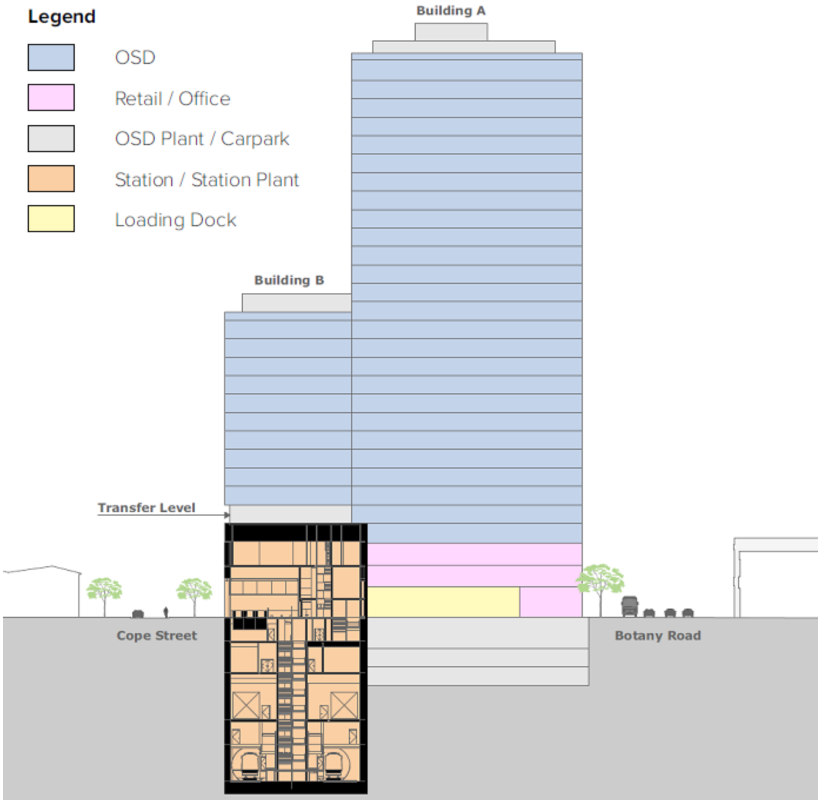

Figure 2 Delineation between the Metro station and OSD

It is noted that the structural and service requirements and space provisioning to support OSD vary from station to station. For example, based on the current level of design, Waterloo Station is not expected to provide for OSD lobbies, end of trip facilities and plant rooms. However, the detailed design may be amended to incorporate these elements as part of the integrated station development.

The CSSI Approval also establishes the general concept for the ground plane of Waterloo Station including access strategies for commuters, pedestrians and workers. In this regard, the main pedestrian access to the station would be via an entry located at the corner of Raglan and Cope Streets. The station design has continued to be developed having regard to its integration with the Metro Quarter OSD, and as a result, a second entrance to the station is to be provided from a proposed public plaza adjacent to Cope Street. Retail uses (approved under the CSSI Approval) would be located on the ground floor of the station development along the Cope Street frontage of the site.

Since the issue of the CSSI Approval, Sydney Metro has undertaken design work to determine the technical requirements for the structural integration of the OSD with the station. This level of design work, together with the planning and design undertaken for the remainder of the Metro Quarter has informed the concept proposal for the OSD. It is noted that ongoing design development of the works to be delivered under the CSSI Approval would continue with a view to developing an Interchange Access Plan (IAP) and Station Design Precinct Plan (SDPP) for Waterloo Station to satisfy Conditions E92 and E101 of the CSSI Approval. The detailed design for the Metro Quarter would continue to evolve having regard to the IAP and SDPP.

Public domain improvement works immediately adjacent to Waterloo Station would be delivered as part of the CSSI Approval to support pedestrian movements between transport modes (including to new and relocated bus stops, bike parking on Cope Street, and taxi and kiss-and-ride bays on Cope Street), while other public domain works within the Metro Quarter are proposed as part of the OSD. Final details of public domain works for the OSD will be provided with the detailed SSD Application(s) following finalisation of the SDPP and IAP for the CSSI Approval.

1.5 The site

1.5.1 Location

The site is located within the City of Sydney Local Government Area (LGA).

The Metro Quarter comprises land to the west of Cope Street, east of Botany Road, south of Raglan Street and north of Wellington Street. The heritage listed Waterloo Congregational Church located at 103–105 Botany Road is within this block but is not part of the site.

The site has an approximate area of 1.287 hectares (refer to **Figure 3**).

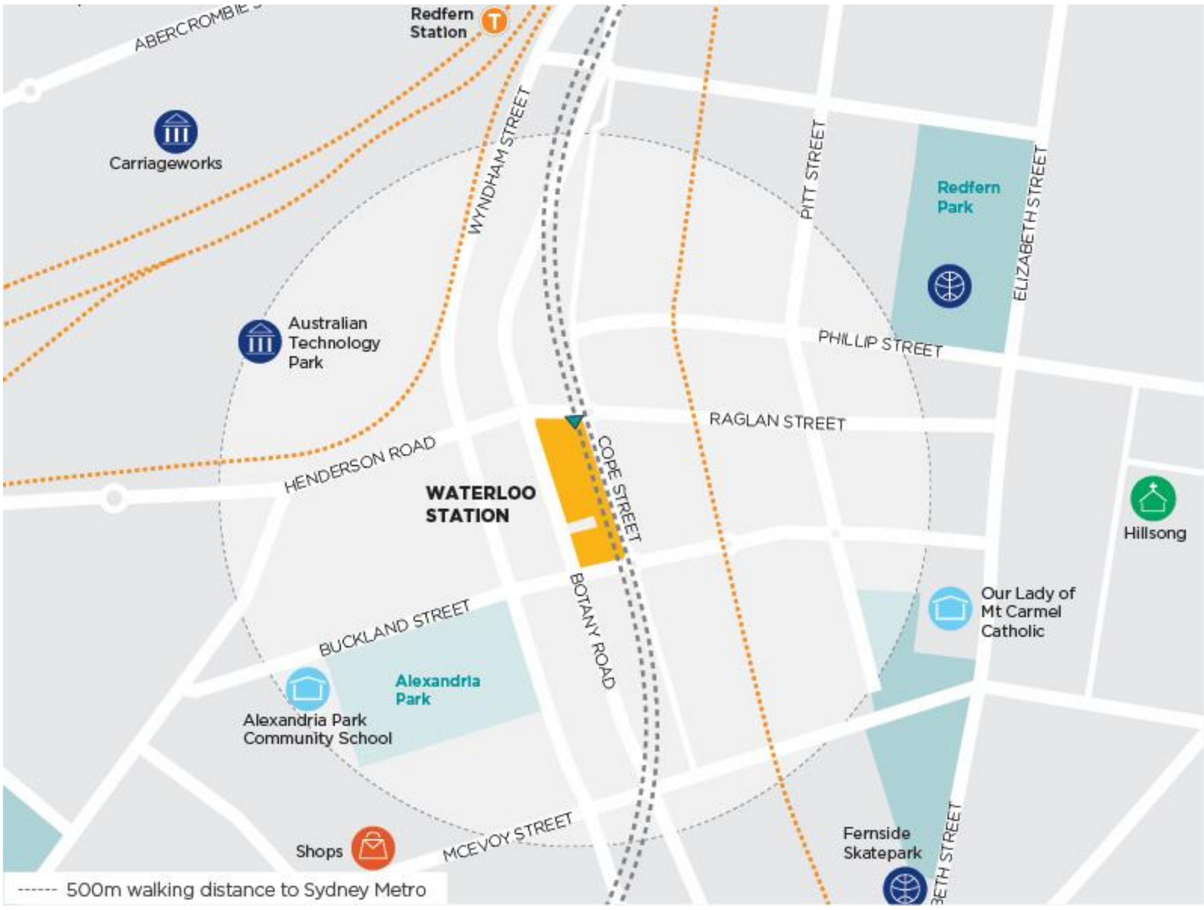

Figure 3 Waterloo Station location plan

1.5.2 Site context

The Metro Quarter is located in Redfern Street Village (see **Figure 4**) in the City of Sydney LGA approximately 3.3 kilometres south of Sydney CBD, 1 kilometre north of Green Square and less than 1 kilometre south of Redfern Station.

Directly east is the Waterloo Estate, which is owned by the NSW Government and is under the management of NSW LAHC. The Waterloo Estate comprises 2,012 social housing dwellings and a small number of private dwellings in medium and high density forms, ranging from single storey attached dwellings to apartment buildings of up to thirty storeys.

The Metro Quarter is less than 1 kilometre southeast of the Australian Technology Park (ATP), a technology micro-cluster that currently contains around 3,000 – 3,500 workers with a range of businesses in technology and creative industries; and a start-up/business incubator hub. It is set to grow into a business park that will soon accommodate new premises currently under construction (i.e. Commonwealth Bank Australia (CBA) has committed to two major office towers).

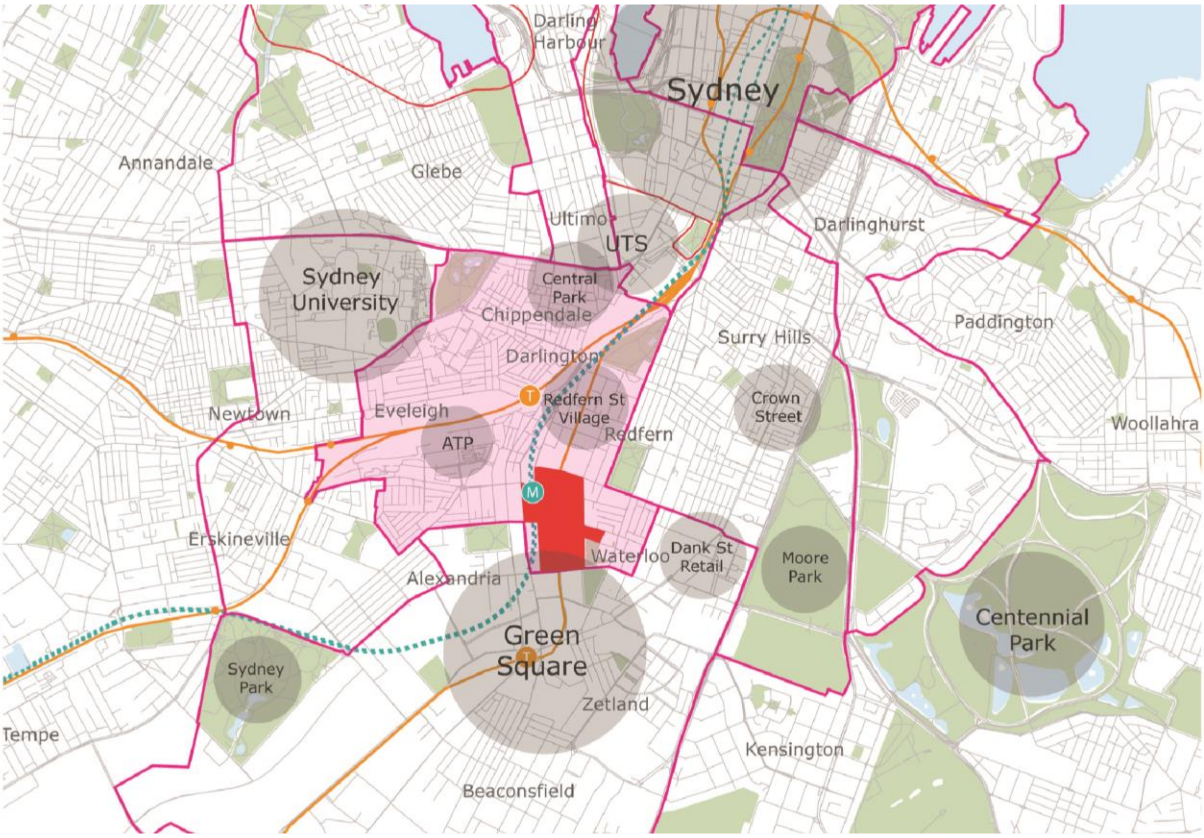

Figure 4 Location and site plan of the Waterloo State Significant Precinct (in red) and Redfern Street Village (in pink)

Figure 5 Nominated State Significant Precinct - Waterloo

The site comprises the following properties:

• 136B Raglan Street	Lot 4 DP 215751
• 59 Botany Road	Lot 5 DP 215751
• 65 Botany Road	Lot 1 DP814205
• 67 Botany Road	Lot 1 DP228641
• 124-128 Cope Street	Lot 2 DP228641
• 69-83 Botany Road	SP75492
• 130-134 Cope Street	Lot 12 DP399757
• 136-144 Cope Street	Lots A-E DP108312
• 85 Botany Road	Lot 1 DP27454
• 87 Botany Road	Lot 2 DP27454
• 89-91 Botany Road	Lot 1 DP996765
• 93-101 Botany Road	Lot 1 DP433969 & Lot 1 DP738891
• 156-160 Cope Street	Lot 31 DP805384
• 107-117A Botany Road	Lot 32 DP805384 & Lot A DP408116
• 119-121 Botany Road	Lot 1 DP205942 & Lot 1 DP436831
• 170-174 Cope Street	Lot 2 DP205942

The buildings and structures on the site are now demolished in accordance with the CSSI Approval with the exception of one building which is being used to support construction.

1.6 Overview of the proposed development

This concept SSD Application follows the submission of a SSP Study which supports a proposal to amend existing controls to facilitate the proposed development. The concept SSD Application will in turn comprises the first stage of seeking SSD development consent for the Waterloo OSD project. It will be followed by a future detailed SSD Application(s) for the design and construction of the OSD built form.

This concept SSD Application seeks approval for the planning and development framework and strategies to inform the future detailed design of the OSD. It specifically seeks approval for:

- maximum building envelopes, including maximum building heights, street-wall heights and ground and upper level setbacks
- a maximum gross floor area (GFA) of 69,000 square metres, comprising:
  - approximately 56,200 square metres GFA of residential accommodation, with potential to deliver approximately 700 dwellings, comprising a 5 to 10 percent affordable housing and 70 social housing dwellings
  - Approximately 3,905 square metres GFA of retail premises and entertainment facilities

- Approximately 8,645 square metres GFA for business and commercial premises and community, health service and recreational facilities (indoor), including at least 2,000 square metres of floor spaces for community uses

- a three storey podium and a free standing building located within a public plaza, accommodating non-residential land uses
- residential uses above podium level in various building forms including three buildings of 23, 25 and 29 storeys (Relative Level (RL) 96.9, 104.2 and 116.9 metres Australian Height Datum (AHD) respectively)
- use of OSD space provisioning within the footprint of the CSSI Approval
- public domain works, through-site links, footpaths, provision for cycle facilities and enhanced pedestrian crossings and roads
- car parking for up to 427 vehicles
- loading, vehicular and pedestrian access arrangements
- strategies for utilities and services provision
- strategies for managing stormwater and drainage
- a strategy for the achievement of ecologically sustainable development
- a public art strategy
- provision for future signage zones
- a design excellence framework
- the future subdivision of parts of the OSD footprint (if required).

It is noted that the Sydney Metro comprises GFA of approximately 8,415 square metres on the site, approved under CSSI Approval. The total GFA for the integrated station development, including the station GFA is approximately 77,165 square metres, which is equivalent to an FSR of approximately 6:1.

Key parameters of the Concept proposal based on the current level of design development are indicated at **Figure 6** and **Figure 7**.

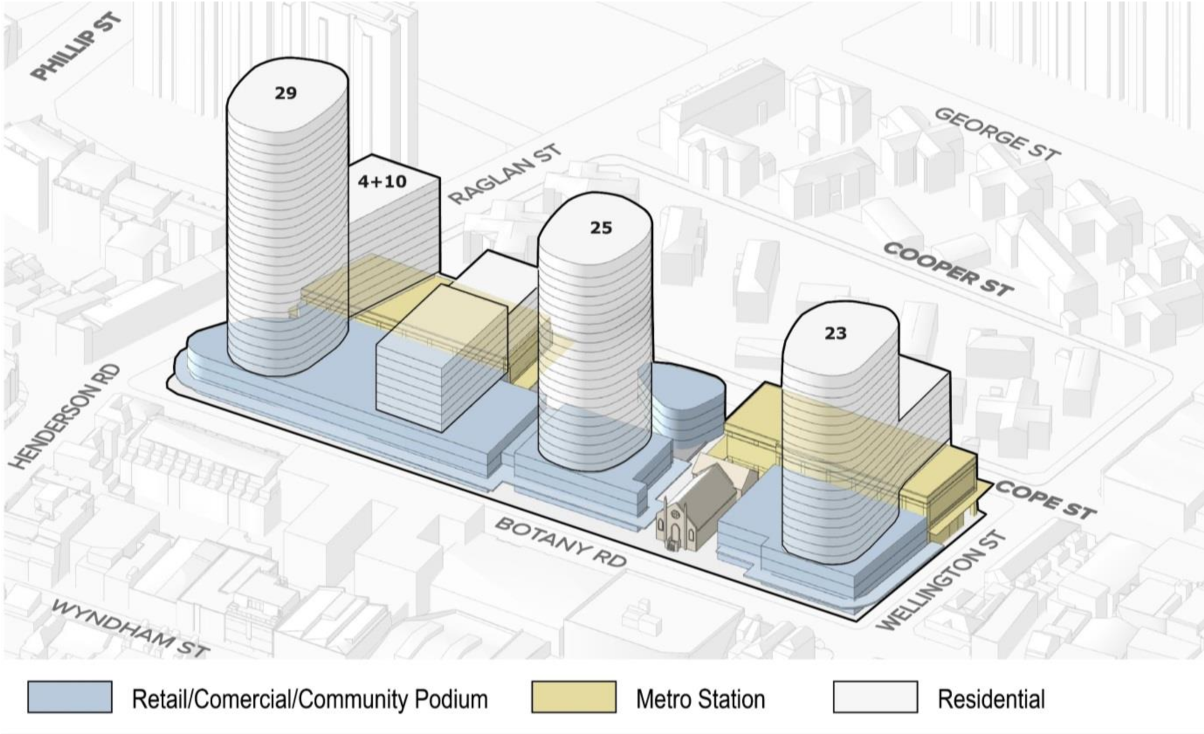

Figure 6 Proposed massing, viewed from the west

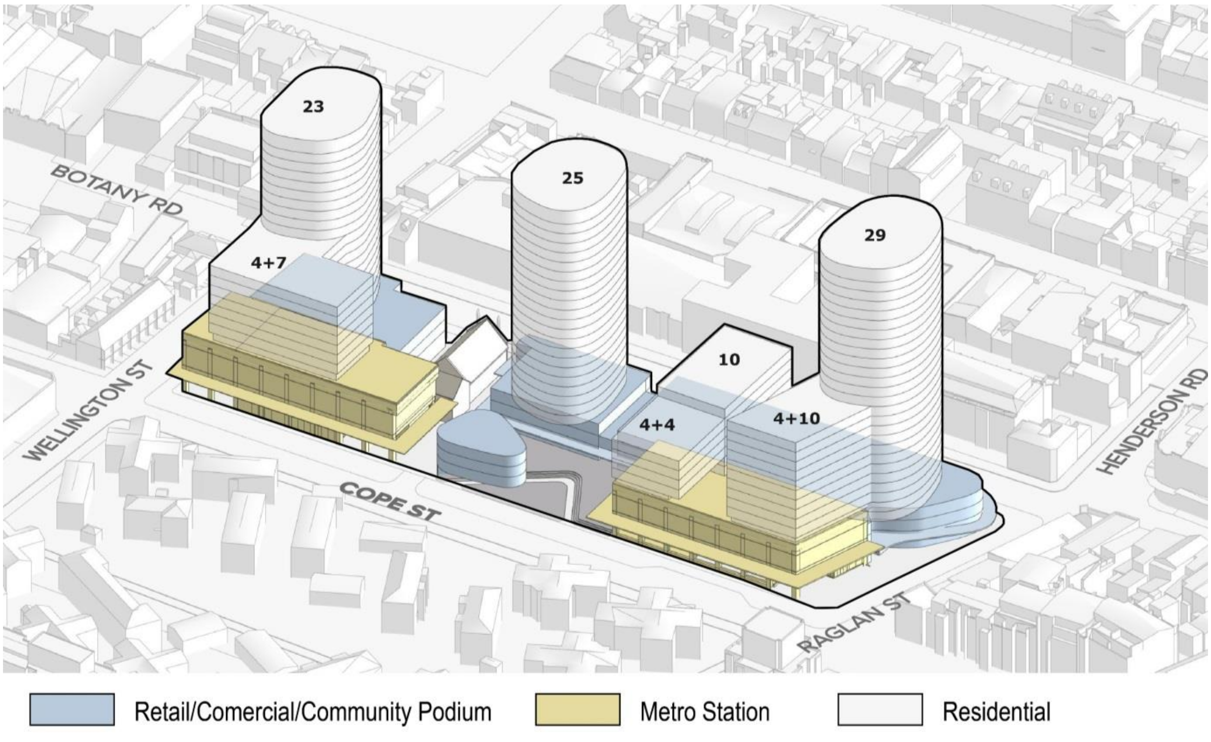

Figure 7 Proposed massing, viewed from the east

The proposal is a significant opportunity to contribute to the urban renewal process for the Waterloo SSP. The objective to deliver the Metro Quarter project as soon as reasonably possible after completion of the Sydney Metro works (earmarked to open 2024) would ensure buildings within the Metro Quarter are occupied to support maximum patronage of the proposed metro station.

The Metro Quarter would contain a mix of uses including residential, commercial, retail, community facilities and services and cultural opportunities sufficient for daily life to be provided for within the wider neighbourhood and to support the activation of the precinct. This would help make Waterloo one of the most connected and attractive inner-city places to live, work and visit.

The concept design of the Metro Quarter incorporates a number of measures in order to reduce the likelihood of air quality impacts. These include:

- Locating no sensitive receptors within a 20 metre radius of Botany Road and at elevations above 12 metres.
- Minimising the formation of urban canyons[1] by having buildings of different heights interspersed with open areas, and setting back the upper storeys of multi-level building.
- Orienting living areas and bedrooms as far as practicable from Botany Road.
- Using vegetative screens to assist in maintaining local ambient air amenity.

[1] a street that is flanked on either side with tall buildings creating a structure that's similar to a canyon. Within an urban canyon, air recirculation is poor and there is a risk of pollutant accumulation.

1.7 Staging and framework for managing environmental impacts

Sydney Metro proposes to procure the delivery of the Waterloo integrated station development in one single package, which would entail the following works:

- station structure fit-out, including mechanical and electrical
- OSD structure fit-out, including mechanical and electrical.

Separate delivery packages are also proposed by Sydney Metro to deliver the excavation of the station boxes/shafts ahead of the integrated station development delivery package, and linewide systems (e.g. track, power, ventilation) and operational readiness works prior to the Sydney Metro City & Southwest metro system being able to operate.

For the purposes of considering construction related impacts, three possible staging scenarios have been identified for delivery of the integrated station development:

1. Scenario 1 – the station and OSD are constructed concurrently by constructing the transfer slab first and then building in both directions. Both the station and OSD would be completed in 2024.
2. Scenario 2 – the station is constructed first and ready for operation in 2024. OSD construction may still be incomplete or soon ready to commence after station construction is completed. This means that some or all OSD construction is likely to still be underway upon opening of the station in 2024.
3. Scenario 3 – the station is constructed first and ready for operation in 2024. The OSD is built at a later stage, with timing yet to be determined. This creates two distinct construction periods for the station and OSD.

The final staging for the delivery of the OSD would be resolved as part of the detailed SSD Application(s).

For the purposes of providing a high level assessment of the potential environmental impacts associated with construction, the following have been considered:

- Impacts directly associated with the OSD, the subject of this SSD Application
- Cumulative impacts of the construction of the OSD at the same time as the station works (subject of the CSSI Approval).

Given the integration of the delivery of Waterloo Station with an OSD development, Sydney Metro proposes the framework detailed in **Figure 8** to manage the design and environmental impacts, in relation to Air Quality, consistent with the framework adopted for the CSSI Approval.

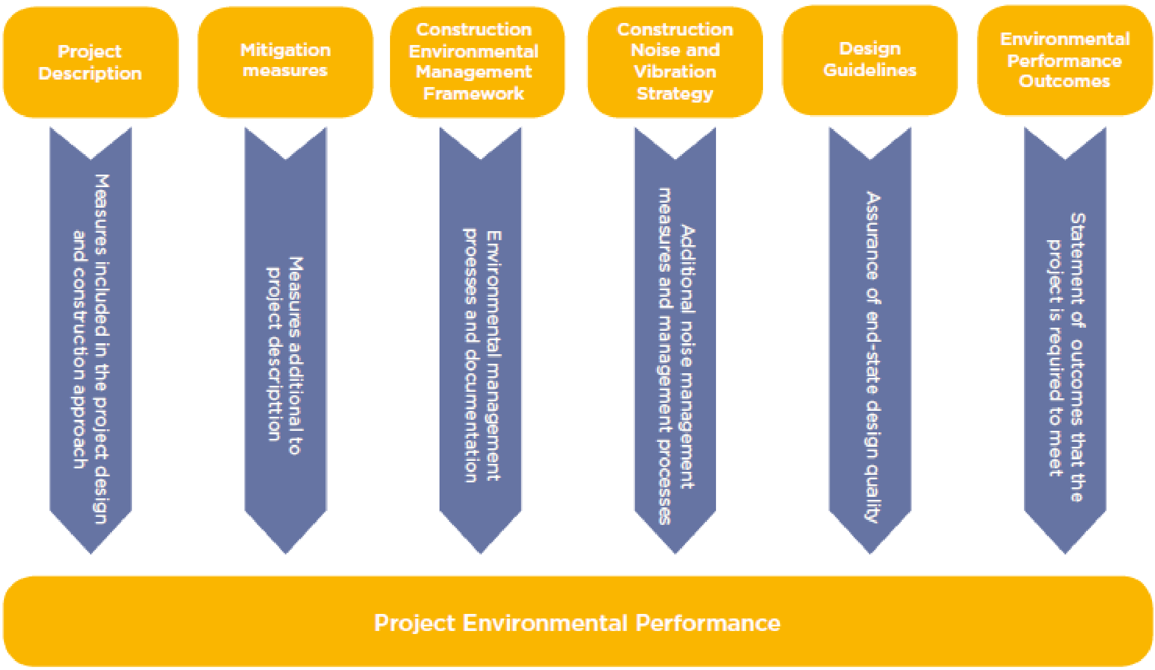

Figure 8 Project approach to environmental mitigation and management

This approach would be implemented until such time as completion of the station works (i.e. works under the CSSI Approval) is achieved. Beyond that point, standard construction environmental management practices would be implemented by the OSD developer in accordance with relevant guidelines and any conditions of approval.

2.0 Scope of Assessment

As outlined in **Section 1.1**, the purpose of this report is to address the Secretary's Environmental Assessment Requirements (SEARs) pertaining to potential air quality impacts.

The assessment addresses this requirement by assessing the incremental and cumulative potential air quality impacts from and on the Metro Quarter. This Air Quality Assessment (AQA) has been prepared in general accordance with The Approved Methods (NSW Environmental Protection Authority (EPA), 2017) with reference to the Infrastructure SEPP and the NSW Department of Planning document "*Development near Rail Corridors and Busy Roads – Interim Guideline*" (DoP, 2008) (the Guideline).

3.0 Baseline Investigations

3.1 Project setting

3.1.1 Local topography

Topography is important in air quality studies as local atmospheric dispersion can be influenced by night-time katabatic (downhill) drainage flows from elevated terrain or channelling effects in valleys or gullies around the Metro Quarter.

A three dimensional representation of the region is provided in **Figure 9**. The topography of the local area within a 7 kilometre radius of the Metro Quarter ranges from an approximate elevation of -10 metres to 110 metres Australian Height Datum (AHD).

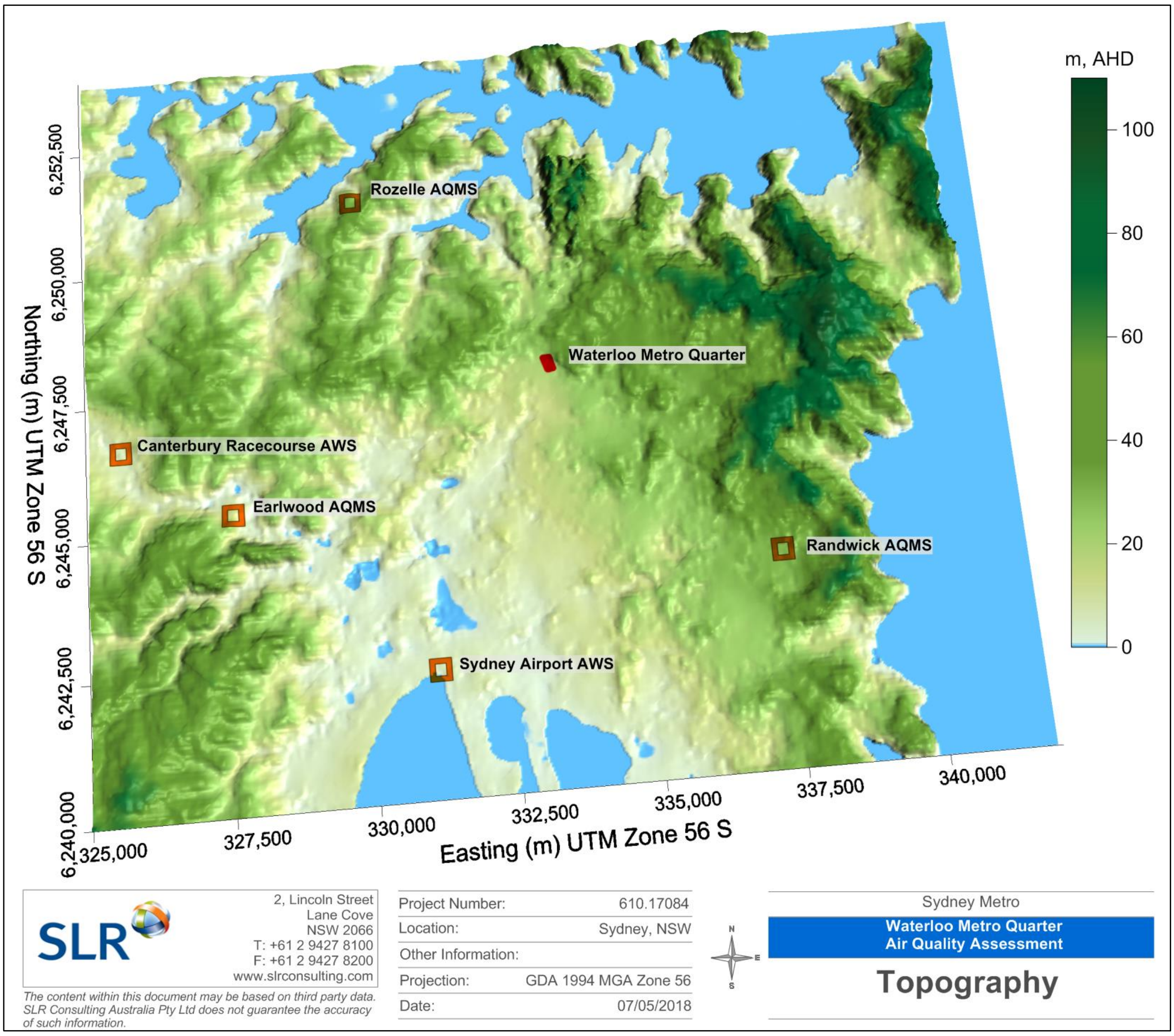

Figure 9 Topography of Area Surrounding the Metro Quarter

The Metro Quarter and surrounding area is reasonably flat, hence any increase in vehicular emissions on surrounding roads associated with road gradient is not likely. The area immediately surrounding the Metro Quarter is also currently relatively open, which will facilitate the dispersion of air emissions and prevent 'pooling' of air pollutants.

3.1.2 Local meteorology

Local wind speed and direction influence the dispersion of air pollutants. Wind speed determines both the distance of downwind transport and the rate of dilution as a result of 'plume' stretching. Wind direction, and the variability in wind direction, determines the general path pollutants will follow and the extent of crosswind spreading. Surface roughness (characterised by features such as the topography of the land and the presence of buildings, structures and trees) affects the degree of mechanical turbulence, which also influences the rate of dispersion of air pollutants.

The Bureau of Meteorology (BoM) maintains and publishes data from weather stations across Australia. The closest such stations recording wind speed and wind direction data include the Sydney Airport Automatic Weather Station (AWS) (approximately 6 kilometres southwest of the Metro Quarter) and Canterbury Racecourse AWS (approximately 8 kilometres west of the Metro Quarter) (refer **Figure 9**).

Annual and seasonal wind roses for the years 2013-2017 (inclusive), compiled from data recorded by the Sydney Airport AWS and Canterbury Racecourse AWS are presented in and **Figure 10** and **Figure 11** respectively. The wind roses show the frequency of occurrence of winds by direction and strength. The bars correspond to the 16 compass points (degrees from north). The bar at the top of each wind rose diagram represents winds blowing from the north (i.e. northerly winds), and so on. The length of the bar represents the frequency of occurrence of winds from that direction, and the widths of the bar sections correspond to wind speed categories, the narrowest representing the lightest winds. Thus it is possible to visualise how often winds of a certain direction and strength occur over a long period, either for all hours of the day, or for particular periods during the day.

A comparison of **Figure 10** and **Figure 11** shows that the Sydney Airport AWS recorded much higher frequencies of stronger winds than the Canterbury Racecourse AWS during the 2012-2017 period. The annual frequency of calm wind conditions was recorded to be 0.3 percent by the Sydney Airport AWS and 18.5 percent by the Canterbury Racecourse AWS. This is to be expected given that the Sydney Airport AWS is located close to Botany Bay and in relatively open surroundings.

In terms of wind direction, while there are differences between the data recorded at the two locations, the annual wind rose for the years 2012-2017 for both sites indicates the predominant wind directions in the area are from the northwest, with a low frequency of winds from the east.

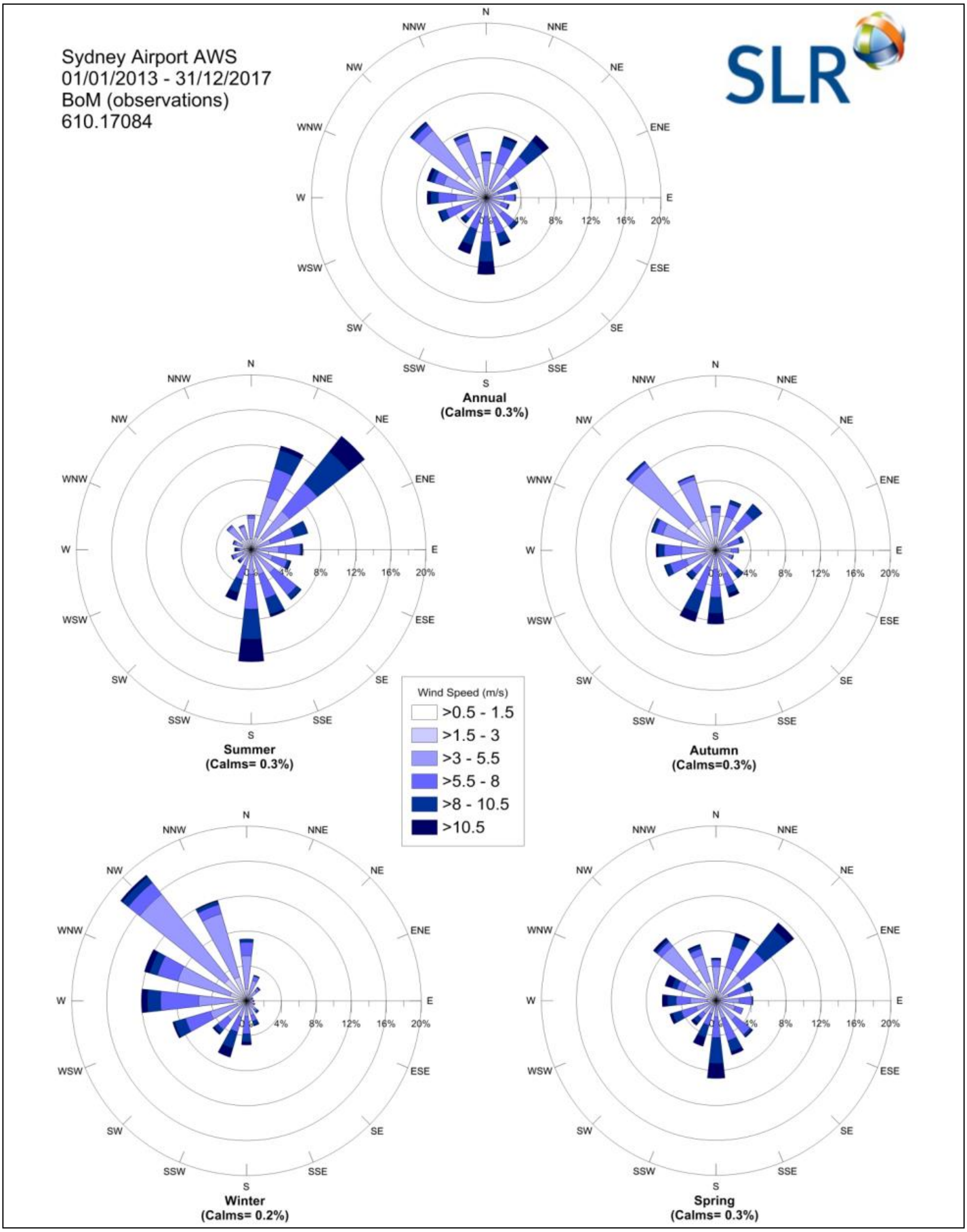

Figure 10 Sydney Airport AWS Annual and Seasonal Wind Roses, 2013-2017

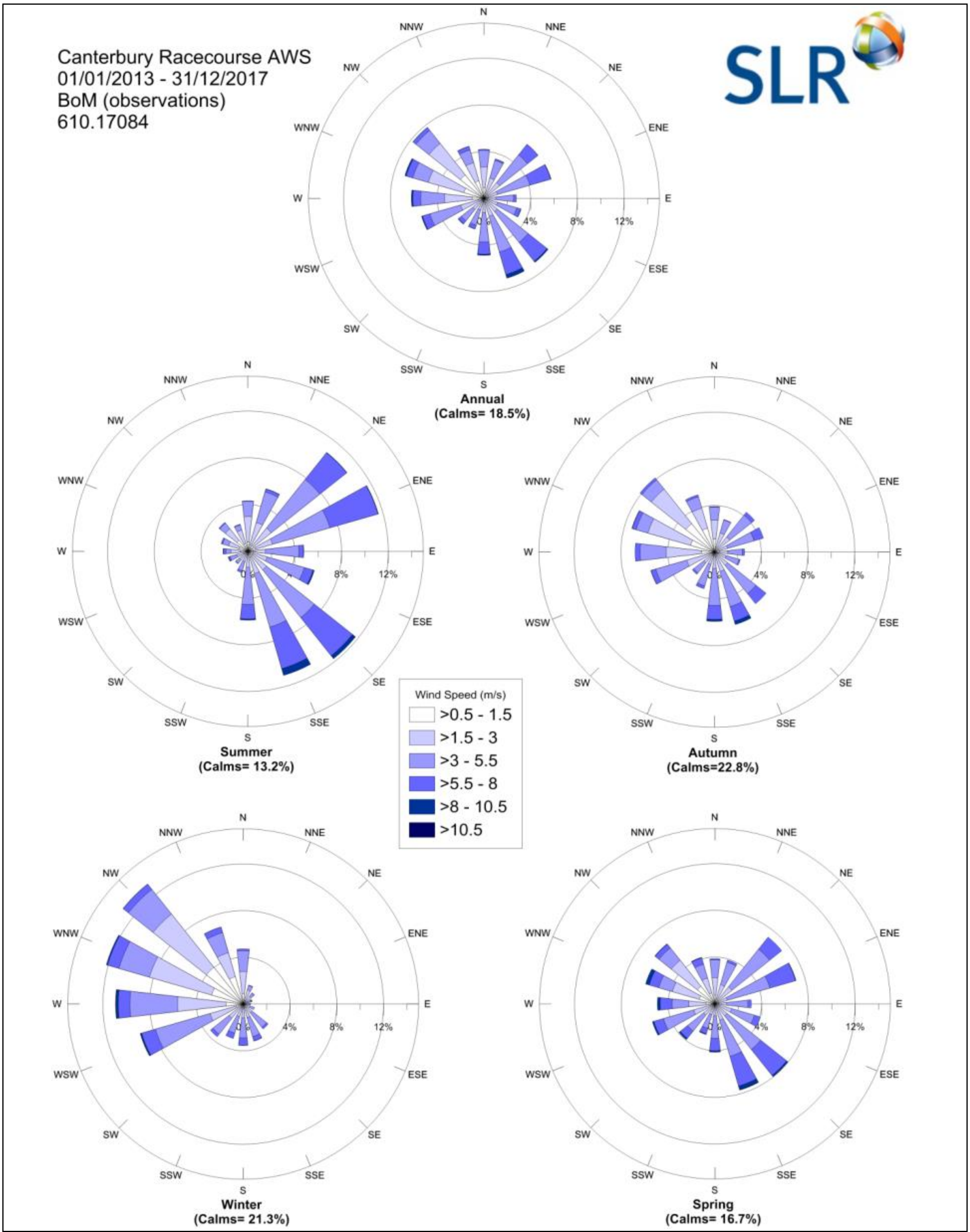

Figure 11 Canterbury Racecourse AWS Annual and Seasonal Wind Roses, 2013-2017

The seasonal wind roses for the 2012-2017 period indicate that:

- In summer, winds are predominantly from the northeast and southeast, with negligible winds from the western quadrant. Calms were recorded to occur approximately 0.3 percent of the time during the summer months by the Sydney Airport AWS and 13 percent by the Canterbury Racecourse AWS.
- In autumn, winds are predominantly from the northwestern quadrant with few winds from the east and east-southeast. Calms were recorded for approximately 0.3 percent of the time during the autumn months by the Sydney Airport AWS and 23 percent by the Canterbury Racecourse AWS.
- In winter, winds are predominantly from the northwest with very few winds from the east-northeastern quadrant. Calms were recorded for approximately 0.2 percent of the time during the winter months by the Sydney Airport AWS and 21 percent by the Canterbury Racecourse AWS.
- In spring, there are winds from all directions, with the highest frequency recorded by the Sydney Airport AWS as being from the northeast quadrant, and by the Canterbury Racecourse AWS as being from the southeast quadrant. Calms were recorded for approximately 0.3 percent of the time during the spring months by the Sydney Airport AWS and 17 percent by the Canterbury Racecourse AWS.

From the long term wind patterns recorded by the Sydney Airport AWS and Canterbury Racecourse AWS, and assuming that the same wind conditions will be experienced at the Metro Quarter, it can be concluded that that the Metro Quarter is likely to be subjected to winds from all directions, with the lowest frequency of winds from the east and southwest quadrants.

Considering the relatively complex topographical features of the land between the Metro Quarter and the two BoM weather stations (see **Figure 9**), the actual winds experienced at the Metro Quarter may be different to those recorded by the BoM stations. Therefore, meteorological modelling was carried out to provide site-representative wind data for the Metro Quarter (see **Section 6.1.2.6**).

3.1.3 Surrounding land use

As illustrated in **Figure 12**, the lots immediately surrounding the Metro Quarter are zoned as Mixed Use and General Residential by the *Sydney Local Environment Plan 2012*. Within a 500 metre radius of the Metro Quarter, the land is predominantly zoned as General Residential, Mixed Use, Public Recreation, Local Centre, Business Park and Infrastructure. The nearest residential receptors are located on Cope Street, approximately 25 metres east of the Metro Quarter. Some commercial and light industry uses are located within the Mixed Use zones to the south, west and north. Potential air emissions from these activities are addressed in **Section 6.1.3**.

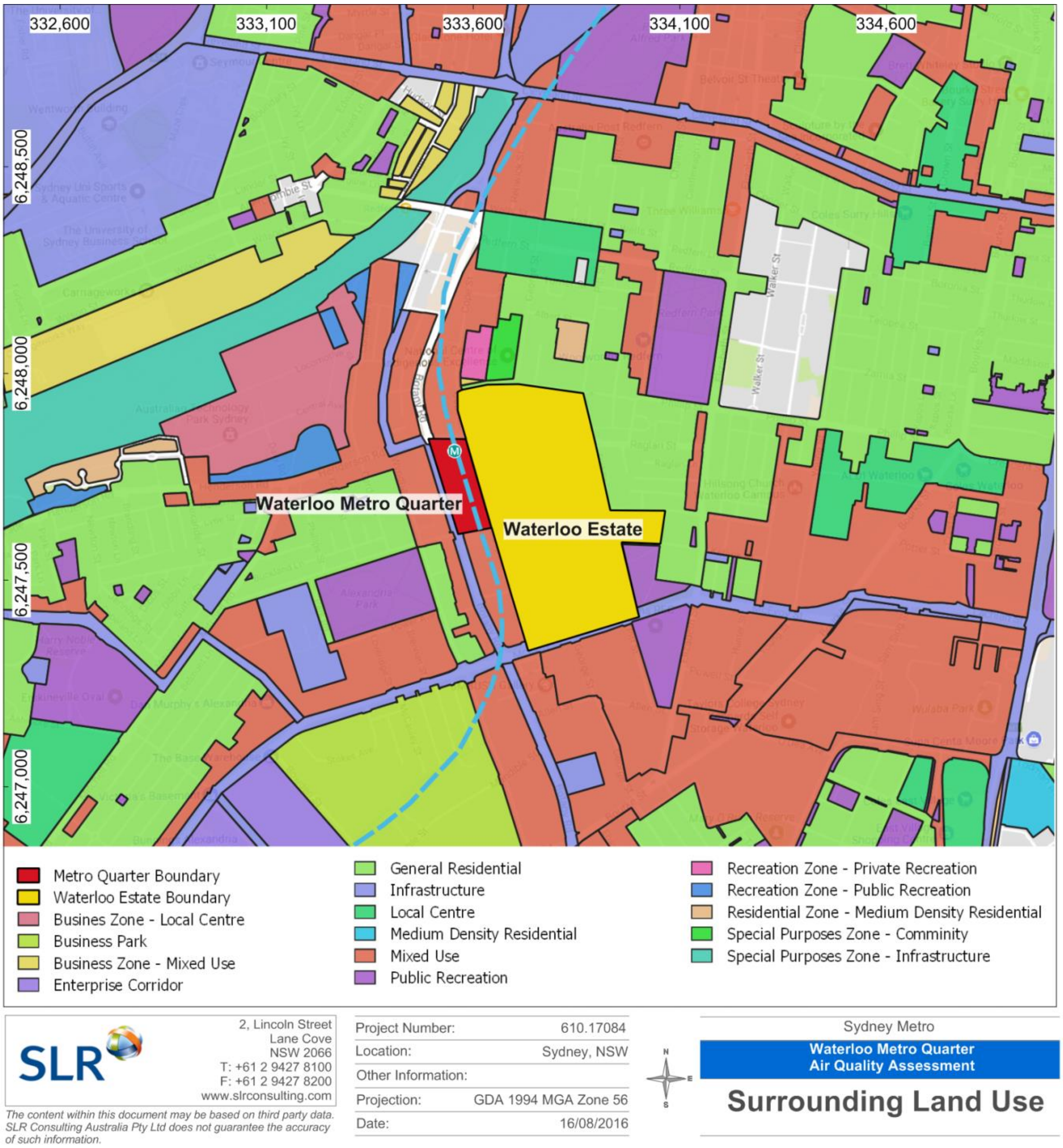

Figure 12 Surrounding Land Use

3.2 Identified pollutant sources and types

3.2.1 Construction activities

Potential air emissions associated with the construction phase include:

- Fugitive dust emissions from construction of buildings and other structures; and
- Products of combustion from construction plant and machinery.

3.2.1.1 Dust emissions from construction phase activities

During the construction phase, the potential for dust to be emitted from the Metro Quarter would be directly influenced by the nature of the activities being performed. Activities that may lead to short-term emissions of dust include:

- Dust emissions from earthworks activities (e.g. excavation and loading of soils to trucks).
- Wind-generated dust from disturbed surfaces and stockpiles.
- Wheel-generated dust and particulate matter emissions in diesel exhaust emissions from on-site plant and equipment and construction traffic movements.

These activities should be managed appropriately to ensure off-site impacts are minimised.

Temporary elevation in the emissions of particulate matter and local dust is considered to be inevitable as part of the construction works, particularly where those activities are undertaken during periods of low rainfall and/or windy conditions. The impact of elevated dust emissions is dependent upon the potential for particulates to become and remain airborne prior to being deposited as dust or experienced as an ambient particulate concentration.

The indicative construction schedule for the Metro Quarter identifies that construction works is expected to require a number of years to complete. It is noted that the construction of the development would likely be staged and dust-generating activities would not be occurring continuously throughout this period.

3.2.1.2 Products of combustion from construction phase plant and machinery

Exhaust emissions from cranes, trucks, plant and other equipment associated with the construction of the Metro Quarter would be a source of emissions to air (additional to existing emissions from the local road network) the site during the construction phase.

Given the nature of the proposed development, the number and scale of construction plant and machinery, and road traffic vehicles is anticipated to be relatively small. Therefore, the potential for exhaust emissions during the construction phase is considered to be correspondingly low.

3.2.2 Road traffic

The primary source of air emissions in the area immediately surrounding the Metro Quarter is expected to be vehicles travelling along Botany Road which is classified as a "Main Road" under the *NSW Roads Act 1993* (Gazetted Road Number: 170). A review of the *National Pollutant Inventory Emission Estimation Technique Manual* (NPI EET) for Combustion Engines (DEWHA , 2008) identifies the primary pollutants from combustion engines as:

- Total Volatile Organic Compounds (TVOCs)
- Carbon monoxide (CO)
- Oxides of nitrogen (NO_x)
- Particulate matter less than 2.5 microns in aerodynamic diameter ($PM_{2.5}$)
- Particulate matter less than 10 microns in aerodynamic diameter (PM_{10})
- Sulfur dioxide (SO_2)

Other substances that are also emitted from vehicle exhausts in trace amounts include products of incomplete combustion, such as metallic additives which contribute to the particulate content of the exhaust (DEWHA , 2008). In addition, ozone (O3) is formed as a secondary pollutant from reactions between TVOCs and NO_x, and is used as a key indicator of smog in urban environments).

The rate and composition of air pollutant emissions from road vehicles is a function of a number of factors, including the type, size and age of vehicles within the fleet, the type of fuel combusted, number and speed of vehicles and the road gradient.

The proximity of a classified road to the Metro Quarter means that road traffic emissions have the potential to result in elevated air pollutant concentrations during peak periods in areas within the Metro Quarter closest to Botany Road.

3.2.3 Industrial sources

Industrial sites located in and surrounding the Metro Quarter with the potential to be significant emitters of air pollutants were identified through:

- A desktop mapping of industrial sites regulated by the EPA;
- A review of facilities required to report to the National Pollutant Inventory (NPI); and
- A site visit.

Environment Protection Licences (EPLs) are issued under the *Protection of the Environment Operations Act 1997* (POEO Act) and are regulated by the EPA. EPLs stipulate emission limits to water, land and/or air and provide operational protocols to ensure industrial emissions/operations comply with relevant standards. The NPI database provides details on industrial emissions of over 4,000 facilities across Australia. The requirement to return annual reports to the NPI quantifying a facility's emissions is determined by the activities/processes being undertaken at the facility, and also whether those processes exceed process-specific thresholds in terms of activity rates (i.e. throughput and/or consumption). It is not intended to make a statement that the emissions associated with those activities will be significant in terms of their potential for impact and/or generation of complaint, however it provides a tool to identify significant emission sources in a specific area that then may be investigated further to assess their potential to impact on local air quality.

A search of the EPA public register and NPI database for the project area returned several records of industries in the vicinity of the precinct which could potentially be a source of air pollutant emissions. The locations of these facilities relative to the Metro Quarter is illustrated in **Figure 13** with further details presented in **Table 1**.

As outlined in **Table 1**, considering the separation distances and activity types associated with the identified emission sources, significant air quality impacts at the Metro Quarter due to air emissions from these facilities are considered unlikely.

Table 1 Identified Sources of Air Emissions in the Vicinity of the Metro Quarter

Facility Name	Type of Activity	Approximate Distance from the Metro Quarter	Likelihood of Significant Impact
Alexandria Asphalt Plant	Petroleum and coal product manufacturing	2.3 kilometres (SW)	Low
Australian Refined Alloys Alexandria	Basic non-ferrous metal manufacturing	1.1 kilometres (SW)	Low
Monroe Springs	Metal product manufacturing	1.7 kilometres (SSW)	Low
Spotless Facility Services	Laundry and dry-cleaning services	1.6 kilometres (SSE)	Low
Dial a Dump Industries	Waste processing (non-thermal treatment)	1.7 kilometres (SW)	Low
Malt Shovel Brewery	Brewing and packaging of beer	2.6 kilometres (NW)	Low

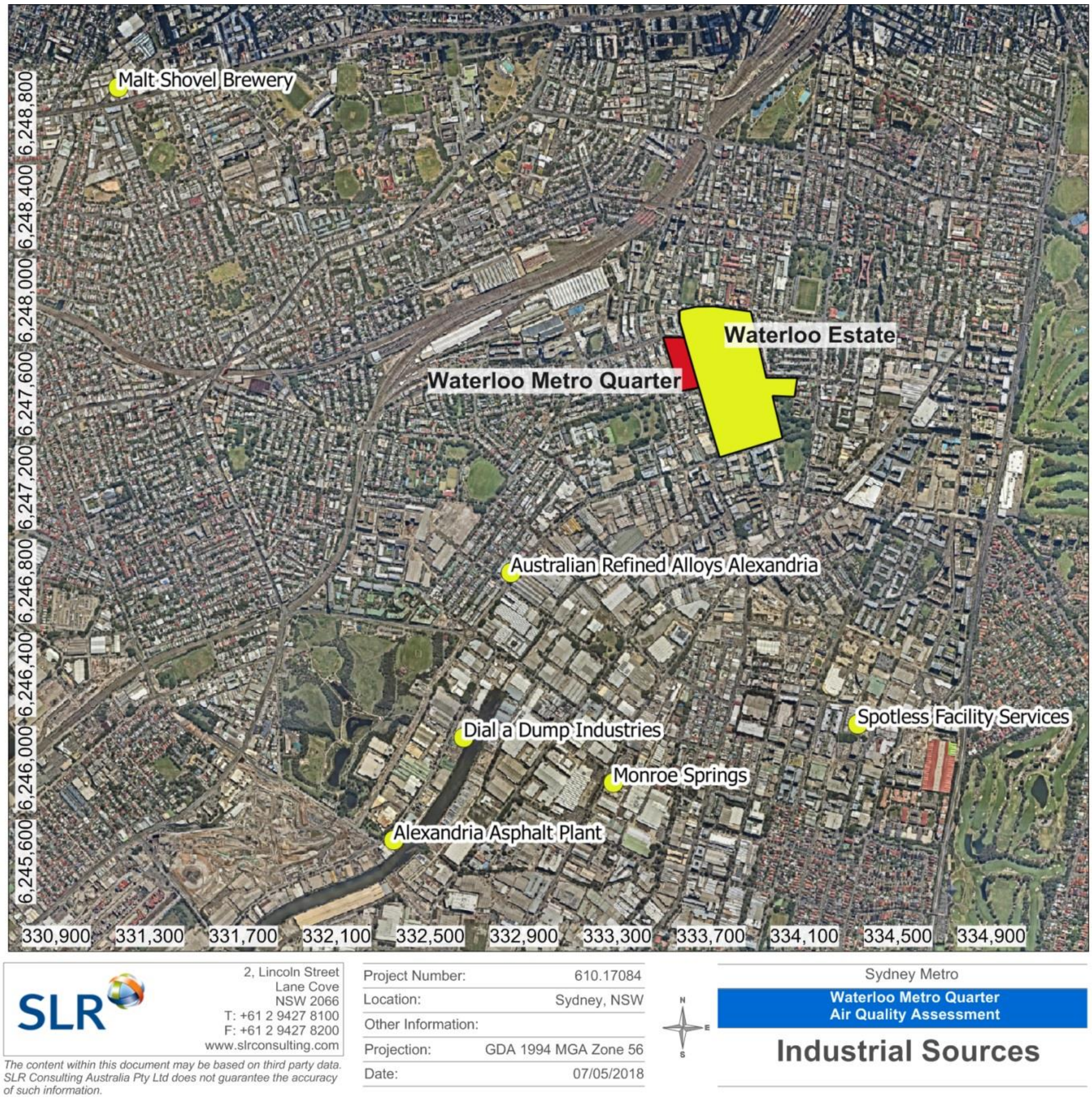

Figure 13 Location of Nearby Industrial Sources

3.2.4 Other sources

There is potential for additional industrial and commercial activities to be present in the local area, that operate below the activity threshold specified for the relevant industry type, and hence do not need to report under the NPI program and do not have an EPA licence. Sources that potentially fall under this category could potentially impact on air quality within the Metro Quarter, but on a smaller scale than those that are licenced and/or are required to report under the NPI program.

During the site visit, a number of activities including service stations, automotive workshops and food and beverage outlets were identified within 400 metres of the Metro Quarter boundary. Details of these facilities are presented in **Table 2**. It is noted that the distances specified in **Table 2** indicate the distance between the identified source and the Metro Quarter boundary. Given the setback of the buildings proposed within the Metro Quarter and the elevated location of sensitive receptors, the actual distance would be greater. Potential emissions from these facilities are discussed in the following sections.

In addition to the existing sources identified in **Table 2**, emissions from proposed activities within the Metro Quarter itself (e.g. food outlets) may lead to potential amenity/nuisance impacts at nearby sensitive receptors. Depending on the type and scale of the activities, emitted pollutant concentrations could range from very low to very high. However, emissions from any activity (including food outlets) can be controlled and concentrations reduced to very low levels if appropriate emission controls are put in place.

In the absence of detailed information in relation to the type and scale of any potentially polluting activities within the Metro Quarter, potential impacts have not been assessed further in this assessment. It is recommended that once the final design is available and tenants/activity types have been identified, additional air quality assessment(s) be carried out to ensure sufficient control measures have been adopted and that no nuisance or loss of amenity is caused by odour and fumes from these activities.

Table 2 Identified Small Scale Sources of Air Emissions in the Vicinity of the Metro Quarter

Facility Name	Type of Activity	Approximate Distance from the Metro Quarter Boundary*
Abbotts Hotel	Food Outlet	25 metres (N)
Daily French Hot Bread	Food Outlet	50 metres (N)
Eddy's Bakery	Food Outlet	140 metres (N)
John Smith Specialty Coffee	Food Outlet	180 metres (S)
Lord Raglan	Food Outlet	80 metres (W)
McDonalds Alexandria	Food Outlet	350 metres (W)
Mr Toast	Food Outlet	20 metres (W)
Thai Thai Restaurant	Food Outlet	80 metres (NW)
The Cauliflower Hotel	Food Outlet	25 metres (S)
The Rag Land	Food Outlet	25 metres (N)
Waterloo Cafe Pizzeria	Food Outlet	130 metres (N)
Wildcockatoo Bakery	Food Outlet	110 metres (NW)
Yens Vietnamese Restaurant	Food Outlet	70 metres (N)
Yum Yai	Food Outlet	30 metres (W)
B & B Mechanical Repairs	Automotive Workshops	220 metres (N)
Hahn Automotive Services	Automotive Workshops	160 metres (SSW)
Hargrave Motor Repairs	Automotive Workshops	60 metres (SW)
BP Service Station	Service Station	340 metres (N)
Caltex Service Station	Service Station	370 metres (SSW)

3.2.4.1 Food outlets

The main air emission from food and beverage outlets (including bakeries and restaurants) is odour, primarily generated from the cooking process. Studies (including analysis of cooking fume emissions) have shown that many odorous hydrocarbons or Volatile Organic Compounds (VOCs), such as alkenes, aromatics, aldehydes and organic acids are formed in the cooking process as breakdown products of natural fats and oils (NSW EPA, 2007). The strength and offensiveness of the odours varies widely, depending on what is being cooked and the manner of cooking. The potential impact from these food outlets has been assessed in **Section 6.4.1**.

3.2.4.2 Service stations and automotive workshops

Emissions of VOCs from service stations occur due to evaporative losses during filling as well as working and standing losses from the fuel storage tanks.

As described in the National Pollutant Inventory's *Emission Estimation Technique Manual for Fuel and Organic Liquid Storage* (Environment Australia, 2012), working losses are the combined loss from filling and emptying a tank containing hydrocarbon liquids. As the liquid level increases, the pressure inside the tank increases and vapours containing VOCs are expelled from the tank. A loss during emptying occurs when air drawn into the tank becomes saturated with organic vapour and expands, thus exceeding the capacity of the vapour space. In addition to losses from the underground storage tanks, working losses can occur from the vehicle fuel tanks being filled at the bowser.

Standing losses occur through the expulsion of vapour from a tank due to the vapour expansion and contraction as a result of changes in temperature and barometric pressure. This loss occurs without any change in the liquid level in the tank.

Emissions of VOCs also occur at automotive workshops, albeit to a lesser degree. *The Environmental Action for Automotive Servicing and Repairs* document published by the NSW EPA (NSW EPA, 2008) identifies the potential emissions to atmosphere from automotive workshops as:

- Invisible vapours released by volatile fluids (e.g. solvents, petrol and paints)
- Dust generated from friction materials in brakes and clutches
- Fumes emitted from engines
- Release of LPG from vehicles and storage tanks
- Ozone depleting substances found in air conditioning units.

Other emissions to air that will occur at both service stations and automotive workshops will be emissions of products of fuel combustion from vehicle exhausts as they enter and exit the site. Given all engines will most likely be switched off once the vehicles are parked within these facilities, emissions from idling vehicles will be minor. The potential impact from these facilities has been assessed in **Section 6.4.2**.

3.2.4.3 Waterloo Station

The proposed Metro Quarter OSD is situated over and adjacent to Waterloo Station. Potential air quality impacts from the future metro station were assessed by Transport for NSW and presented in *the Sydney Metro Chatswood to Sydenham Environmental Impact Statement* (TfNSW, 2016). In relation to potential air quality issues, the EIS states:

> *As the project would be powered by electricity, local emissions generated during operation are expected to be minimal and highly dispersed.*
>
> *The project would include a ventilation system to circulate fresh air through the tunnels and underground stations and prevent the build-up of heat. Fresh air would be drawn into the tunnels and air would be extracted from the tunnels through the portals by the piston effect of the trains, and by mechanical ventilation at the stations.*
>
> *Air would be discharged from the tunnel portals and through ventilation outlets integrated into each station. The stations would also provide separate fresh air ventilation systems to draw fresh air in and extract air from the station environment. Air discharged from the tunnels and stations would be well diluted and dispersed into the outdoor air.*

Minor quantities of particulate matter (PM_{10}) emissions would be generated in the tunnels, mainly due to wear of the train brake pads, vaporisation of metals due to sparking, wear of steel due to friction between wheels and rail, and recirculation of particulates from tunnel walls. Most of these emissions would be vented through the fresh air ventilation system in very low concentrations.

Vented air is also likely to comprise minor concentrations of carbon dioxide, volatile organic compounds and oxides of nitrogen as well as ash and soot particulates generated during maintenance. The ventilation outlet air would contain small quantities of particulates at low concentrations due to the large volumes of exhaust air. Given the low concentrations of particulates, it is very unlikely that the project would have air quality impacts on the surrounding environment, including sensitive receivers.

The fresh air ventilation system would also respond to emergency conditions such as fire incidents where smoke-laden air would be discharged through the emergency ventilation system to prevent smoke entering stations or recirculating through ventilation shafts or tunnel portals. The design and location of the fresh air ventilation shafts at stations would ensure sensitive receivers were not unnecessarily affected; suitable emergency plans would be in place for these circumstances.

Given the above, the likelihood of significant incremental impacts from the operation of the Waterloo Station is highly unlikely and further assessment is not warranted.

3.3 Review of NSW OEH Ambient Air Quality Monitoring Data

The NSW Office of Environment and Heritage (OEH) maintains a network of Air Quality Monitoring Stations (AQMSs) across NSW. The nearest such OEH station is located at Rozelle, approximately 4.8 kilometres to the northwest of the Metro Quarter. Other nearby stations include Randwick and Earlwood, which are located approximately 5.5 kilometres southeast and 6.4 kilometres southwest of the Metro Quarter respectively (see Figure 9). Brief comments on these stations are provided below:

- The Rozelle AQMS was commissioned in 1978 and is located in the grounds of Rozelle Hospital, off Balmain Road, Rozelle. It is situated in a residential area in the Parramatta River valley and is at an elevation of 22 metres.
- The Randwick AQMS was commissioned in 1995 and is located in the grounds of the Randwick Army Barracks, on the corner of Avoca and Bundock Streets, Randwick. It is situated in the eastern suburbs of Sydney in a residential area and is at an elevation of 28 metres.
- The Earlwood AQMS was commissioned in 1978 and is located in Beaman Park, off Riverview Road, Earlwood. It is situated in a residential area in the Cook's River valley at an elevation of 6 metres.

Due to the presence of trees within 20 metres of the Rozelle and Earlwood stations, the clear sky angle is less than 120° which means these stations do not currently comply with Australian Standard AS/NZS 3580.1.1:2007 - *Methods for sampling and analysis of ambient* *air - Guide to siting air monitoring equipment*. Therefore, data from the Randwick AQMS have been used for the contemporaneous cumulative impact assessment, which is required for a Level 2 AQA (as per the Approved Methods). Data from the Randwick AQMS have been supplemented by data from the Earlwood and Rozelle AQMSs to address $PM_{2.5}$ and CO data gaps. The air pollutants and meteorological variables currently measured by the Randwick, Earlwood and Rozelle AQMSs are presented in **Table 3**.

Table 3 Air Pollutants and Meteorological Variables Measured by Nearby Monitoring Stations

	Rozelle AQMS	Randwick AQMS	Earlwood AQMS
Ozone (O_3)	✓	✓	✓
Oxides of nitrogen (NO, NO_2 & NO_x)	✓	✓	✓
Sulphur dioxide (SO_2)	✓^	✓	×
Fine particles less than 10 microns (PM_{10})	✓	✓	✓
Fine particles less than 2.5 microns ($PM_{2.5}$)	✓^	✓*	✓
Carbon monoxide (CO)	✓	×	✓^

^ 2015 onwards

* 2017 onwards

Air quality monitoring data recorded by the Randwick AQMS were obtained for the calendar years 2013 - 2017 and are summarised in **Table 4**. To be consistent with the NSW OEH monitoring reports, the data for gaseous pollutants are presented in parts per hundred million (pphm) or parts per million (ppm), rather than micrograms per cubic metre ($\mu g/m^3$) and milligrams per cubic metre (mg/m^3) as used in **Section 5.0**.

A review of the data shows that exceedances of the 24-hour average PM_{10} criterion were recorded by the Randwick AQMS in 2013, 2015 and 2017. A review of the exceedances recorded during 2013 (NSW OEH, 2014), 2015 (NSW OEH, 2017) and 2017 (NSW OEH, 2017b) indicates that they were due to natural events such as bushfires or dust storms, or hazard reduction burns.

Exceedances of the 24-hour average $PM_{2.5}$ criterion were also recorded by the Randwick AQMS in 2017 (the only year for which $PM_{2.5}$ monitoring data is currently available from the Randwick AQMS). Ambient $PM_{2.5}$ concentrations often exceed the 24-hour and annual average criteria set out in the Approved Methods across the Sydney Greater Metropolitan Area.

Ambient concentrations of the gaseous pollutants SO_2, NO_2, O_3 and CO were all below the relevant criteria for all years that data are available. In 2015 and 2017, maximum 1-hour average O_3 concentrations exceeding the criterion of 10 parts per hundred million (pphm) were recorded.

Table 4 Summary of Randwick AQMS Data (2013 – 2017)

Pollutant	Averaging Period	Criteria	Year	Randwick AQMS		Units
				Maximum Concentration	Number of Exceedances	
SO_2	1-hour	20 pphm	2013	2.7	0	pphm
			2014	2.6	0	pphm
			2015	3.1	0	pphm
			2016	3.4	0	pphm
			2017	2.9	0	pphm
	24-hour	8 pphm	2013	0.4	0	pphm
			2014	0.4	0	pphm
			2015	0.4	0	pphm
			2016	0.3	0	pphm
			2017	0.8	0	pphm
	Annual	2 pphm	2013	0.09	0	pphm
			2014	0.09	0	pphm
			2015	0.08	0	pphm
			2016	0.09	0	pphm
			2017	0.10	0	pphm
NO_2	1-hour	12 pphm	2013	4.6	0	pphm
			2014	4.7	0	pphm
			2015	4.3	0	pphm
			2016	4.4	0	pphm
			2017	4.1	0	pphm
	Annual	3 pphm	2013	0.7	0	pphm
			2014	0.6	0	pphm
			2015	0.9	0	pphm
			2016	0.8	0	pphm
			2017	0.7	0	pphm
Ozone	1-hour	10 pphm	2013	7.5	0	pphm
			2014	6.6	0	pphm
			2015	11.3	1	pphm
			2016	9.9	0	pphm
			2017	11.6	3	pphm
	4-hour	8 pphm	2013	6.7	0	pphm
			2014	6.1	0	pphm
			2015	8.5	2	pphm
			2016	9.0	2	pphm
			2017	10.2	12	pphm
PM_{10}	24-hour	50 µg/m^3	2013	55[1]	3	µg/m^3

Pollutant	Averaging Period	Criteria	Year	Randwick AQMS		Units
				Maximum Concentration	Number of Exceedances	
			2014	46	0	µg/m^3
			2015	77[2]	1	µg/m^3
			2016	44	0	µg/m^3
			2017	56[3]	1	µg/m^3
	Annual	25 µg/m^3	2013	19	0	µg/m^3
			2014	18	0	µg/m^3
			2015	19	0	µg/m^3
			2016	18	0	µg/m^3
			2017	19	0	µg/m^3
$PM_{2.5}$	24-hour	25 µg/m^3	2013	ND	ND	µg/m^3
			2014	ND	ND	µg/m^3
			2015	ND	ND	µg/m^3
			2016	ND	ND	µg/m^3
			2017	45[4]	1	µg/m^3
	Annual	8 µg/m^3	2013	ND	ND	µg/m^3
			2014	ND	ND	µg/m^3
			2015	ND	ND	µg/m^3
			2016	ND	ND	µg/m^3
			2017	6.96*	0	µg/m^3

Notes:

ND- No data

* based on approximately 9 months of data as $PM_{2.5}$ monitoring commenced end of March 2017

[1] For 2013, the maximum 24-hour average PM_{10} was recorded on 8 November 2013.

[2] For 2015, the maximum 24-hour average PM_{10} was recorded on 6 May 2015.

[3] For 2017, the maximum 24-hour average PM_{10} was recorded on 14 August 2017.

[4] For 2017, the maximum 24-hour average $PM_{2.5}$ was recorded on 14 August 2017.

As outlined above, limited $PM_{2.5}$ data and no CO data are available from the Randwick AQMS. In order to characterise background $PM_{2.5}$ concentrations for 2014 (concurrent with the meteorological modelling period), data from the next nearest OEH AQMSs with a full set of data, (Earlwood AQMS for $PM_{2.5}$ and Rozelle AQMS for CO) were used.

A comparison of the $PM_{2.5}$ data available from the Earlwood AQMS during 2017 with that recorded by the Randwick AQMS during the same period shows that on average, the 24-hour average $PM_{2.5}$ concentration was approximately 11 percent higher than that recorded by the Randwick Station. Therefore, the use of Earlwood data is considered conservative.

$PM_{2.5}$ data recorded by the Earlwood AQMS was obtained for the calendar years 2013 - 2017 and is summarised in **Table 5**. Exceedances of the 24-hour average $PM_{2.5}$ criterion were recorded by the Earlwood AQMS in 2013, 2015, 2016 and 2017. As noted above, ambient $PM_{2.5}$ concentrations often exceed the 24-hour and annual average criteria set out in the Approved Methods across the Sydney Greater Metropolitan Area.

CO data recorded by the Rozelle AQMS was obtained for the calendar years 2013 - 2017 and is summarised in **Table 6**. No exceedances of the 1-hour average CO criterion were recorded by the Rozelle AQMS over this period.

Table 5 Summary of Earlwood $PM_{2.5}$ Data (2012 – 2017)

Pollutant	Averaging Period	Criteria	Year	Rozelle AQMS		Units
				Maximum Concentration	Number of Exceedances	
$PM_{2.5}$	24-hour	25 µg/m³	2013	37[1]	4	µg/m³
			2014	23	0	µg/m³
			2015	28[2]	2	µg/m³
			2016	33[3]	5	µg/m³
			2017	51[4]	2	µg/m³
	Annual	8 µg/m³	2013	7.9	0	µg/m³
			2014	7.8	0	µg/m³
			2015	8.5	1	µg/m³
			2016	8.1	1	µg/m³
			2017	7.3	0	µg/m³

Notes:
1 For 2013, the maximum 24-hour average $PM_{2.5}$ was recorded on 17 May 2013.
2 For 2015, the maximum 24-hour average $PM_{2.5}$ was recorded on 21 August 2015.
3 For 2016, the maximum 24-hour average $PM_{2.5}$ was recorded on 9 May 2016.
4 For 2017, the maximum 24-hour average $PM_{2.5}$ was recorded on 14 August 2016.

Table 6 Summary of Rozelle AQMS Data (2013 – 2017)

Pollutant	Averaging Period	Criteria	Year	Rozelle AQMS		Units
				Maximum Concentration	Number of Exceedances	
CO	1-hour	8 ppm	2013	2.5	0	ppm
			2014	1.4	0	ppm
			2015	1.6	0	ppm
			2016	1.7	0	ppm
			2017	1.2	0	ppm

4.0 Air Quality Policy and Guidance

The following air quality policy and guidance documents have been referenced within this assessment and have been used to identify the relevant air quality criteria (see **Section 5.0**).

4.1 Approved methods

State air quality guidelines adopted by the NSW EPA are published in the NSW EPA's *Approved Methods for Modelling and Assessment of Air Pollutants in NSW* publication (NSW Environmental Protection Authority (EPA), 2017), hereafter referred as the Approved Methods.

The Approved Methods lists the statutory methods for modelling and assessing air pollutants from stationary sources and specifies criteria which reflect the environmental outcomes adopted by the EPA. The Approved Methods are referred to in the *POEO (Clean Air) Regulation 2002* for assessment of impacts of air pollutants.

The air quality criteria set out in the Approved Methods relevant to the Metro Quarter are reproduced and discussed in **Section 5.0**.

4.2 Infrastructure SEPP

NSW *State Environmental Planning Policy (Infrastructure) 2007* (the 'Infrastructure SEPP') refers to guidelines which must be taken into account where development is proposed in, or adjacent to, specific roads and railway corridors under clause 101 – *Development with Frontage to a Classified Road*[2]. The objective of clause 101 is to ensure that new development does not compromise the effective and ongoing operation and function of classified roads and to reduce the potential for impacts from traffic noise and vehicle emissions on development adjacent to classified roads.

Reference is also made to the NSW Department of Planning document "*Development near Rail Corridors and Busy Roads – Interim Guideline*" (DoP, 2008) (the Guideline) which supports the specific rail and road provisions of the Infrastructure SEPP.

An aim of the Guideline is to assist in reducing the health impacts of adverse air quality from road traffic on sensitive adjacent development and assists in the planning, design and assessment of development adjacent to busy roads. Section 4.4 of the guideline provides the following guidance on when air quality should be a design consideration and some of the principles that should be considered at the design stage to achieve improved air quality:

When air quality should be a design consideration:

2 The NSW State Roads Act 1986 No. 85 defines 'Classified Road' as a main road, a secondary road, a state highway, a tourist road, a state work, a freeway or a controlled access road.

- Within 10 metres of a congested collector road (traffic speeds of less than 40 kilometres/hour at peak hour) or a road grade > 4 percent or heavy vehicle percentage flows > 5 percent;
- Within 20 metres of a freeway or main road (with more than 2,500 vehicles per hour, moderate congestions levels of less than 5 percent idle time and average speeds of greater than 40 kilometres/hour);
- Within 60 metres of an area significantly impacted by existing sources of air pollution (road tunnel portals, major intersection / roundabouts, overpasses or adjacent major industrial sources); or
- As considered necessary by the approval authority based on consideration of site constraints, and associated air quality issues.

Air quality design considerations:

- Minimising the formation of urban canyons that reduce dispersion. Having buildings of different heights interspersed with open areas, and setting back the upper stories of multi-level buildings helps to avoid urban canyons.
- Incorporating an appropriate separation distance between sensitive uses and the road using broad-scale site planning principles such as building siting and orientation. The location of living areas, outdoor space and bedrooms and other sensitive uses (such as childcare centres) should be as far as practicable from the major source of air pollution.
- Ventilation design and open-able windows should be considered in the design of development located adjacent to roadway emission sources. When the use of mechanical ventilation is proposed, the air intakes should be sited as far as practicable from the major source of air pollution.
- Using vegetative screens, barriers or earth mounds where appropriate to assist in maintaining local ambient air amenity. Landscaping has the added benefit of improving aesthetics and minimising visual intrusion from an adjacent roadway.

4.3 Local Air Quality Toolkit

The Local Government Air Quality Toolkit (AQ Toolkit) has been developed by the EPA to assist local government in their management of air quality issues and provides guidelines for air quality management and for the use of air pollution control techniques. A relevant AQ Toolkit air quality guidance notes include Food Outlets (NSW EPA, 2007).

5.0 Relevant Air Quality Criteria

A general overview of key air pollutants associated with emission sources identified in the vicinity of the Metro Quarter is provided below. These pollutants are:

- Airborne particulate matter.
- Products of combustion such as oxides of nitrogen (NO_x), carbon monoxide (CO), sulphur dioxide (SO_2) and volatile organic compounds (VOCs).
- Odour.

Section 7.1 of the Approved Methods outlines the impact assessment criteria for each of the above pollutants. The criteria listed in the Approved Methods are derived from a range of sources (including NHMRC, NEPC, WHO, ANZEEC and DoE). The criteria specified in the Approved Methods are the defining ambient air quality criteria for NSW, and are considered to be appropriate for the setting.

5.1 Suspended particulate matter

Airborne contaminants that can be inhaled directly into the lungs can be classified on the basis of their physical properties as gases, vapours or particulate matter. In common usage, the terms “dust” and “particulates” are often used interchangeably. The term “particulate matter” refers to a category of airborne particles, typically less than 30 microns in diameter and ranging down to 0.1 microns and is termed total suspended particulate (TSP).

The annual criterion for TSP recommended by the NSW EPA is 90 micrograms per cubic metre of air ($\mu g/m^3$). The TSP criterion was developed before the more recent results of epidemiological studies which suggested a relationship between health impacts and exposure to concentrations of finer particulate matter.

Emissions of particulate matter less than 10 microns and 2.5 microns in diameter (referred to as PM_{10} and $PM_{2.5}$ respectively) are considered important pollutants due to their ability to penetrate into the respiratory system. In the case of the $PM_{2.5}$ category, recent health research has shown that this penetration can occur deep into the lungs. Potential adverse health impacts associated with exposure to PM_{10} and $PM_{2.5}$ include increased mortality from cardiovascular and respiratory diseases, chronic obstructive pulmonary disease and heart disease, and reduced lung capacity in asthmatic children.

The NSW EPA PM_{10} impact assessment criteria set out in the Approved Methods are as follows:

- a 24-hour maximum of 50 micrograms per cubic metre; and,
- an annual average of 25 micrograms per cubic metre.

The NSW EPA $PM_{2.5}$ impact assessment criteria set out in the Approved Methods are as follows:

- a 24-hour maximum of 25 micrograms per cubic metre; and
- an annual average of 8 micrograms per cubic metre.

A summary of the particulate impact assessment criteria is shown in **Table 7**.

Table 7 EPA Impact Assessment Criteria for Particulates

Pollutant	Averaging Time	Impact Assessment Criteria
TSP	Annual	90 $\mu g/m^3$
PM_{10}	24 Hours Annual	50 $\mu g/m^3$ 25 $\mu g/m^3$
$PM_{2.5}$	24 Hours Annual	25 $\mu g/m^3$ 8 $\mu g/m^3$

5.2 Oxides of nitrogen

Oxides of nitrogen (NO_x) is a general term used to describe any mixture of nitrogen oxides formed during combustion. In atmospheric chemistry NO_x generally refers to the total concentration of nitric oxide (NO) and nitrogen dioxide (NO_2).

NO is a colourless and odourless gas that does not significantly affect human health. However, in the presence of oxygen, NO can be oxidised to form NO_2 which can have significant health effects including damage to the respiratory tract and increased susceptibility to respiratory infections and asthma. Long term exposure to NO_2 can lead to lung disease. NO will be converted to NO_2 in the atmosphere after leaving a car exhaust.

The impact assessment criteria specified within the Approved Methods for NO_2 are provided in **Table 8**.

Table 8 Assessment Criteria for Nitrogen Dioxide (NO_2)

Pollutant	Averaging Period	Criterion
NO_2	1-hour	12 pphm (246 $\mu g/m^3$)
	Annual	3 pphm (62 $\mu g/m^3$)

Note: pphm = parts per hundred million

5.3 Carbon monoxide

Carbon monoxide (CO) is an odourless, colourless gas formed from the incomplete burning of fuels in motor vehicles. CO bonds to the haemoglobin in the blood and reduces the oxygen carrying capacity of red blood cells, thus decreasing the oxygen supply to the tissues and organs, in particular the heart and the brain.

It can be a common pollutant at the roadside and highest concentrations are found at the kerbside with concentrations decreasing rapidly with increasing distance from the road. CO in urban areas results almost entirely from vehicle emissions and its spatial distribution follows that of traffic flow. The impact assessment criteria specified within the Approved Methods for CO are provided in **Table 9**.

Table 9 Assessment Criteria for Carbon Monoxide (CO)

Pollutant	Averaging Period	Criterion
CO	15-minutes	87 ppm (100 mg/m^3)
	8-hour	9 ppm (10 mg/m^3)

Note: ppm = parts per million

5.4 Sulphur dioxide

Sulphur dioxide (SO_2) is a colourless, pungent gas with an irritating smell. When present in sufficiently high concentrations, exposure to SO_2 can lead to impacts on the upper airways in humans (i.e. the noise and throat irritation). SO_2 can also mix with water vapour to form sulphuric acid (acid rain) which can damage vegetation, soil quality and corrode materials.

The main sources of SO_2 in the air are industries that process materials containing sulphur (i.e. wood pulping, paper manufacturing, metal refining and smelting, textile bleaching, wineries etc.). SO_2 is also present in motor vehicle emissions, however since Australian fuels are relatively low in sulphur, high ambient concentrations are not common.

Table 10 Assessment Criteria for Sulphur Dioxide (SO_2)

Pollutant	Averaging Period	Criterion
SO_2	10-minutes	25 pphm (712 µg/m^3)
	1-hour	20 pphm (570 µg/m^3)
	24-hour	8 pphm (228 µg/m^3)
	Annual	2 pphm (60 µg/m^3)

Note: pphm = parts per hundred million

5.5 Volatile organic compounds

Volatile Organic Compounds (VOCs) are organic compounds (i.e. contain carbon) that have high vapour pressure at normal room-temperature conditions. Their high vapour pressure leads to evaporation from liquid or solid form and emission release to the atmosphere.

VOCs are emitted by a variety of sources, including motor vehicles, chemical plants, automobile repair services, painting/printing industries, and rubber/plastics industries. VOCs that are often typical of these sources include benzene, cyclohexane, ethylbenzene, toluene and xylenes. Biogenic (natural) sources of VOC emissions are also significant (e.g. vegetation).

Impacts due to emissions of VOCs can be health or nuisance (odour) related. Benzene is a known carcinogen and a key VOC linked with the combustion of motor vehicle fuels.

5.6 Odour

Impacts from odorous air contaminants are often nuisance-related rather than health-related. Odour performance goals guide decisions on odour management, but are generally not intended to achieve "no odour".

The detectability of an odour is a sensory property that refers to the theoretical minimum concentration that produces an olfactory response or sensation. This point is called the odour threshold and defines 1 odour unit (ou). An odour impact assessment criterion of less than 1 ou would theoretically result in no odour impact being experienced.

In practice, the character of a particular odour can only be judged by the receiver's reaction to it, and preferably only compared to another odour under similar social and regional conditions. Based on the literature available, the level at which an odour is perceived to be a nuisance can range from 2 odour units to 10 odour units depending on a combination factors including population sensitivity, background level, public expectation (considered offensive or easily tolerated), source characteristics (i.e. emitted from a stack or general area) and health effects.

Odour performance goals need to be designed to take into account the range in sensitivities to odours within the community, and provide additional protection for individuals with a heightened response to odours, using a statistical approach which depends on the size of the affected population.

It is often not possible or practical to determine and assess the cumulative odour impacts of all odour sources that may impact on a receptor in an urban environment. Therefore, the proposed odour performance goals allow for population density, cumulative impacts, anticipated odour levels during adverse meteorological conditions, and community expectations of amenity.

A summary of the impact assessment criteria given for various population densities, as drawn from the Approved Methods, is given in **Table 11**. The Approved Methods states that the impact assessment criteria for complex mixtures of odorous air pollutants must be applied at the nearest existing or likely future off-site sensitive receptor(s). In an urban area such as the Metro Quarter, the relevant criterion is 2 ou (nose-response-time average, 99th percentile).

Table 11 Impact Assessment Criteria - Complex Mixtures of Odorous Air Pollutants

Population of Affected Community	Impact Assessment Criteria for Complex Mixtures of Odours (odour units, nose-response-time average, 99th percentile)
Urban area (≥ 2000)	2
~500	3
~125	4
~30	5
~10	6
Single residence (≤ 2)	7

Source: Approved Methods, NSW EPA 2017.

6.0 Assessment

6.1 Methodology

The key issues identified for air quality at the Metro Quarter are emissions of combustion products and particulate matter from the surrounding road network as well as dust emissions from construction activities.

A qualitative (risk-based) assessment of construction impacts has been performed based on the information available, to identify those activities that have the potential for off-site air quality impacts if not adequately controlled, so that appropriate mitigation measures can be identified and incorporated into the construction management plans which would support the detailed SSD Application. The transient and changeable nature of construction emissions makes the use of appropriate management strategies to reduce emissions more important than quantitative assessment.

Emissions from the closest surrounding roads were modelled using the GRAMM/GRAL modelling system to predict the incremental impact of these emissions across the Metro Quarter. Regional monitoring data available from the NSW EPA/OEH ambient monitoring networks (see **Section 3.3**) were then used to assess the potential cumulative concentrations of these pollutants that future residents of the Metro Quarter would potentially be exposed to, and to assess compliance against relevant air quality guidelines.

As outlined in **Section 3.2.1**, atmospheric pollutants emitted from road traffic include NO_x, $PM_{2.5}$, PM_{10}, SO_2 and TVOCs. Given the low level of CO and SO_2 emissions from vehicles and the low ambient concentrations recorded in Sydney (see **Section 3.3**), it is reasonable to assume that CO and SO_2 emissions from road traffic are highly unlikely to result in any exceedances of the relevant criteria at the Metro Quarter. SLR's experience in modelling VOC emissions from roads has also shown that kerbside concentration of VOCs are typically well below the relevant air quality guidelines. Moreover, a review of the Air Quality Impact Assessment prepared for M4 East (Pacific Environment, 2015), which will have significantly higher traffic volumes than the roads surrounding the Metro Quarter, showed that ground level VOC concentrations at the nearest receptors were predicted to be well below the relevant assessment criteria. Hence, CO, SO_2 and VOC traffic emissions have not been considered further in this assessment and only emissions of NO_x, PM_{10} and $PM_{2.5}$ have been modelled.

Other sources of air pollutants identified in the local area with the potential to impact on air quality at the Metro Quarter include a service station and a number of food and beverage outlets. Considering detailed information on the operational activities within these facilities is not available, a large number of assumptions would be required to be used as input to any quantitative (i.e. air dispersion modelling) assessment. The uncertainty associated with the output of such studies means it would be of limited value. SLR has therefore performed a qualitative (risk-based) assessment for these activities, based on the information available.

In addition to the above, emission sources within the Metro Quarter (e.g. food outlets) could potentially lead to amenity/nuisance impacts at surrounding sensitive receptors or at residential locations within the Metro Quarter itself. Considering detailed information on the type and scale of these facilities is not available at this stage impacts from these potential sources have not been assessed further for the purpose of this assessment. However, it is recommended that assessment of any potentially air polluting activities proposed within the Metro Quarter be carried out during the detailed design stage so that appropriate mitigation measures are adopted to reduce the risk of any exceedances of the relevant air quality criteria.

6.1.1 Qualitative assessment of construction impacts

For the assessment of construction phase impacts, the IAQM Guidance on the Assessment of Dust from Demolition and Construction developed in the United Kingdom by the Institute of Air Quality Management (IAQM 2014) has been used to provide a qualitative assessment method (see Appendix B for full methodology). The IAQM method uses a four-step process for assessing dust impacts from construction activities:

Step 1: Screening based on distance to the nearest sensitive receptor; whereby the sensitivity to dust deposition and human health impacts of the identified sensitive receptors is determined.

Step 2: Assess risk of dust effects from activities based on:

- the scale and nature of the works, which determines the potential dust emission magnitude; and
- the sensitivity of the area surrounding dust-generating activities.

Step 3: Determine site-specific mitigation for remaining activities with greater than negligible effects.

Step 4: Assess significance of remaining activities after management measures have been considered.

6.1.2 Quantitative assessment of traffic emissions

6.1.2.1 Estimation of traffic emissions

Individual vehicle emissions are a combination of emissions produced by:

- the engine
- the fuel system
- the braking system
- materials from the road surface disturbed by the wheels and by air movement around the vehicle.

The principal factors that influence the generation of traffic air pollution, and thus the potential for air quality impacts, are:

- Traffic volume – the total numbers of cars on the road and diurnal pattern of traffic numbers throughout the day.
- Vehicle type – pollutant emission rates are different for different vehicle types (e.g. passenger cars versus heavy duty vehicles).
- Vehicle age – older vehicles will tend to produce higher emission rates than newer vehicles. Newer vehicles are subject to more stringent emission standards, and also vehicles will tend to become less efficient as they age and engine components wear.
- Fuel type – the combustion of petrol, diesel, ethanol-blends, natural gas fuels emit the various constituent pollutants at different rates, and therefore the rate of emissions will vary by the fleet engine composition.
- Road gradient – driving uphill results in a greater load on the engine and thus higher pollutant emission rates. If the average road gradient is larger than a value of about 2 percent, the emissions of ascending and descending vehicles do not balance each other, even if the traffic is the same in the two directions. That is, the lower emissions in the downhill direction do not balance the higher emissions of the uphill direction.
- Driving conditions and average traffic speed – vehicle speed is normally assumed to be represented by the posted speed limit. Emissions from congested traffic are greater than for free-flowing traffic.
- Other driver behaviour and vehicle operating conditions, such as:
    - air conditioner use
    - braking and acceleration patterns
    - gear operations
    - maintenance
    - engine temperature
    - ambient temperature.

A spatial emissions inventory was developed for the emissions of NO_x, PM_{10} and $PM_{2.5}$ from vehicles travelling on the main roads surrounding the Metro Quarter using the 'Computer Programme to calculate Emissions from Road Transport' (COPERT) Australia software. The most important input to COPERT Australia is a detailed breakdown of the total number of on-road vehicles for 226 vehicle classes (Uniquest, 2014). The vehicle classifications used in COPERT Australia are presented in **Table 12**. Multiplying the hourly traffic volumes by the length of the road segment gives an estimate of the hourly vehicle kilometres travelled (VKT). The information on VKT is then used to estimate emission levels by the COPERT software using emission factors in grams per kilometre or grams per VKT. Information on the parameters used as input to COPERT Australia is presented in detail in **Appendix B**.

Table 12 COPERT Australia Vehicle Classifications

Main Category	Sub Category	Fuel Type	Emission Control Standard
Passenger car	Small (<2.0 litre) Medium (2.0-3.0 litre) Large (>3.0 litre)	Petrol Diesel LPG E10	Uncontrolled ADR27 ADR37/00-01 ADR79/00-05
SUV	Compact (< 4.0 litre) Large (>4.0 litre)	Petrol Diesel E10	Similar to PC +ADR36 (SUV-L) +ADR30 (SUV-Diesel)
Light Commercial Vehicle	Gross Vehicle Mass < 3.5 tonnes	Petrol Diesel	Uncontrolled ADR36 (P) ADR30(D) ADR37/00-01 ADR79/00-05
Heavy Duty Truck	Medium (MCV 3.5-12.0 tonnes) Heavy (HCV 12.0-25.0 tonnes) Articulated (AT >25 tonnes)	Petrol Diesel LPG	Uncontrolled ADR30 ADR70 ADR80/00 ADR80/02-05
Bus	Light bus (<8.5 tonnes) Heavy bus (>8.5 tonnes)	Diesel	
Moped	2-stroke 4 stroke	Petrol	Conventional; Euro 1-3
Motorcycle	2-Stroke; 4-Stroke <250 cm^3 4-Stroke 250-750 cm^3 4-Stroke >750 cm^3		

6.1.2.2 Assumptions used to compile COPERT input parameters

The COPERT Australia input data file requires detailed information on vehicle counts within each vehicle sub-category, fuel type and emission control standard listed in **Table 12**. However such detailed information on the distribution of vehicles is not publicly available for the roads surrounding the Metro Quarter. Therefore, in order to compile the COPERT Australia input files, the following assumptions were applied:

- The annual vehicle counts were subdivided into each sub category, fuel type and emission control standard using statistical data compiled for NSW by the National Pollutant Inventory (NPI) team of the Australian Government Department of the Environment (DSITIA, 2014), for use in preparing the Australian Motor Vehicle Emission Inventory for the NPI (see **Appendix B**).
- The emissions were estimated for a nominal 1 kilometre length of road based on a low vehicle speed of 10 kilometres/hour (potential worst case emission rate that would be representative of congested traffic conditions).

- Meteorological conditions, including maximum and minimum temperature and relative humidity were estimated based on available long term average data for the Sydney region (see **Appendix B**).

6.1.2.3 Peak traffic volumes

In May 2017, Jacobs conducted traffic surveys around the Metro Quarter to provide data for existing traffic volumes on the surrounding road network. The findings of these surveys were provided to SLR for the purpose of this report. **Table 13** presents the afternoon peak (5 – 6 pm) traffic survey results for the surrounding roads. The location of each corridor is illustrated in **Figure 15**.

The traffic surveys performed by Jacobs mainly covered the morning and afternoon peak periods, and information on the daily variation in traffic flows for the roads surrounding the Metro Quarter was not obtained during these surveys. Information on the daily variation of traffic on O'Riordan Street (Station ID: 02309 – 100 metres north of Johnson Street, Alexandria) was therefore obtained from the RMS Traffic Volume Viewer and used to estimate a 'diurnal multiplier' for the roads assessed in this study. As illustrated in **Figure 14**, the diurnal multiplier for each hour of day is the ratio of the reported traffic volume for that hour to the afternoon peak hour (4 – 5 pm) traffic volume.

Table 13 Peak Traffic Volumes – Road Network Surrounding the Metro Quarter

ID	Corridor Name	Peak Volume (vehicles/hour)
1	Botany Road - McEvoy Street to Allen Street	2,088
2	Botany Road - McEvoy Street to Buckland Street	2,075
3	Botany Road - Raglan Street to Boundary Street	1,725
4	Botany Road - Wellington Street to Raglan Street	1,841
5	Buckland Street - Wyndham Street to Gerard Street	215
6	Cope Street - Raglan Street to Phillip Street	290
7	Cope Street - Wellington Street to McEvoy Street	119
8	Cope Street - Wellington Street to Raglan Street	205
9	Elizabeth Street - Allen Street to McEvoy Street	1,710
10	Elizabeth Street - McEvoy Street to Wellington Street	2,122
11	Elizabeth Street - Phillip Street to Raglan Street	1,987
12	Elizabeth Street - Redfern Street to Phillip Street	1,820
13	Elizabeth Street - Wellington Street to Raglan Street	1,936
14	George Street - McEvoy Street to Allen Street	176
15	George Street - Phillip Street to Redfern Street	232
16	Henderson Street - Gerard Street to Wyndham Street	1,577
17	Henderson Street - Wyndham Street to Botany Road	2,160
18	McEvoy Street - Botany Road to George Street	1,190

ID	Corridor Name	Peak Volume (vehicles/hour)
19	McEvoy Street - Elizabeth Street to Morehead Street	882
20	McEvoy Street - George Street to Pitt Street	1,180
21	McEvoy Street - Pitt Street to Elizabeth Street	1,194
22	McEvoy Street - Wyndham Street to Botany Road	1,775
23	McEvoy Street - Wyndham Street to Brennan Street	935
24	Philip Street - Elizabeth Street to Chalmers Street	245
25	Philip Street - Elizabeth Street to Walker Street	715
26	Phillip Street - George Street to Cope Street	214
27	Phillip Street - Pitt Street to George Street	201
28	Phillip Street - Walker Street to Morehead Street	660
29	Pitt Street - McEvoy Street to Allen Street	112
30	Pitt Street - McEvoy Street to Wellington Street	74
31	Pitt Street - Phillip Street to Raglan Street	415
32	Pitt Street - Phillip Street to Redfern Street	335
33	Pitt Street - Wellington Street to Raglan Street	393
34	Raglan Street - Botany Road to Cope Street	610
35	Raglan Street - Cope Street to Pitt Street	451
36	Raglan Street - Elizabeth Street to Pitt Street	298
37	Wellington Street - Botany Road to Wyndham Street	137
38	Wellington Street - Cope Street to Botany Road	392
39	Wellington Street - Elizabeth Street to Morehead Street	408
40	Wellington Street - Elizabeth Street to Pitt Street	592
41	Wellington Street - Pitt Street to Cope Street	318
42	Wyndham Street - Buckland Street to Henderson Street	607
43	Wyndham Street - Henderson Street to Boundary Street	1,528
44	Wyndham Street - McEvoy Street to Buckland Street	1,555
45	Wyndham Street - McEvoy Street to Mandible Street	786

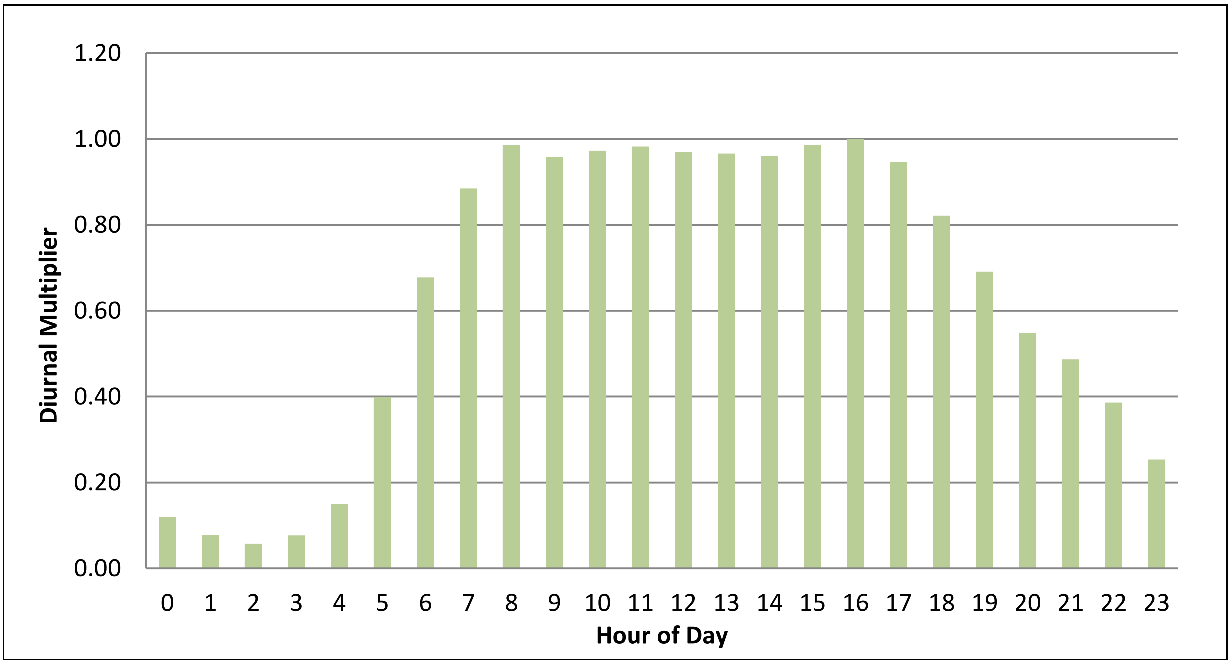

Figure 14 Diurnal Variation of Traffic on O'Riordan Street

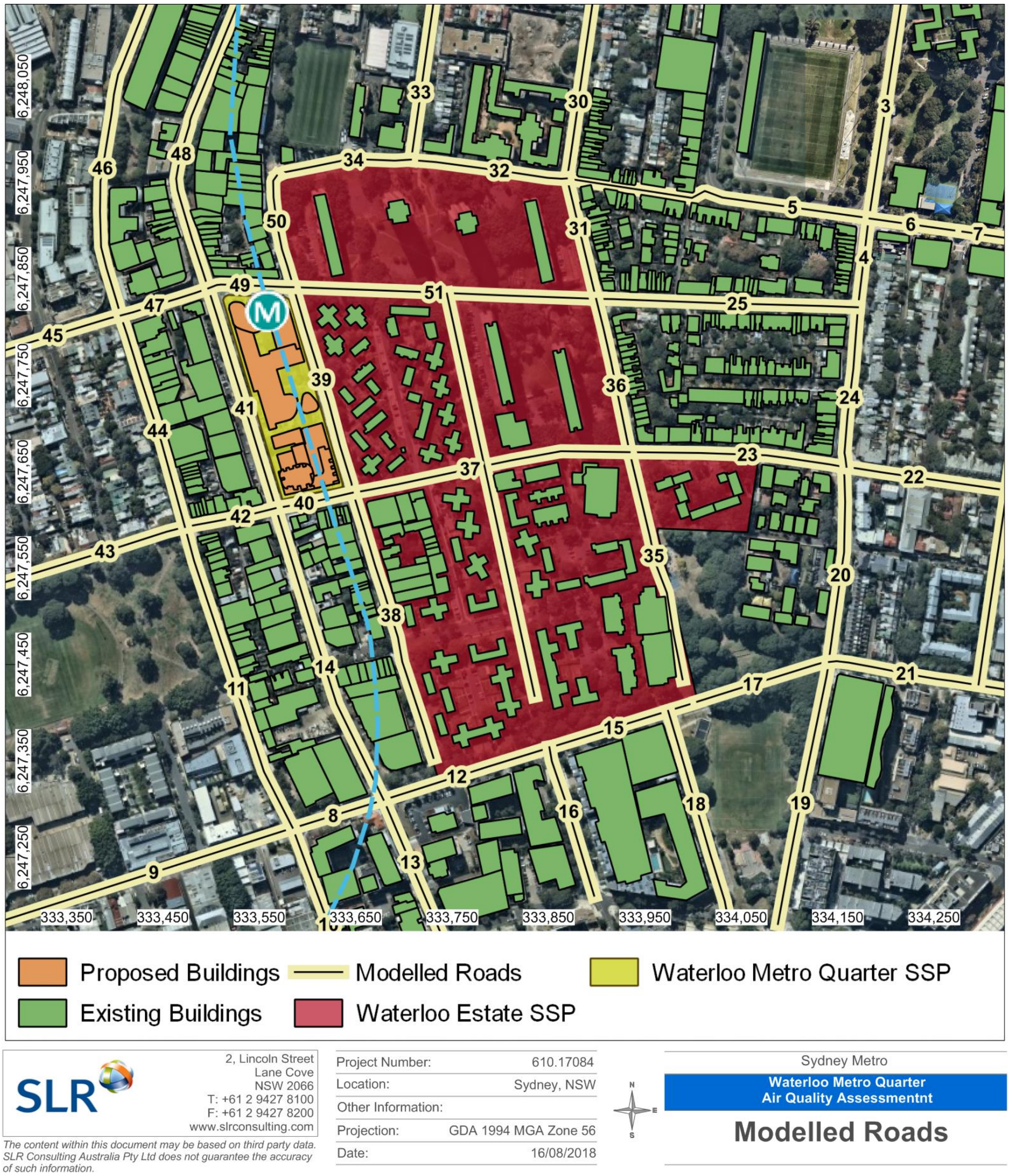

Figure 15 Modelled Road Sources and Buildings

6.1.2.4 Estimated emission rates

The peak hourly NO_x, PM_{10} and $PM_{2.5}$ emission rates estimated using COPERT Australia for the road sections modelled in this assessment using the methodology outlined above are presented in **Table 14**.

Table 14 Estimated Emission Rates – Traffic

ID	Corridor Name	Emission Rates (kg/km/h)		
		NO_x	$PM_{2.5}$	PM_{10}
1	Botany Road - McEvoy Street to Allen Street	2.28	0.11	0.13
2	Botany Road - McEvoy Street to Buckland Street	2.49	0.12	0.15
3	Botany Road - Raglan Street to Boundary Street	0.31	0.02	0.02
4	Botany Road - Wellington Street to Raglan Street	0.89	0.04	0.05
5	Buckland Street - Wyndham Street to Gerard Street	0.83	0.04	0.05
6	Cope Street - Raglan Street to Phillip Street	2.22	0.11	0.13
7	Cope Street - Wellington Street to McEvoy Street	1.17	0.06	0.07
8	Cope Street - Wellington Street to Raglan Street	0.98	0.05	0.06
9	Elizabeth Street - Allen Street to McEvoy Street	1.95	0.10	0.12
10	Elizabeth Street - McEvoy Street to Wellington Street	1.49	0.07	0.09
11	Elizabeth Street - Phillip Street to Raglan Street	2.61	0.13	0.15
12	Elizabeth Street - Redfern Street to Phillip Street	2.60	0.13	0.15
13	Elizabeth Street - Wellington Street to Raglan Street	1.48	0.07	0.09
14	George Street - McEvoy Street to Allen Street	0.22	0.01	0.01
15	George Street - Phillip Street to Redfern Street	1.49	0.07	0.09
16	Henderson Street - Gerard Street to Wyndham Street	0.14	0.01	0.01
17	Henderson Street - Wyndham Street to Botany Road	2.14	0.11	0.13
18	McEvoy Street - Botany Road to George Street	2.65	0.13	0.16
19	McEvoy Street - Elizabeth Street to Morehead Street	1.10	0.05	0.07
20	McEvoy Street - George Street to Pitt Street	0.51	0.03	0.03
21	McEvoy Street - Pitt Street to Elizabeth Street	0.74	0.04	0.04
22	McEvoy Street - Wyndham Street to Botany Road	2.42	0.12	0.14
23	McEvoy Street - Wyndham Street to Brennan Street	0.37	0.02	0.02
24	Philip Street - Elizabeth Street to Chalmers Street	0.42	0.02	0.02
25	Philip Street - Elizabeth Street to Walker Street	0.52	0.03	0.03
26	Phillip Street - George Street to Cope Street	0.25	0.01	0.01
27	Phillip Street - Pitt Street to George Street	0.29	0.01	0.02
28	Phillip Street - Walker Street to Morehead Street	0.27	0.01	0.02
29	Pitt Street - McEvoy Street to Allen Street	0.09	0.00	0.01
30	Pitt Street - McEvoy Street to Wellington Street	0.49	0.02	0.03
31	Pitt Street - Phillip Street to Raglan Street	0.40	0.02	0.02
32	Pitt Street - Phillip Street to Redfern Street	0.15	0.01	0.01
33	Pitt Street - Wellington Street to Raglan Street	0.26	0.01	0.02
34	Raglan Street - Botany Road to Cope Street	0.49	0.02	0.03
35	Raglan Street - Cope Street to Pitt Street	2.30	0.11	0.14

ID	Corridor Name	Emission Rates (kg/km/h)		
		NO_x	$PM_{2.5}$	PM_{10}
36	Raglan Street - Elizabeth Street to Pitt Street	0.17	0.01	0.01
37	Wellington Street - Botany Road to Wyndham Street	0.27	0.01	0.02
38	Wellington Street - Cope Street to Botany Road	0.76	0.04	0.04
39	Wellington Street - Elizabeth Street to Morehead Street	1.97	0.10	0.12
40	Wellington Street - Elizabeth Street to Pitt Street	1.91	0.09	0.11
41	Wellington Street - Pitt Street to Cope Street	2.70	0.13	0.16
42	Wyndham Street - Buckland Street to Henderson Street	2.16	0.11	0.13
43	Wyndham Street - Henderson Street to Boundary Street	0.76	0.04	0.05
44	Wyndham Street - McEvoy Street to Buckland Street	0.36	0.02	0.02
45	Wyndham Street - McEvoy Street to Mandible Street	0.56	0.03	0.03

6.1.2.5 Dispersion modelling

Model Selection

The GRAL modelling system was selected for the dispersion modelling of traffic emissions from roads surrounding the Metro Quarter primarily due to its ability to take account of the localised effects of buildings and obstacles. Like the US-EPA CALPUFF model, GRAL is suitable for regulatory applications, can utilise a full year of meteorological data and has the ability to handle low-wind-speed conditions.

GRAMM/GRAL is a coupled Eulerian (GRAMM, Graz Mesoscale Model wind fields) and Lagrangian (microphysics Graz Lagrangian Model) model, developed by the Graz University of Technology, Austria. It is designed to solve the sources accurately and to compute concentrations with a very high resolution in complex topographic and building configurations.

The Eulerian model GRAMM solves the conservation equations for mass, enthalpy, momentum and humidity. The surface energy balance is calculated in a surface module of GRAMM, where several different land use categories are used to define the surface roughness, the albedo, the emissivity, the soil moisture content, the specific heat capacity of the soil and the heat transfer coefficient.

The Lagrangian model GRAL uses three-dimensional meteorological data generated by GRAMM and computes steady state concentration fields for classified meteorological conditions using 3-7 stability classes, 36 wind direction classes and several wind speed classes to reduce the computational time. Typically, 500-600 bins of meteorological scenarios are required to characterise the dispersion situations that may occur at a given site within a year. Each of the steady-state concentration fields is stored as a separate file. Based on these results, the concentration fields for the annual mean value, maximum daily mean value and maximum value are calculated using a post-processing routine. In this way, the annual average, maximum daily mean, or maximum concentration for defined periods can be computed rapidly. The pseudo time series of concentration field can be obtained by taking the corresponding time series of classified meteorological situations of a certain period and multiplying each concentration field corresponding to certain hours of that period with some emission modulation factors.

Accuracy of Modelling

All atmospheric dispersion models, including GRAL, represent a simplification of the many complex processes involved in the dispersion of pollutants in the atmosphere. To obtain good quality results it is important that the most appropriate model is used and the quality of the input data (meteorological, terrain, source characteristics) is adequate.

The main sources of uncertainty in dispersion models, and their effects, are discussed below.

- **Oversimplification of physics:** This can lead to both under-prediction and over-prediction of ground level pollutant concentrations. Errors are greater in Gaussian plume models as they do not include the effects of non-steady-state meteorology (i.e. spatially- and temporally-varying meteorology).
- **Errors in emission rates:** Ground level concentrations are proportional to the pollutant emission rate. In addition, most modelling studies assume constant worst case emission levels or are based on the results of a small number of stack tests, however operations (and thus emissions) are often quite variable. Accurate measurement of emission rates and source parameters requires continuous monitoring.
- **Errors in source parameters:** Plume rise is affected by source dimensions, temperature and exit velocity. Inaccuracies in these values will contribute to errors in the predicted height of the plume centreline and thus ground level pollutant concentrations.
- **Errors in wind direction and wind speed**: Wind direction affects the direction of plume travel, while wind speed affects plume rise and dilution of plume. Errors in these parameters can result in errors in the predicted distance from the source of the plume impact, and magnitude of that impact. In addition, aloft wind directions commonly differ from surface wind directions. The preference to use rugged meteorological instruments to reduce maintenance requirements also means that light winds are often not well characterised.
- **Errors in mixing height:** If the plume elevation reaches 80 percent or more of the mixing height, more interaction will occur, and it becomes increasingly important to properly characterise the depth of the mixed layer as well as the strength of the upper air inversion.
- **Errors in temperature:** Ambient temperature affects plume buoyancy, so inaccuracies in the temperature data can result in potential errors in the predicted distance from the source of the plume impact, and magnitude of that impact.

- **Errors in stability estimates:** Gaussian plume models use estimates of stability class, and 3D models use explicit vertical profiles of temperature and wind (which are used directly or indirectly to estimate stability class for Gaussian models). In either case, errors in these parameters can cause either under-prediction or over-prediction of ground level concentrations.

The US EPA makes the following statement in its Modelling Guideline (US EPA, 2005) on the relative accuracy of models:

> *"Models are more reliable for estimating longer time-averaged concentrations than for estimating short-term concentrations at specific locations; and the models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area. For example, errors in highest estimated concentrations of ± 10 to 40 percent are found to be typical, i.e., certainly well within the often quoted factor-of-two accuracy that has long been recognised for these models. However estimates of concentrations that occur at a specific time and site, are poorly correlated with actually observed concentrations and are much less reliable."*

To maximise the accuracy of the model predictions, this AQA utilises the GRAL dispersion model in prognostic mode, enabling the representation of dynamic effects due to local topography such as obstacle-influenced air flows, and accommodating complex topography with high a horizontal resolution. The meteorological dataset was compiled using observations from nearby automatic weather stations and a five year period of meteorological data was reviewed to ensure that the year selected for use in the modelling is representative of long-term meteorological conditions.

Dispersion Model Configuration

Emissions from the vehicles travelling on the surrounding road network with available traffic volume data were represented by a series of line sources. **Figure 15** illustrates the roads modelled as part of this study. The proposed buildings as well as existing buildings and structures that may affect the dispersion of pollutants through channelling and blocking effects were included in the modelling. Outlines of these building are illustrated in **Figure 15** and the heights for all existing building were derived using high resolution Light Detection and Ranging (LIDAR) data.

A total of 590 discrete receptors were distributed across the Metro Quarter to predict the incremental impact of emissions from the surrounding roads on pollutant concentrations at potential residential areas. The time series of hourly average pollutant concentrations predicted by GRAL for these discrete receptor locations were then added to contemporaneous background time series data for the same period as the meteorological data used in the modelling to allow an assessment of potential cumulative impacts.

In addition to the discrete receptors discussed above, the GRAL model was set up to predict concentrations across the modelling domain based on a Cartesian grid of points with an equal spacing of 5 metres in the x and y directions. This results in 69,168 grid locations across the domain, which were used to produce contour plots.

In order to assess pollutant concentrations at various elevations, discrete and gridded receptors were located at 12 metres and 15 metres in addition to those located at 1 metre above ground level (i.e. ground level receptors). 12 metres and 15 metres elevations were selected to assess the highest potential impact at residential receivers. As outlined in **Section 1.6** all residential receivers are proposed to be located above an elevation of 12 metres. Concentrations above this height will be lower than the predictions presented in this report.

The Ozone Limiting Method (OLM) was used for the conversion of modelled NO_x to NO_2 using contemporaneous hourly-varying 1-hour average ozone concentration data from the Randwick AQMS. This method assumes that all available ambient ozone will react instantaneously with the emitted NO to form NO_2. This is a conservative approach for near-source receptor locations as assessed in this study.

6.1.2.6 Meteorological modelling

To provide the meteorological data required by GRAMM, information is needed on the prevailing wind regime, mixing depth and atmospheric stability and other parameters such as ambient temperature and relative humidity. In absence of any site-specific observed meteorological data, a site-representative meteorological dataset was compiled using the CSIRO model TAPM, the US EPA's CALMET model and the GRAMM meteorological processor.

Selection of the Meteorological Year

In order to determine a representative meteorological year for use in the dispersion modelling, five years of meteorological data (2013-2017) from the Sydney Airport AWS and the Canterbury Racecourse AWS were analysed against the 5-year average meteorological conditions. Specifically, the following parameters were analysed:

- Percentage of calm wind speed events (wind speed <0.5 metres per second): Calm wind conditions are conducive to higher concentrations of air pollutants due to poor dispersion of the plume.
- Wind speeds: Monthly average as well as hourly average observed at 9:00 am and 3:00 pm.
- Temperature: Monthly average as well as hourly average at 9:00 am and 3:00 pm.

Figure 16 presents the annual wind roses for the two BoM stations, which show relatively similar wind roses for all five years analysed. **Figure 17** illustrates average monthly wind speeds for the two stations and compares them against the 5-year average.

While the temperatures and average wind direction and wind speed frequencies for the years analysed were generally similar for each BoM station, the analysis showed a relatively higher frequency of calms and lower than average wind speeds for the year 2014. Using this year as the representative year would therefore be a conservative approach because low wind speeds are associated with less effective plume dispersion. No other parameters significantly deter the use of this year's data. Consequently, 2014 was selected as the representative year of meteorology.

As noted in **Section 3.3**, the NSW OEH maintains a network of AQMSs across NSW that record wind speed and wind direction as well as air quality data. The nearest such OEH stations are located at Rozelle (approximately 5 kilometres to the northeast of the Metro Quarter), Randwick (approximately 5.2 kilometres southeast of the Metro Quarter) and Earlwood approximately 6.9 kilometres southwest of the Metro Quarter) (refer **Figure 9**).

As noted on the OEH website, the Rozelle and Earlwood monitoring stations do not currently comply with the relevant siting standards as the clear sky angle for both sites is < 120 degrees due to trees within 20 metres of the monitoring site. The data from the Randwick AQMS was reviewed and agreed with the BoM data summarised above.

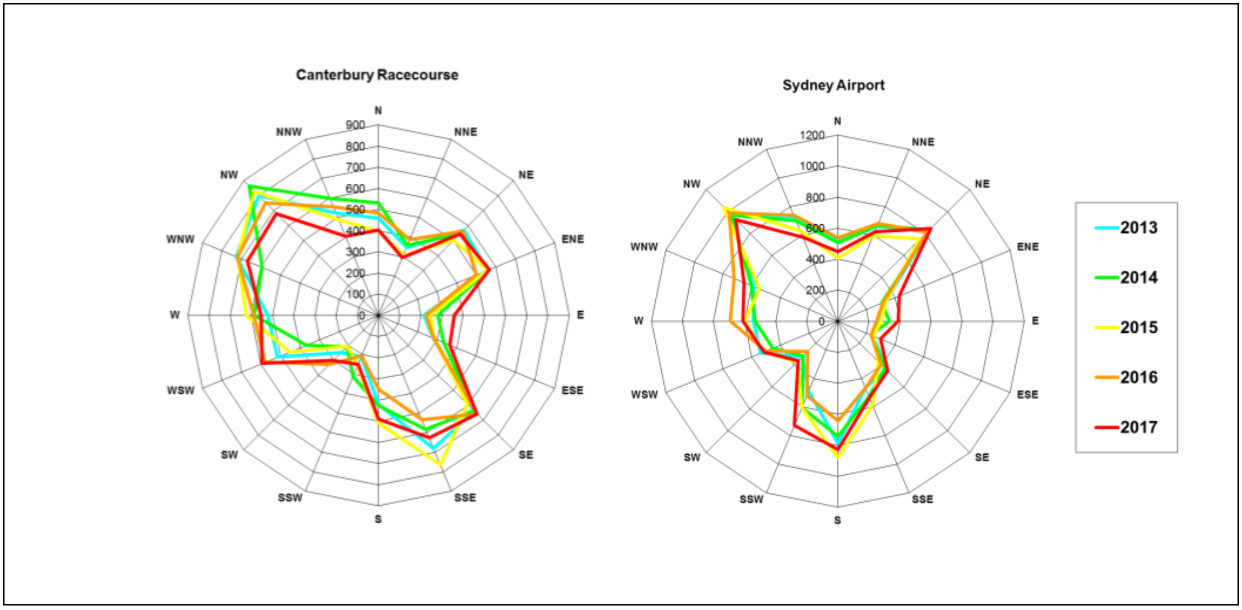

Figure 16 Sydney Airport AWS and Canterbury Racecourse AWS Annual Wind Roses, 2013-2017

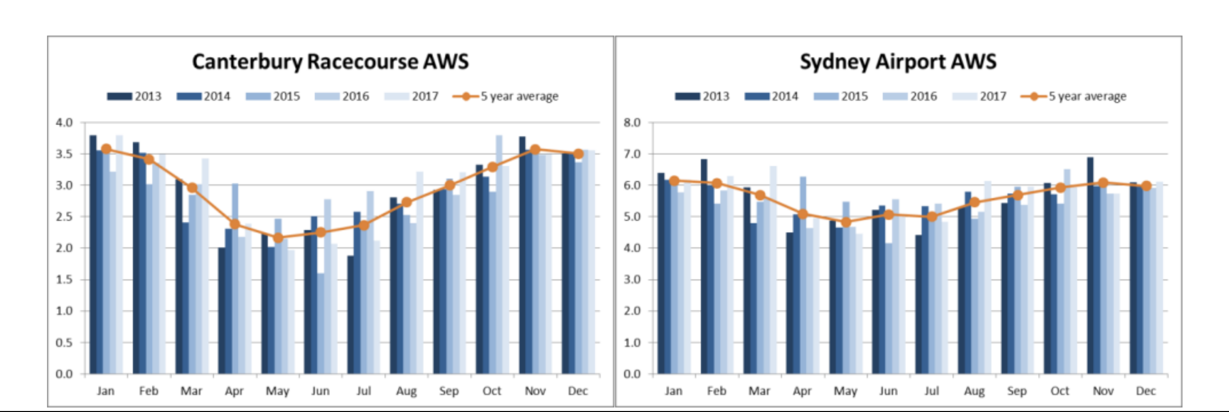

Figure 17 Sydney Airport and Canterbury Racecourse Monthly Average Wind Speeds, 2013-2017

TAPM

The TAPM prognostic model, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) was used to generate the three dimensional upper air data required for CALMET modelling as outlined below.

TAPM predicts wind speed and direction, temperature, pressure, water vapour, cloud, rain water and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate one full year of hourly meteorological observations at user-defined levels within the atmosphere.

Additionally, TAPM may assimilate actual local wind observations so that they can optionally be included in a model solution. The wind speed and direction observations are used to realign the predicted solution towards the observation values. Available observed meteorological data from the nearby BoM stations were incorporated into the TAPM setup. **Table 15** details the parameters used in the TAPM meteorological modelling for this assessment.

Table 15 Meteorological Parameters used for the AQA – TAPM

Parameter	Value
Modelling Period	1 January 2014 to 31 December 2014
Centre of analysis	332,750 metres Easting 6,250,232 metres Northing (UTM Coordinates)
Number of grid points	35 × 35 × 35
Number of grids (spacing)	4 (30 kilometres, 10 kilometres, 3 kilometres, 1 kilometres)
Data assimilation	Sydney Airport AWS (Station # 66037) Canterbury Racecourse AWS (Station # 66194)
Terrain	AUSLIG 9 second DEM

CALMET

In order to further refine TAPM outputs, the CALMET model was used. In the simplest terms, CALMET is a meteorological model that develops hourly wind and other meteorological fields on a three-dimensional gridded modelling domain. Associated two dimensional fields such as mixing height, surface characteristics and dispersion properties are also included in the file produced by CALMET. The interpolated wind field is then modified within the model to account for the influences of topography, sea breeze, as well as differential heating and surface roughness associated with different land uses across the modelling domain. These modifications are applied to the winds at each grid point to develop a final wind field. The final hourly varying wind field thus reflects the influences of local topography and land uses.

CALMET modelling was conducted using the nested CALMET approach, where the final results from a coarse-grid run were used as the initial guess of a fine-grid run. This has the advantage that off-domain terrain features including slope flows, blocking effect can be allowed to take effect and the larger-scale wind flow provides a better start in the fine-grid run.

The outer domain was modelled with a resolution of 0.3 kilometres. The TAPM-generated 3-dimensional meteorological data was used as the 'initial guess' wind field and the local topography and available surface weather observations in the area were used to refine the wind field predetermined by TAPM. Hourly surface meteorological data from BoM stations located at Sydney Airport and Canterbury Racecourse were incorporated in the outer domain modelling.

The output from the outer domain CALMET modelling was then used as the initial guess field for the inner domain CALMET modelling. A horizontal grid spacing of 0.1 kilometres was used in the inner domain to adequately represent the important local terrain features and land use. Finer scale land use data were used in the inner domain run to refine the wind field parameters given by the coarse CALMET run. **Table 16** details the parameters used in the meteorological modelling to drive the CALMET model.

Table 16 Meteorological Parameters used for this Study – CALMET (v 6.42)

Outer Domain	
Meteorological grid	15 kilometres × 15 kilometres
Meteorological grid resolution	0.3 kilometres
Surface station data	Sydney Airport AWS (Station # 66037) Canterbury Racecourse AWS (Station # 66194)
Initial guess filed	3D output from TAPM modelling
Inner Domain	
Meteorological grid	5 kilometres × 5 kilometres
Meteorological grid resolution	0.1 kilometres
Initial guess field	3D output from outer domain modelling

GRAMM

The GRAMM domain was defined so that it covered the whole extent of the Metro Quarter as well as the surrounding road network, with a sufficient buffer zone. The model was run with a 100 metre horizontal resolution and 15 vertical layers to adequately resolve surrounding topography and land use.

Topographical data used in GRAMM were sourced from the Geoscience Australia database that has corrected Shuttle Radar Topography Mission (SRTM) topography data for Australia with a 1 arc second (approximately 30 metre) spacing. The land use data for the modelling domain was defined by CORINE land use categories using values specified for urban land use.

The site-representative predicted meteorological data extracted from the inner domain output from the CALMET model was used as input to the GRAMM model.

Meteorological Data Used in Modelling

Wind Speed and Direction

A summary of the annual wind behaviour predicted by CALMET, extracted at a location within the Metro Quarter is presented as wind roses in **Figure 18**.

Figure 18 indicates that winds predicted at the Metro Quarter are predominantly light to moderate (between 1.5 metres per second and 8 metres/second). Calm wind conditions (wind speed less than 0.5 metres/second) were predicted to occur approximately 0.5 percent of the time throughout the modelling period.

The seasonal wind roses indicate that:

- In summer, winds are predicted to be light to moderate, occurring predominantly from the northeast, with the smallest percentage of winds blowing from the western quadrant. Calm winds were predicted 0.5 percent of the time during summer.
- In autumn, winds are predicted to be light to moderate and predominantly from the northwest quadrant, with the smallest percentage of winds blowing from the southeastern quadrant. Calm winds were predicted 0.5 percent of the time during autumn.
- In winter, winds are predicted to be light to moderate and predominantly from the west-northwestern quadrant, with very few winds from the eastern quadrant. Calm winds were predicted 0.3 percent of the time during winter.
- In spring, winds are predicted to be light to moderate, predominantly from the northeast. Calm winds were predicted 0.6 percent of the time during spring.

It is noted that the wind conditions predicted by the model at other areas within the modelling domain may vary from the wind roses presented in **Figure 18** for one point within the Metro Quarter, and within GRAL the dispersion of pollutants from each source within the models will reflect the local conditions.

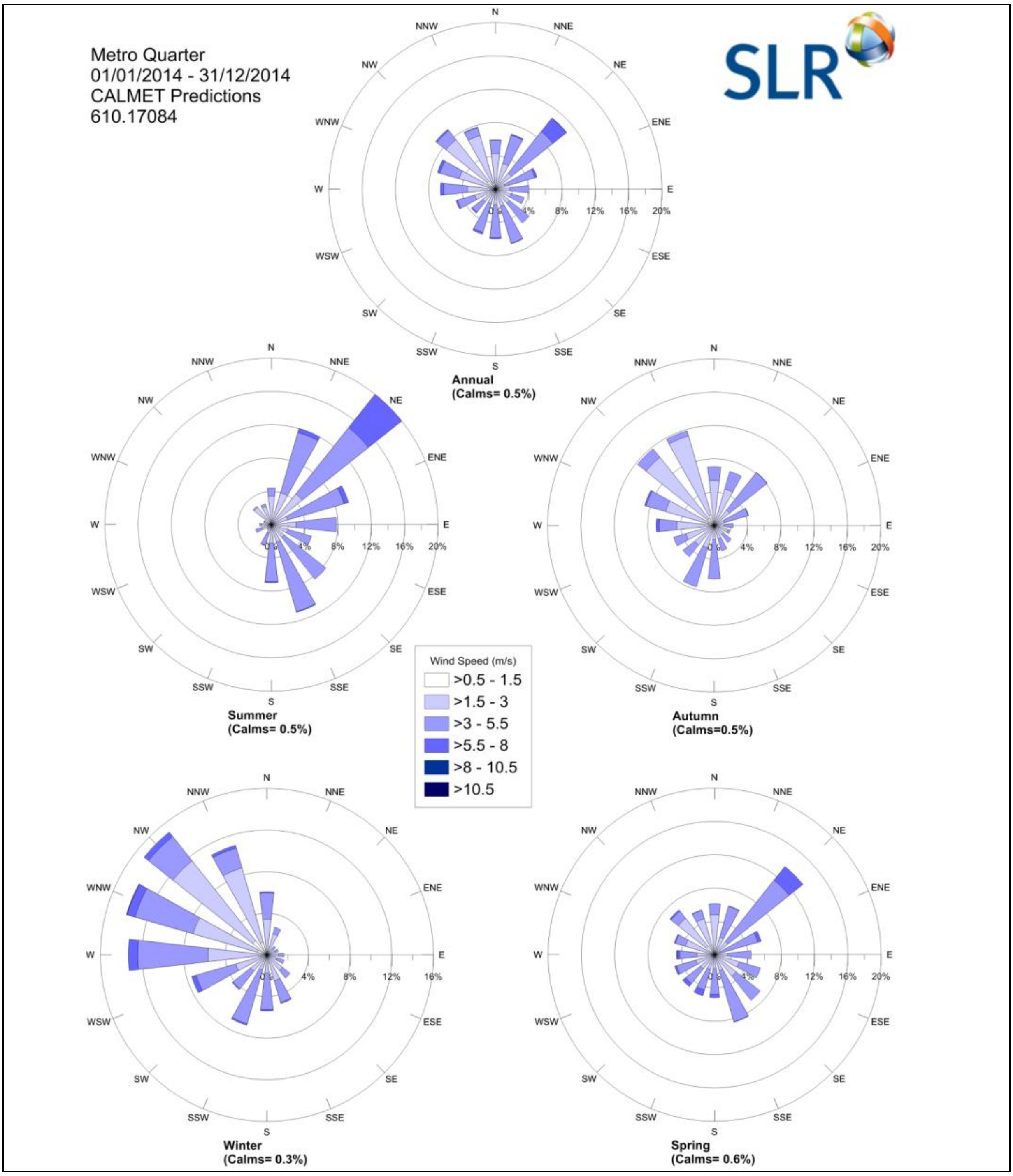

Figure 18 Predicted Seasonal Wind Roses for the Metro Quarter (CALMET predictions, 2014)

Atmospheric Stability

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Gifford-Turner (PGT) assignment scheme identifies six stability classes, A to F, to categorise the degree of atmospheric stability as follows:

- A = Extremely unstable conditions
- B = Moderately unstable conditions
- C = Slightly unstable conditions
- D = Neutral conditions
- E = Slightly stable conditions
- F = Moderately stable conditions

The meteorological conditions defining each PGT stability class are shown in **Table 17**.

Table 17 Meteorological Conditions Defining PGT Stability Classes

Surface wind speed (m/s)	Daytime insolation		Night-time conditions	
	Strong	Moderate	Strong	Moderate
< 2	A	A - B	A	A - B
2 - 3	A - B	B	A - B	B
3 - 5	B	B - C	B	B - C
5 - 6	C	C - D	C	C - D
> 6	C	D	C	D

Source: (NOAA, 2018)

Notes:

1. Strong insolation corresponds to sunny midday in midsummer in England; slight insolation to similar conditions in midwinter.
2. Night refers to the period from 1 hour before sunset to 1 hour after sunrise.
3. The neutral category D should also be used, regardless of wind speed, for overcast conditions during day or night and for any sky conditions during the hour preceding or following night as defined above.

The frequency of each stability class predicted by CALMET during the modelling period, extracted at a location within the Metro Quarter is presented in **Figure 19**. The results indicate a high frequency of conditions typical to Stability Classes D and F. Stability Class D is indicative of neutral conditions, conducive to a moderate level of pollutant dispersion due to mechanical mixing. Stability Class F is indicative of stable night time conditions, which will inhibit pollutant dispersion resulting in higher pollutant concentrations at ground level at surrounding areas.

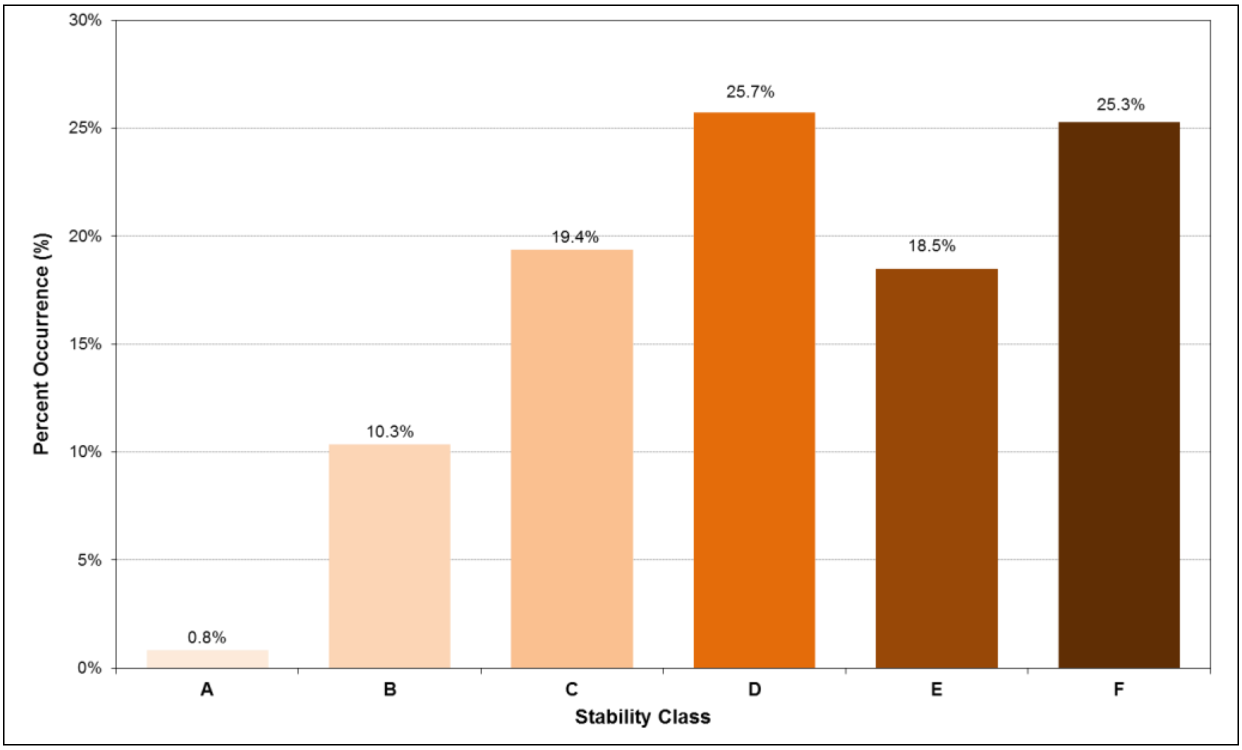

Figure 19 Predicted Stability Class Frequencies at the Metro Quarter (CALMET predictions, 2014)

Mixing Heights

Daily variations in maximum and average mixing heights predicted by CALMET at the Metro Quarter during the 2014 modelling period are illustrated in **Figure 20**.

As would be expected, an increase in mixing depth during the morning is apparent, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground based temperature inversions and growth of the convective mixing layer.

Temperature

The modelled temperature variations as predicted at the Metro Quarter during the year 2014 are illustrated in **Figure 20**. The maximum temperature (36.9 degrees Celsius) was predicted on 14 November 2014 and the minimum temperature 3.4 degrees Celsius) was predicted on 12 July 2014.

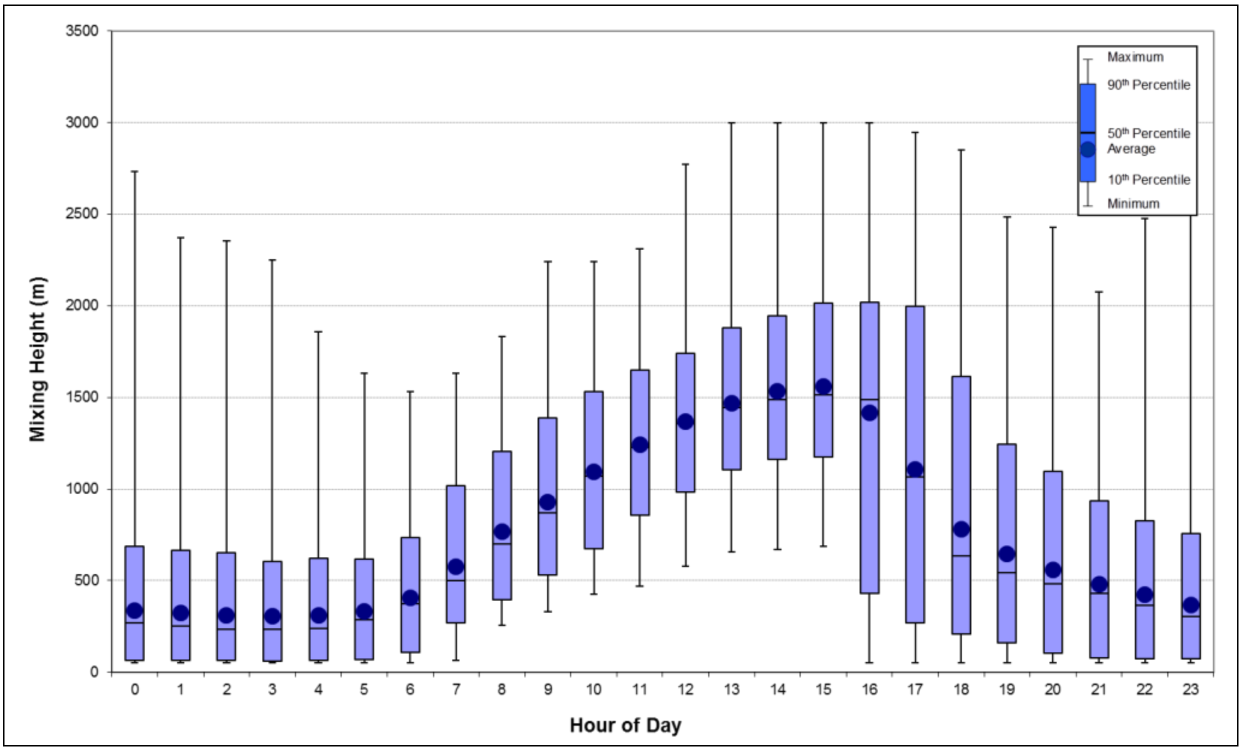

Figure 20 Predicted Mixing Heights at the Metro Quarter (CALMET predictions, 2014)

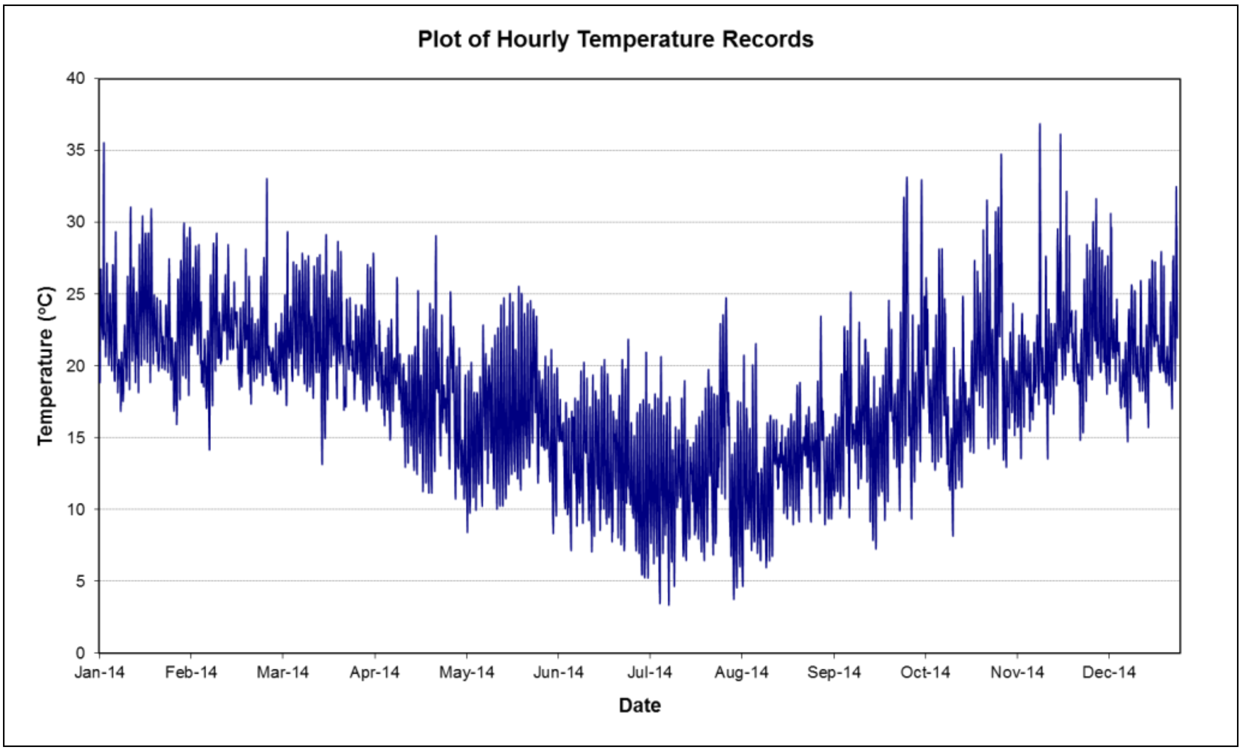

Figure 21 Predicted Temperatures at Metro Quarter (CALMET predictions, 2014)

6.1.3 Qualitative Assessment of Other Identified Sources

A risk-based qualitative assessment approach has been adopted for emission sources other than traffic which may impact the Metro Quarter (see **Appendix C** for full methodology). This risk-based assessment methodology takes account of a range of impact descriptors, including the following:

- **Nature of Impact**: does the impact result in an adverse or beneficial environment?
- **Sensitivity**: how sensitive is the receiving environment to the anticipated impacts? This may be applied to the sensitivity of the environment in a regional context or specific receptor locations.
- **Magnitude**: what is the anticipated scale of the impact?

The integration of sensitivity with impact magnitude is used to derive the predicted significance of that change. Given the small scale of the identified activities, and the limited operational details available, it is considered that this approach is appropriate to identify those key activities that have the potential to lead to air quality impacts at the Metro Quarter.

6.2 Construction phase impacts

6.2.1 Products of combustion due to fuel combustion

Ambient air quality monitoring performed in the Sydney area over the last few decades has shown that the city's air quality has improved and is continuing to improve. A major driver of this improvement in urban air quality is the fact that newer vehicles produce significantly less emissions than older vehicles. This is in part as a result of improvements in the quality and composition of fuels as well as improved engine designs and fuel efficiency. According to Trends in Motor Vehicles and their Emissions (NSW EPA, 2014), cars built from 2013 onwards emit only 3 percent of the NO_X emissions compared to vehicles built in 1976, and diesel trucks built from 2011 onwards emit just 8 percent of the particles emitted by vehicles built in 1996. Thus even as Sydney's population and total vehicle kilometres travelled each year have increased (NSW EPA, 2014), key measures of air pollution have dropped significantly and this trend is expected to continue.

The results from the background air quality concentrations show that the monitored concentrations have been below the respective criteria for NO_2 and SO_2 for five years running (2013-2017) (see **Section 3.3**).

Given the relatively short-term nature of the construction works, emissions generated due to the combustion of fuel in construction plant and machinery will be of limited duration and small compared to the emissions generated by road traffic on Botany Road. They are therefore considered unlikely to have any potential for significant impacts on local air quality and have not been considered any further in this assessment.

6.2.2 Dust impacts from construction works

The key potential air pollution and amenity issues associated with fugitive dust emissions from the proposed activities during construction works at the Metro Quarter are:

- annoyance due to dust deposition (soiling of surfaces) and visible dust plumes; and
- elevated suspended particulate concentrations (PM_{10} and $PM_{2.5}$).

As noted in **Section 6.1.1** modelling of dust from construction activities is generally not considered appropriate, as emission rates can vary significantly depending on a combination of the activity (and activity intensity) and prevailing meteorological conditions (i.e. rainfall and wind speed). The following sections therefore present a qualitative assessment of the potential risks to air quality associated with dust from construction activities at the site. Details of the IAQM methodology used to perform the risk assessment are provided in **Appendix A**.

6.2.2.1 Step 1 – screening based on separation distance

The nearest existing residential receptors have been identified as being located on Cope Street, approximately 20 metres east of the Metro Quarter.

As the sensitive receptors are located within 350 metres from the boundary of the site, less than 50 metres from the route used by construction vehicles on public roads and within 500 metres from the site entrance, further assessment is required.

6.2.2.2 Step 2a – assessment of scale and nature of the works

Based upon the above assumptions and the IAQM definitions presented in **Appendix A**, the dust emission magnitudes have been categorised as presented in **Table 18**.

Demolition activities have not been considered as demolition activities at the Metro Quarter have been completed as part of the Sydney Metro City & Southwest project which includes the construction of Waterloo Station.

Table 18 Categorisation of Dust Emission Magnitude

Activity	Dust Emission Magnitude	Basis
Earthworks	Large	Total site area greater than 10,000 m^2, potentially dusty soil type (e.g. clay, which will be prone to suspension when dry due to small particle size), more than 10 heavy earth moving vehicles active at any one time, formation of bunds greater than 8 metres in height, total material moved more than 100,000 tonnes. *Note: The excavation of the station box and tunnel has been assessed and approved as part of the CSSI Approval. Remaining major earth works includes the excavation of the Metro Quarter basements. Excavation of approximately 66,800 m^3 of material from a 22,865m^2 excavation area would be required for the basements. Assuming the average density of material to be 2,400 kg/m^3, the total material moved is estimated to be ~160,000 tonnes. Even though formation of bunds greater than 8 metres in height is not anticipated, the dust emissions magnitude has been categorised as large based on the total material moved .*
Construction	Large	Total building volume greater than 100,000 m^3, piling *Note: The total building volumes is calculated to be approximately 350,250 m^3. While no on-site concrete batching or sandblasting is anticipated, the construction activities have ben categorised as large based on the building volume.*
Trackout	Medium	Between 10 and 50 heavy vehicle movements per day, surface materials with a moderate potential for dust generation, between 50 metres and 100 metres of unpaved road length. *Note: it is anticipated that on average 43 heavy vehicle movements will occur per day.*

6.2.2.3 Step 2b – risk assessment

6.2.2.3.1 Receptor sensitivity

Based on the criteria listed in **Table A1** in **Appendix A**, the sensitivity of the identified receptors in this study is concluded to be *high* for health impacts and *high* for dust soiling, as they include residential areas where people may be reasonably expected to be present continuously as part of the normal pattern of land use.

6.2.2.3.2 Sensitivity of an area

Using the classifications shown in **Table A2** in **Appendix A**, the sensitivity of the area to dust soiling is classified as *high* and the sensitivity of the surrounding area to health effects (**Table A3** in **Appendix A**) has been classified as *medium*. This categorisation has been made taking into account the individual receptor sensitivities derived above, the annual mean background PM_{10} concentration of 18-19 micrograms per cubic metre recorded at the Randwick AQMS (see **Section 3.3**) and the anticipated number of receptors present, i.e. >100 within 50 metres for both dust soiling and health impacts.

6.2.2.4 Risk assessment

Given the sensitivity of the general area is classified as *high* for dust soiling and *medium* for health effects, and the dust emission magnitudes for the various construction phase activities as shown in **Table 18**, the resulting risk of air quality impacts is as presented in **Table 19**.

The results indicate that there is a high risk of adverse dust soiling and medium risk of adverse human health impacts occurring at the off-site sensitive receptor locations as a result of the proposed earthworks and construction activities if no mitigation measures were to be applied to control emissions. There is a medium risk of adverse dust soiling and low risk of adverse human health impacts due to trackout activities if no mitigation measures were to be applied to control emissions.

Table 19 Preliminary Risk of Air Quality Impacts from Construction Works (Uncontrolled)

Impact	Sensitivity of Area	Dust Emission Magnitude			Preliminary Risk		
		Earthworks	Construction	Trackout	Earthworks	Construction	Trackout
Dust Soiling	High	Large (**Table 18**)	Large (**Table 18**)	Medium (**Table 18**)	High Risk	High Risk	Medium Risk
Human Health	High				Medium Risk	Medium Risk	Low Risk

6.2.2.5 Step 3 - mitigation measures

Table 20 lists the relevant mitigation measures designated as *highly recommended* (H) or *desirable* (D) by the IAQM methodology for a development shown to have a high risk of adverse impacts.

Not all these measures would be practical or relevant to the proposed works at the Metro Quarter, hence these have been provided as guidance and a detailed review of the recommendations should be performed as part of the development of the Construction Environmental Management Plan (CEMP) and the most appropriate measures adopted.

Further work would be undertaken as part of the development of the detailed construction methodology and addressed as part of the detailed SSD Application.

Table 20 Site-Specific Management Measures Recommended by the IAQM

	Activity	Recommendation Designation *
1	Communications	
1.1	Develop and implement a stakeholder communications plan that includes community engagement before work commences on site.	H
1.2	Display the name and contact details of person(s) accountable for air quality and dust issues on the site boundary. This may be the environment manager/engineer or the site manager.	H
1.3	Display the head or regional office contact information.	H
1.4	Develop and implement a Dust Management Plan (DMP), which may include measures to control other emissions, approved by the Local Authority.	H
2	Site Management	
2.1	Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken.	H
2.2	Make the complaints log available to the local authority when asked.	H
2.3	Record any exceptional incidents that cause dust and/or air emissions, either on- or offsite, and the action taken to resolve the situation in the log book.	H
2.4	Hold regular liaison meetings with other high risk construction sites within 500 metres of the site boundary, to ensure plans are co-ordinated and dust and particulate matter emissions are minimised. It is important to understand the interactions of the off-site transport/deliveries which might be using the same strategic road network routes.	H
3	Monitoring	
3.1	Perform daily on-site and off-site inspections where receptors (including roads) are nearby, to monitor dust, record inspection results, and make the log available to the local authority when asked. This should include regular dust soiling checks of surfaces such as street furniture, cars and window sills within 100 metres of site boundary.	H
3.2	Carry out regular site inspections to monitor compliance with the DMP, record inspection results, and make an inspection log available to the local authority when asked.	H
3.3	Increase the frequency of site inspections by the person accountable for air quality and dust issues on site when activities with a high potential to produce dust are being carried out and during prolonged dry or windy conditions.	H
3.4	Agree dust deposition, dust flux, or real-time PM10 continuous monitoring locations with the Local Authority. Where possible commence baseline monitoring at least three months before work commences on site or, if it a large site, before work on a phase commences. Further guidance is provided by IAQM on monitoring during demolition, earthworks and	H

	construction.	
4	Preparing and Maintaining the Site	
4.1	Plan site layout so that machinery and dust causing activities are located away from receptors, as far as is possible.	H
4.2	Erect solid screens or barriers around dusty activities or the site boundary that are at least as high as any stockpiles on site.	H
4.3	Fully enclose site or specific operations where there is a high potential for dust production and the site is active for an extensive period.	H
4.4	Avoid site runoff of water or mud.	H
4.5	Keep site fencing, barriers and scaffolding clean using wet methods.	H
4.6	Remove materials that have a potential to produce dust from site as soon as possible, unless being re-used on site. If they are being re-used on-site cover as described below	H
4.7	Cover, seed or fence stockpiles to prevent wind erosion	H
5	Operating Vehicle/Machinery and Sustainable Travel	
5.1	Ensure all on-road vehicles comply with relevant vehicle emission standards, where applicable	H
5.2	Ensure all vehicles switch off engines when stationary - no idling vehicles	H
5.3	Avoid the use of diesel or petrol powered generators and use mains electricity or battery powered equipment where practicable	H
5.4	Impose and signpost a maximum-speed-limit of 25 kilometres/hour on surfaced and 15 kilometres per hour on un-surfaced haul roads and work areas (if long haul routes are required these speeds may be increased with suitable additional control measures provided, subject to the approval of the nominated undertaker and with the agreement of the local authority, where appropriate).	H
5.5	Produce a Construction Logistics Plan to manage the sustainable delivery of goods and materials.	H
5.6	Implement a Travel Plan that supports and encourages sustainable travel (public transport, cycling, walking, and car-sharing)	H
6	Operations	
6.1	Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction, e.g. suitable local exhaust ventilation systems.	H
6.2	Ensure an adequate water supply on the site for effective dust/particulate matter suppression/ mitigation, using non-potable water where possible and appropriate	H
6.3	Use enclosed chutes and conveyors and covered skips	H
6.4	Minimise drop heights from loading shovels and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate	H
6.5	Ensure equipment is readily available on site to clean any dry spillages, and clean up spillages as soon as reasonably practicable after the event using wet cleaning methods.	H

7	Waste Management	
7.1	Avoid bonfires and burning of waste materials.	H
8	Earthworks	
8.1	Re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces as soon as practicable.	H
8.2	Use Hessian, mulches or trackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable	H
8.3	Only remove the cover in small areas during work and not all at once	H
9	Construction	
9.1	Avoid scabbling (roughening of concrete surfaces) if possible	H
9.2	Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place.	H
9.3	Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery.	H
9.4	For smaller supplies of fine power materials ensure bags are sealed after use and stored appropriately to prevent dust.	D
10	Trackout	
10.1	Use water-assisted dust sweeper(s) on the access and local roads to remove, as necessary, any material tracked out of the site.	H
10.2	Avoid dry sweeping of large areas.	H
10.3	Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport.	H
10.4	Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable.	H
10.5	Record all inspections of haul routes and any subsequent action in a site log book.	H
10.6	Install hard surfaced haul routes, which are regularly damped down with fixed or mobile sprinkler systems, or mobile water bowsers and regularly cleaned.	H
10.6	Implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud prior to leaving the site where reasonably practicable).	H
10.6	Ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permits.	H
10.6	Access gates to be located at least 10 m from receptors where possible.	H

* H = Highly recommended; D = Desirable

6.2.2.6 Step 4 - residual impacts

A reappraisal of the predicted unmitigated air quality impacts on sensitive receptors has been performed to demonstrate the opportunity for minimising risks associated with the use of mitigation strategies. These are termed 'residual impacts'. The results of the reappraisal are presented below in **Table 21**.

Table 21 Residual Risk of Air Quality Impacts from Construction Works

Impact	Sensitivity of Area	Earthworks	Construction	Trackout
Dust Soiling	High	Medium Risk	Medium Risk	Low Risk
Human Health	High	Low Risk	Low Risk	Negligible Risk

The mitigated dust deposition and human health impacts for earthworks and construction activities are anticipated to be low. For almost all construction activity, the IAQM Methods notes that the aim should be to prevent significant effects on receptors through the use of effective mitigation and experience shows that this is normally possible.

6.3 Impacts from the surrounding road network

Ambient air quality monitoring performed in the Sydney area over the last few decades has shown that the city's air quality has improved and is continuing to improve. A major driver of this improvement in urban air quality is the fact that newer vehicles produce significantly less emissions than older vehicles. This is in part as a result of improvements in the quality and composition of fuels as well as improved engine designs and fuel efficiency. According to *Trends in Motor Vehicles and their Emissions* (NSW EPA, 2014), cars built from 2013 onwards emit only 3 percent of the NO_x emissions compared to vehicles built in 1976, and diesel trucks built from 2011 onwards emit just 8 percent of the particles emitted by vehicles built in 1996. Thus even as Sydney's population and total vehicle kilometres travelled each year have increased (NSW EPA, 2014), key measures of air pollution have dropped significantly and this trend is expected to continue.

This section presents a summary of the air quality impacts predicted by the modelling of vehicle emissions from the main roads surrounding the Metro Quarter, based on current vehicle numbers and emission factors representative of the current Sydney fleet. Future impacts can be expected to be lower than those predicted for current conditions, due to improved vehicle emissions performance as outlined above.

6.3.1 $PM_{2.5}$

The maximum incremental and cumulative 24-hour and annual average $PM_{2.5}$ concentrations predicted at ground level, 12 metres elevation and 15 metres elevation within the Metro Quarter are presented in **Table 22**.

Figure 22 illustrates the cumulative 24-hour average ground level $PM_{2.5}$ concentrations predicted within the Metro Quarter, while **Figure 23** illustrates the cumulative annual average ground level concentrations. Contour plots showing the predicted incremental impacts at ground level, 12 metres elevation and 15 metres elevation are presented in **Appendix D**. It should be noted that contour plots do not represent the dispersion pattern for any individual time period, but rather illustrate the maximum 24-hour average or annual average concentration that was predicted to occur at each model calculation point over the range of meteorological conditions occurring during the 2014 modelling period.

Table 22 Predicted $PM_{2.5}$ Concentrations

Elevation	Location	Maximum Incremental Concentrations (µg/m³)		Maximum Cumulative Concentrations (µg/m³)	
		24-Hour Average	Annual Average	24-Hour Average	Annual Average
Ground Level	Maximum at Boundary [1]	12.1	7.0	30.5	14.8
	Maximum at Building Facade [2]	3.5	1.6	24.6	9.4
12 m Elevation	Maximum at Boundary [1]	7.7	4.2	27.6	12.3
	Maximum at Building Facade [2]	3.2	1.6	24.5	9.4
15 m Elevation	Maximum at Boundary [1]	7.2	3.7	27.1	11.5
	Maximum at Building Facade [2]	3.1	1.4	24.4	9.2
			CRITERIA	**25**	**8**

Note: Red text indicates exceedance of relevant ambient air quality criteria
[1] Maximum concentrations were predicted at western boundary of the Metro Quarter
[2] Maximum concentrations were predicted on the western frontage of the buildings

The modelling results presented in **Table 22** show that while no exceedances of the 24-hour average $PM_{2.5}$ criterion are predicted at any modelled discrete receptor location on the façade of the building, where sensitive receptors may potentially be affected, exceedances of the 24-hour average $PM_{2.5}$ criterion are predicted along the western boundary of the Metro Quarter. The predicted cumulative annual $PM_{2.5}$ concentrations on the western facades of the proposed residential towers within the Metro Quarter also do not comply with the relevant ambient air quality criteria outlined in **Section 5.0**.

Seven (7) exceedances of the 24-hour average $PM_{2.5}$ criterion are predicted per year for the worst-affected boundary receptors. As illustrated in **Figure 22**, the highest 24-hour average $PM_{2.5}$ concentrations are predicted to occur within close proximity of Botany Road.

Exceedances of the annual average $PM_{2.5}$ criterion are predicted along all four site boundaries of the Metro Quarter (see **Figure 23**). This is primarily due to high background concentrations of $PM_{2.5}$ within the local airshed. As outlined in **Section 3.3**, exceedances of the annual average $PM_{2.5}$ criterion were recorded by the Earlwood AQMS in two of the last five years and the annual average background $PM_{2.5}$ concentration used in this assessment of 7.8 µg/m^3 is already only fractionally below the criterion of 8 µg/m^3.

Figure 22 Maximum Predicted Cumulative 24-Hour Average $PM_{2.5}$ Concentrations – 1 metre Elevation

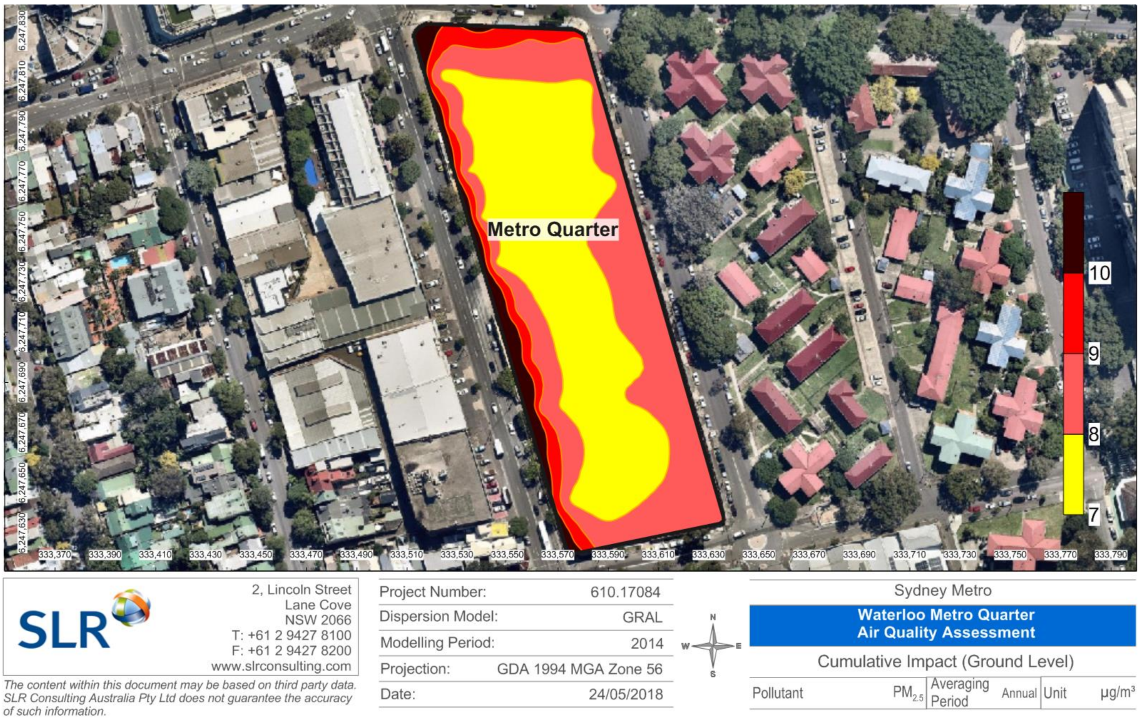

Figure 23 Predicted Cumulative Annual Average $PM_{2.5}$ Concentrations – 1 metre Elevation

6.3.2 PM_{10}

The maximum incremental and cumulative 24-hour and annual average PM_{10} concentrations predicted at ground level, 12 metres elevation and 15 metres elevation within the Metro Quarter are presented in **Table 23**.

Figure 24 illustrates the cumulative 24-hour average ground level PM_{10} concentrations predicted within the Metro Quarter, while **Figure 25** illustrates the cumulative annual average ground level concentrations. Contour plots showing the predicted incremental impacts at ground level, 12 metres elevation and 15 metres elevation are presented in **Appendix D**.

The modelling results presented in **Table 22** show that while exceedances of the 24-hour and annual PM_{10} criteria are predicted at the western boundary of the Metro Quarter, no exceedances of the 24-hour and annual PM_{10} criteria are predicted at any modelled discrete receptor location on the façade of the building, where sensitive receptors may potentially be affected.

Four (4) exceedances of the 24-hour average PM_{10} criterion are predicted per year for the worst-affected boundary discrete receptors modelled. As illustrated in **Figure 24**, the highest 24-hour average PM_{10} concentrations are predicted to occur within close proximity of Botany Road.

Table 23 Predicted PM_{10} Concentrations

Elevation	Location	Maximum Incremental Concentrations (µg/m³)		Maximum Cumulative Concentrations (µg/m³)	
		24-Hour Average	Annual Average	24-Hour Average	Annual Average
Ground Level	Maximum at Boundary [1]	14.9	8.5	54.3	26.7
	Maximum at Building Facade [2]	4.3	1.9	49.2	20.2
12 m Elevation	Maximum at Boundary [1]	8.8	4.9	49.8	23.1
	Maximum at Building Facade [2]	3.8	1.9	48.3	20.2
15 m Elevation	Maximum at Boundary [1]	8.4	4.4	49.4	22.6
	Maximum at Building Facade [2]	3.7	1.7	48.0	19.9
			CRITERIA	**50**	**25**

Note: Red text indicates exceedance of relevant ambient air quality criteria

[1] Maximum concentration were predicted at western boundary of the Metro Quarter

[2] Maximum concentrations were predicted on the western frontage of the buildings

Figure 24 Maximum Predicted Cumulative 24-Hour Average PM_{10} Concentrations – 1 metre Elevation

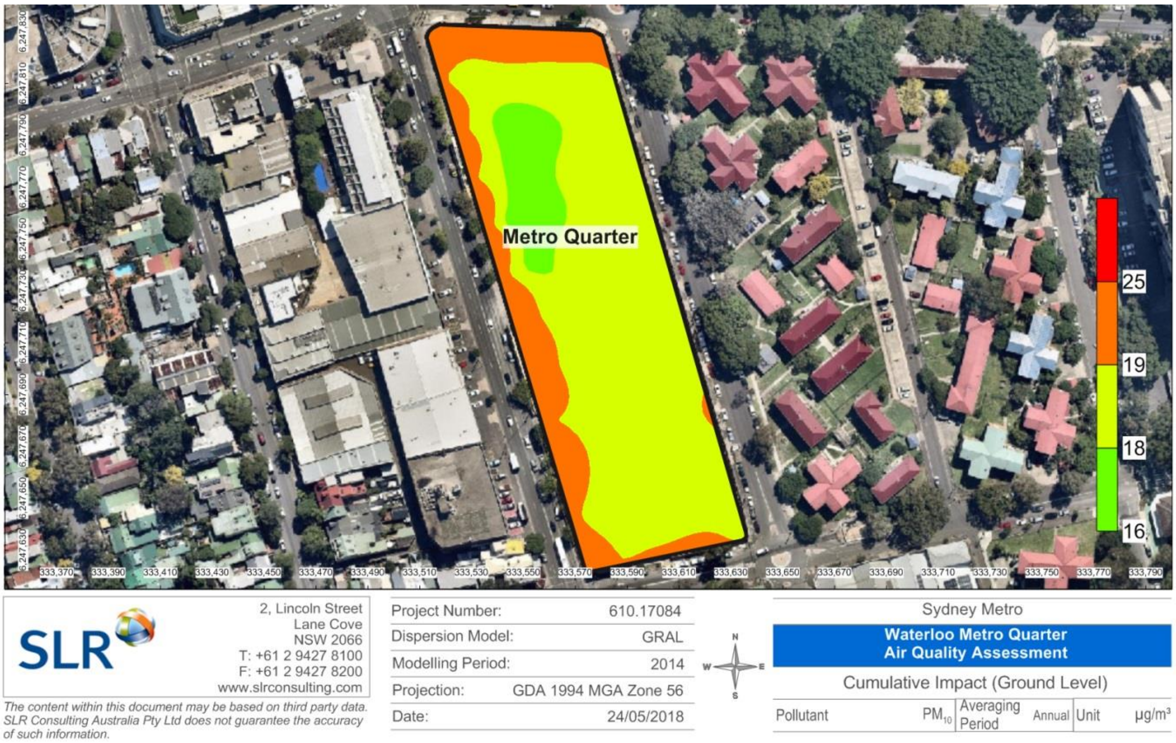

Figure 25 Predicted Cumulative Annual Average PM_{10} Concentrations – 1 metre Elevation

6.3.3 NO_2

The maximum incremental and cumulative 1-hour and annual average NO_2 concentrations predicted at ground level, 12 metres elevation and 15 metres elevation within the Metro Quarter are presented in **Table 24**. These NO_2 concentrations were derived from the ground level NO_x concentrations predicted by the modelling using the Ozone Limiting Method and contemporaneous hourly-varying 1-hour average ozone concentration data from the Randwick AQMS, as described in **Section 6.1.2.5**. **Figure 26** and **Figure 27** illustrate the cumulative maximum 1-hour average and annual average NO_2 concentrations predicted across the Metro Quarter, and plots of the predicted incremental concentrations are included in **Appendix D**.

The modelling results presented in **Table 24** show that no exceedances of the 1-hour or annual NO_2 criteria are predicted.

Table 24 Predicted NO_2 Concentrations

Elevation	Location	Maximum Incremental Concentrations (µg/m³)		Maximum Cumulative Concentrations (µg/m³)	
		1-Hour Average	Annual Average	1-Hour Average	Annual Average
Ground Level	Maximum at Boundary [1]	150	48	154	60
	Maximum at Building Facade[2]	103	22	116	34
12 m Elevation	Maximum at Boundary[1]	142	39	149	51
	Maximum at Building Facade[2]	110	21	120	33
15 m Elevation	Maximum at Boundary[1]	142	37	148	49
	Maximum at Building Facade[2]	109	19	120	30
			CRITERIA	**246**	**62**

[1] Maximum concentration are predicted at western boundary of the Metro Quarter

[2] Maximum concentrations are predicted on the western frontage of the buildings

Figure 26 Maximum Predicted Cumulative 1-Hour Average NO_2 Concentrations – 1 metre Elevation

Figure 27 Predicted Cumulative Annual Average NO_2 Concentrations – 1 metre Elevation

6.4 Impacts from other sources

This section presents a high level assessment of the potential risks of adverse air quality impacts at sensitive receptors within the Metro Quarter due to existing small scale activities in the surrounding area with a potential to impact upon local air quality. The impact assessment uses the methodology summarised in **Section 6.1.3** of this report, which integrates the receptor sensitivity with impact magnitude to derive the potential significance of that impact. Details of the qualitative risk assessment methodology used are provided in **Appendix C**.

6.4.1 Odour emissions from food outlets

As discussed in **Section 3.2.4** odour emissions are the main air emissions from food and beverage outlets. As odour discharged from restaurant outlets has the potential to give rise to nuisance impacts if emitted in significant enough quantities, the nature of the impact is therefore defined as '**adverse**'.

The nearest food outlets to the Metro Quarter are located less than 50 metres from the closest boundary. With regards to the methodology outlined in **Appendix C**, the sensitivity of the residential areas within the Metro Quarter to air pollutant emissions generated by these activities has been classified as ***high***.

Two site visits were conducted by SLR in April and May 2018 in order to better understand the extent of potential odour impacts from the identified restaurants. These site visits were conducted by staff trained in performing ambient odour surveys and whose odour sensitivity has recently (in the last 12 months) been confirmed by a NATA-certified odour laboratory as falling within the acceptable range for odour assessors (in compliance with *AS/NZS 4323.3:2001 Stationary source emissions Part 3: Determination of odour concentration by dynamic olfactometry*). During the site visits, distinct cooking odours could only be detected from the McDonalds restaurant which is located approximately 350 metres to the south of the Metro Quarter. Odours from this restaurant were only detectable approximately 100 metres downwind. Odours from other local restaurants were generally weak in intensity and only detectable in close proximity to the source (typically 1-5 metres).

Given the above, the magnitude of odour impacts from the restaurants operating in the vicinity of the Metro Quarter on the proposed residential areas is concluded to be of '**negligible'** magnitude (i.e. impact is predicted to cause no significant consequences, **Table C2** of **Appendix C**).

Based on the nearest receptors having a '**high**' sensitivity to air quality impacts and the magnitude of the potential impacts from the restaurants being classified as '**negligible'**, the impact significance is concluded to be **'neutral'** (see **Table 25**).

Table 25 Risk Assessment of Odour Impacts – Food Outlets

Sensitivity		Impact Magnitude [Defined by Table C2]			
		Substantial Magnitude	Moderate Magnitude	Slight Magnitude	Negligible Magnitude
[Defined by Table C1]	Very High Sensitivity	Major Significance	Major/ Intermediate Significance	Intermediate Significance	Neutral Significance
	High Sensitivity	Major/ Intermediate Significance	Intermediate Significance	Intermediate/Minor Significance	Neutral Significance
	Medium Sensitivity	Intermediate Significance	Intermediate/Minor Significance	Minor Significance	Neutral Significance
	Low Sensitivity	Intermediate/Minor Significance	Minor Significance	Minor/Neutral Significance	Neutral Significance

6.4.2 VOC emissions from service stations and automotive workshops

As discussed in **Section 3.2.4**, air quality issues associated with service stations and automotive workshops predominantly relate to emissions of volatile organic compounds (VOCs). Emissions of VOCs can give rise to both adverse health impacts due to exposure to specific hydrocarbon compounds, as well as adverse impacts on local amenity levels due to the odorous nature of some petrol and solvent vapour compounds. The nature of the impact is therefore defined as '**adverse**'.

With regards to the methodology outlined in **Appendix C**, the sensitivity of the residential areas within the Metro Quarter to air pollutant emissions generated by these activities has been classified as ***high***.

In order to determine the impact magnitude, reference has been made to Western Australia Environment Protection Authority (WA EPA) policy documentation for minimum recommended separation distances - *Separation distances between Industrial and Sensitive Land Uses* (WA EPA, 2005). In this document, the WA EPA makes recommendations for assessing appropriate separation distances where amenity may be reduced for sensitive or incompatible land uses. A summary of the separation distances which may be applicable to the service stations and automotive workshops located in the vicinity of the Metro Quarter are provided in **Table 26**. These values have been provided for guidance only and are not regulatory guideline values for NSW. The document does not include any specific separation distance between automotive workshops and sensitive land uses. The application of the service station separation distance to automotive workshops is considered to be conservative.

Table 26 Recommended Separation Distances for Industrial Residual Air Emissions

Industry Type	Description	Impacts	Recommended Separation Distance (metres)
Service stations, involving vehicle cleaning/detailing facilities & the retailing of spare parts & foodstuffs	For premises operating during normal hours, i.e. Monday - Saturday from 0700-1900 hours	Gaseous Noise Odour Risk	50
	Freeway service centre (24 hour operations)		100
	All other 24 hour operations		200

The nearest service station to the Metro Quarter is located over 300 metres from the closest boundary. The closest automotive workshop is located approximately 60 metres from the closest boundary. It is noted that while the service stations operate 24/7, the nearest automotive workshop operates only Monday to Saturday from 07:00 am to 05:00 pm.

Given the above considerations, the magnitude of impact from service stations and automotive repair shops is predicted to be '**negligible'** (i.e. impact is predicted to cause no significant consequences, **Table C2** of **Appendix C**).

Based on the nearest receptors having a '**high**' sensitivity to air quality impacts and the magnitude of the potential impacts from the service stations being classified as '**negligible'**, the impact significance is concluded to be **'neutral'** (see **Table 27**).

Table 27 Risk Assessment of VOC Impacts – Service Stations and Automotive Workshops

Sensitivity		Impact Magnitude [Defined by Table C2]			
		Substantial Magnitude	Moderate Magnitude	Slight Magnitude	Negligible Magnitude
[Defined by Table C1]	**Very High Sensitivity**	Major Significance	Major/ Intermediate Significance	Intermediate Significance	Neutral Significance
	High Sensitivity	Major/ Intermediate Significance	Intermediate Significance	Intermediate/Minor Significance	Neutral Significance
	Medium Sensitivity	Intermediate Significance	Intermediate/Minor Significance	Minor Significance	Neutral Significance
	Low Sensitivity	Intermediate/Minor Significance	Minor Significance	Minor/Neutral Significance	Neutral Significance

6.4.3 Emissions from traffic generated by the redevelopment of Waterloo SSP

The predicted increase in peak hour traffic volumes due to the proposed development of the Metro Quarter (based on modelled two-way traffic volumes provided by Jacobs) is presented in **Table 28.** The increase in traffic volumes on roads immediately surrounding the Metro Quarter ranges from 3 percent to 29 percent.

While Botany Road, which has been identified as the main source of traffic emissions (see **Section 3.2.1**), is expected to experience a 3 percent increase in peak hour traffic volumes, other roads immediately surrounding the Metro Quarter are expected to experience higher increases in peak hour traffic volumes. However, given the relatively low traffic volumes on these roads compared to busier roads in the area (e.g. Botany Road and McEvoy Street), emissions from these additional vehicles will only result in a minor increase in overall emissions. Therefore, if recommended mitigation measures outlined in **Section 7.0** are adopted by the final design for the Metro Quarter OSD, additional impacts on local air quality due to increases in road traffic emissions are considered unlikely.

Table 28 Increase in Peak Traffic Volumes due to Metro Quarter OSD

Corridor Name	Current Peak Volume (vehicles/hour)	Increase due to Metro Quarter	
		(vehicles/hour)	(percent)
Cope Street - Wellington Street to Raglan Street	205	20	10%
Wellington Street - Cope Street to Botany Road	392	115	29%
Botany Road - Wellington Street to Raglan Street	1,841	60	3%
Raglan Street - Botany Road to Cope Street	610	110	18%

7.0 Recommended Mitigation Measures

7.1 Construction phase emissions

Potentially relevant mitigation measures designated as highly recommended (H) or desirable (D) by the IAQM methodology for a development shown to have a high risk of adverse impacts are listed in **Section 6.2.2.5**.

As noted in **Section 6.2.2.5,** at this stage, these measures have been provided as guidance only as details of the construction methodology are yet to be confirmed. A detailed review of these measures will be performed as part of the development of the detailed construction methodology to assess the practicality and relevance of these measures. This will be addressed as part of the detailed SSD Application.

7.2 Traffic emissions

The indicative concept design of the Metro Quarter incorporates a number of mitigation measures to reduce the potential impact from traffic emissions on sensitive receptors. The key measures are discussed below.

Location of sensitive receptors

Air pollutant concentrations from road traffic (the main source of emissions identified in the study area) tend to decrease with increasing distance from the road. Considering the significant (75 percent) drop in pollutant concentrations 20 metres away from the road, no sensitive receptors are proposed to be located within a 20 metre radius of Botany Road and at elevations below 12 metres. Lower floors would be used for commercial use while residential would be located on higher floors.

In addition to the above, living areas and bedrooms have been oriented as far as practicable from Botany Road. This further reduces the potential for impact at sensitive receptor locations.

Minimising the formation of urban canyons

The proposed built form has been designed in a way that avoids the creation of street canyons. This has been achieved by having buildings of different heights interspersed with open areas, and setting back the upper stories of multi-level buildings.

Use of vegetative screens

In order to assist in maintaining local ambient air amenity, the proposed concept design incorporates vegetation barriers. Vegetation barriers can play a significant role in mitigating urban air pollution and have many positive health benefits. Vegetation barriers force polluted air to either flow over or to pass through the vegetation; this is dependent upon porosity and physical dimensions. Low density vegetation results in the majority of air flowing through the barrier, whereas high density leads to little or no infiltration.

7.3 Metro station emissions

According to the EIS prepared to support the CSSI Approval (TfNSW, 2016) only minor pollutant emissions from the metro station's ventilation system are likely. However, it is understood that during emergency conditions such as fire incidents, smoke-laden air would be discharged through the fresh air ventilation system. It is therefore recommended that sensitive receptors within the Metro Quarter are located away from the Waterloo Station fresh air ventilation outlet. As an integrated station development, the detailed design for the Metro Quarter OSD would have regard to the detailed design for the station to address these matters.

7.4 Other emissions

As outlined in **Section 3.2**, emissions from future activities within the Metro Quarter (e.g. food outlets) may lead to potential amenity/nuisance impacts. In order to reduce impacts from such activities, suitable air extraction systems should be designed for all polluting activities to ensure air is extracted in compliance with AS 1668.2-2012 and BCA guidelines. If necessary, additional control measured can be adopted. Commonly used emission control options that may be applicable to the types of air emissions that could occur at the Metro Quarter include:

- Emission Height - Increasing the discharge height would improve dispersion by:
    - Allowing more dilution of the emissions by simply increasing the physical separation distance between the discharge point and the sensitive receptor (if at ground level); and
    - Reducing building wake effects. The wind flow at the point of discharge is affected by the interference that physical structures have on wind flow patterns. Buildings may cause a number of effects on air flow such that the air flow (i.e. wind) is increasingly turbulent as it passes over the building, and may lead to poor dispersion conditions through the effect of downwash. In simple terms, if the emission point is located within the turbulent flow zone, dispersion may be significantly hampered and rather than dispersing the pollutant may be washed down preferentially towards the roof.
- Gas Momentum - A significant influencing factor on plume dispersion is gas momentum, or the velocity of the gas being discharged. The lower the discharge

velocity, the less effect initial gas momentum has on the rise of the plume before dispersion via dilution effects. Dispersion of exhausts may be significantly enhanced through physical changes to the discharge dimensions or through the fitting of devices to increase the discharge velocity (e.g. dilution fans). Horizontal discharge vents or raincaps that block the upward flow of the gases should be avoided.

- Treatment
  - Cyclonic Filters - use the cyclone separation principle in order to remove large grease particles.
  - Electrostatic Precipitators (ESP) - are used to separate solid or liquid particles from ventilation air. The particles distributed in the gas are electrostatically charged so that they can be collected onto collection plates.
  - Cold Water Spray / Water Mist Systems – work by removing particulates and condensable materials by means of cold water sprays that run continuously. The cold water spray/mist causes the grease particles in the extracted air to drop in temperature, solidify and drop out of the air stream via a drain.
  - Ultraviolet (UV) Control Systems – work by breaking down organic particles can be effective in neutralising odorous organic compounds. Due consideration needs to be given to the residual ozone that may arise from these systems.
  - Activated Carbon Adsorption - work by adsorbing odorous materials and other gaseous emissions such as VOCs into the pores of the carbon. The filters need to be replaced at appropriate intervals before they become saturated and their control efficiency begins to be compromised.
  - Wet Scrubbing - involves a mass transfer between a soluble gas and a liquid in a gas-liquid tower. This process relies on the preferential solubility of the pollutants present in the exhaust stream. Due consideration needs to be given to disposal requirements for the additional wastewater stream that would be generated by this system.

8.0 Conclusions

SLR Consulting has prepared this AQA to support the assessment of the concept proposal for the Metro Quarter OSD. This AQA has been prepared to outline the Air Quality impacts and specifically respond to the SEARs issued for the concept SSD Application on 29th June 2018 which states that the EIS is to "*Provide an air quality assessment report for the proposal. The assessment shall address the relevant policy guidelines."* This has been addressed by assessing the incremental and cumulative potential air quality impacts from and on the Metro Quarter. This AQA has been prepared in general accordance with The Approved Methods (NSW Environmental Protection Authority (EPA), 2017) with reference to the Infrastructure SEPP and the NSW Department of Planning document "*Development near Rail Corridors and Busy Roads – Interim Guideline*" (DoP, 2008) (the Guideline).

The potential for off-site dust impacts during the construction phase was assessed using a qualitative risk-based approach prescribed by the Institute of Air Quality Management (IAQM). The results of this assessment indicate that dust impacts due to the construction works can be adequately managed with the implementation of site-specific mitigation measures, and that the residual impacts on human health are likely to be low for construction and earthworks activities and negligible for trackout activities. The residual dust soiling impacts are likely to be medium for construction and earthworks activities and low for trackout activities.

Post construction, the primary source of air emissions in the area immediately surrounding the Metro Quarter was identified as vehicles travelling along Botany Road. Other emission sources in the local area that could potentially impact on air quality within the proposed Metro Quarter OSD were identified as service stations, automotive workshops and food outlets. The potential for off-site air quality impacts due to these activities was assessed using a qualitative risk-based approach. Based on this qualitative risk-based assessment, taking into account the nature and scale of these activities and distance from the Metro Quarter, it was concluded that they do not have any significant potential to adversely impact on air quality within the Metro Quarter. No further assessment of these activities is therefore considered to be warranted.

In addition to the above, emission sources within the proposed Metro Quarter (e.g. food outlets) could potentially lead to amenity/nuisance impacts at surrounding sensitive receptors or at residential locations within the Metro Quarter itself. The risk of any impacts would depend on the type and scale of the activities, the location of the activity relative to sensitive receptors, and any emissions controls incorporated into the design (e.g. filtration/control of emissions etc). It is therefore recommended that further assessment of any potentially air polluting activities proposed within the Metro Quarter be carried out during the detailed design stage so that appropriate mitigation measures are adopted to reduce the risk of any exceedances of the relevant air quality criteria.

Mitigation measures consistent with Section 4.4 of the Guideline have been incorporated into the concept design of the Metro Quarter. These include:

- Locating no sensitive receptors within a 20 metres radius of Botany Road.
- Minimising the formation of urban canyons by having buildings of different heights interspersed with open areas, and setting back the upper stories of multi-level buildings.
- Orienting living areas and bedrooms as far as practicable from Botany Road.
- Using vegetative screens, to assist in maintaining local ambient air amenity.

In order to gain a better understanding of the potential worst case air pollutant concentrations within the Metro Quarter due to emissions from local traffic, detailed meteorological and air quality dispersion modelling of emissions from vehicles travelling on the surrounding road network was carried out. Emissions of NO_2 and particulate matter (as PM_{10} and $PM_{2.5}$) were estimated using the COPERT Australia software package. The calculated emissions from the surrounding road network were then modelled using the GRAMM/GRAL modelling system.

The results of the cumulative impact assessment indicated that existing traffic on the surrounding road network has potential to result in slight exceedances of the ambient air quality criteria for PM_{10} and $PM_{2.5}$ at locations within the Metro Quarter, particularly close to Botany Road on days of high regional levels of particulates. However, no exceedance of the ambient air quality criteria are predicted for sensitive receptor locations within the Metro Quarter (i.e. residences), with the exception of annual $PM_{2.5}$ due to high background concentrations.

As noted above, a range of mitigation measures have been incorporated into the concept design in order to reduce the potential for exposure to pollutants emitted from the identified sources. While it is not possible to fully quantify the effects of all proposed mitigation measures, the modelling shows significant reductions in exposure levels achieved by measures such as receptor setback (refer to **Section 6.3**). On this basis, it is considered that the concept design incorporates adequate mitigation measures to minimise the potential for exposure to pollutant concentrations significantly higher than background.

9.0 References

DEWHA . (2008). *National Pollutant Inventory Emission Estimation Technique Manual for Combustion Engines.* Department of Environment, Water, Heritage and Arts.

DoP. (2008). *Development Near Rail Corridors and Busy Roads – Interim Guideline.* NSW Department of Planning.

DSITIA. (2014). Email communication with Dr Robin Smith, Science Leader, Inventory and Air Assessment. Queensland Department of Science, Information Technology and the Arts.

Environment Australia. (2012). *National Pollutant Inventory, Emission Estimation Technique Manual for Fuel and Organic Liquid Storage.*

National Environment Protection Council. (2003). *Variation to the National Environment Protection (Ambient Air Quality) Measure.* Canberra: National Environment Protection Council.

National Environment Protection Council. (2016). *National Environment Protection (Ambient Air Quality) Measure.* Canberra: Department of the Environment.

NOAA. (2018, February 14). *Air Resources Laboratory*. Retrieved February 20, 2018, from National Oceannic and Atmospheric Association: https://www.ready.noaa.gov/READYpgclass.php

NSW DEC. (2006a). *Technical Framework - Assessment and management of odour from stationary sources in NSW.* Sydney: NSW Department of Environment and Conservation.

NSW DEC. (2006b). *Technical Notes: Assessment and management of odour from stationary sources in NSW.* Sydney: NSW Department of Environment and Conservation.

NSW Environmental Protection Authority (EPA). (2017, January). Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. Prepared by NSW Environment Protection Authority, which is part of the NSW Office of Environment and Heritage (OEH).

NSW EPA. (2007). *Local Government Air Quality Toolkit - Food Outlets.*

NSW EPA. (2008). *Environmental Action for Automotive Servicing and Repairs.*

NSW EPA. (2014). *Trends in Motor Vehicles and their Emissions.* Environment Protection Authority.

NSW OEH. (2014). *NSW Annual Compliance Report 2013.*

NSW OEH. (2017). *NSW Annual Compliance Report 2015.*

NSW OEH. (2017b). *Air quality statement 2017.*

Oke, T. R. (2002). *Boundary Layer Climates.* Routledge.

Pacific Environment. (2015). *WestConnex M4 East Air Quality Assessment Report.*

Pasquill. (1961). The estimation of the dispersion of windborne material. *The Meteorological Magazine, 90*(1063), 33-49.

TfNSW. (2016). *Sydney Metro Chatswood to Sydenham Environmental Impact Statement .*

Uniquest. (2014, August 02). Australian Motor Vehicle Emission Inventory for the National Pollutant inventory (NPI). Uniquest, Prepared for Department of Environment.

WA EPA. (2005). *Environmental Assessment Guidelines for Separation distances between Industrial and Sensitive Land Uses.*

APPENDIX A

Construction Assessment Methodology

Step 1 – Screening Based on Separation Distance

The Step 1 screening criteria provided by the IAQM guidance suggests screening out any assessment of impacts from construction activities where sensitive receptors are located more than 350 m from the boundary of the Site, more than 50 m from the route used by construction vehicles on public roads and more than 500 m from the Site entrance. This step is noted as having deliberately been chosen to be conservative, and will require assessments for most projects.

Step 2a – Assessment of Scale and Nature of the Works

Step 2a of the assessment provides "dust emissions magnitudes" for each of four dust generating activities; demolition, earthworks, construction, and track-out (the movement of site material onto public roads by vehicles). The magnitudes are: *Large; Medium; or Small*, with suggested definitions for each category. The definitions given in the IAQM guidance for earthworks, construction activities and track-out, which are most relevant to this Development, are as follows:

Demolition *(Any activity involved with the removal of an existing structure [or structures]. This may also be referred to as de-construction, specifically when a building is to be removed a small part at a time)*:

- ***Large***: Total building volume >50,000 m^3, potentially dusty construction material (e.g. concrete), on-site crushing and screening, demolition activities >20 m above ground level;
- ***Medium***: Total building volume 20,000 m^3 – 50,000 m^3, potentially dusty construction material, demolition activities 10-20 m above ground level; and
- ***Small***: Total building volume <20,000 m^3, construction material with low potential for dust release (e.g. metal cladding or timber), demolition activities <10m above ground, demolition during wetter months.

Earthworks *(Covers the processes of soil-stripping, ground-levelling, excavation and landscaping)*:

- ***Large***: Total site area greater than 10,000 m^2, potentially dusty soil type (e.g. clay, which will be prone to suspension when dry due to small particle size), more than 10 heavy earth moving vehicles active at any one time, formation of bunds greater than 8 m in height, total material moved more than 100,000 t.

- ***Medium***: Total site area 2,500 m^2 to 10,000 m^2, moderately dusty soil type (e.g. silt), 5 to 10 heavy earth moving vehicles active at any one time, formation of bunds 4 m to 8 m in height, total material moved 20,000 t to 100,000 t.
- ***Small***: Total site area less than 2,500 m^2, soil type with large grain size (e.g. sand), less than five heavy earth moving vehicles active at any one time, formation of bunds less than 4 m in height, total material moved less than 20,000 t, earthworks during wetter months.

Construction (Any activity involved with the provision of a new structure (or structures), its modification or refurbishment. A structure will include a residential dwelling, office building, retail outlet, road, etc):

- ***Large***: Total building volume greater than 100,000 m^3, piling, on site concrete batching; sandblasting.
- ***Medium***: Total building volume 25,000 m^3 to 100,000 m^3, potentially dusty construction material (e.g. concrete), piling, on site concrete batching.
- ***Small***: Total building volume less than 25,000 m^3, construction material with low potential for dust release (e.g. metal cladding or timber).

Track-out (The transport of dust and dirt from the construction / demolition site onto the public road network, where it may be deposited and then re-suspended by vehicles using the network):

- ***Large***: More than 50 heavy vehicle movements per day, surface materials with a high potential for dust generation, greater than 100 m of unpaved road length.
- ***Medium***: Between 10 and 50 heavy vehicle movements per day, surface materials with a moderate potential for dust generation, between 50 m and 100 m of unpaved road length.
- ***Small***: Less than 10 heavy vehicle movements per day, surface materials with a low potential for dust generation, less than 50 m of unpaved road length.
- Note: No demolition of existing structures will be performed as part of this Development.

In order to provide a conservative assessment of potential impacts, it has been assumed that if at least one of the parameters specified in the 'large' definition is satisfied, the works are classified as large, and so on.

Step 2b – Risk Assessment

Assessment of the Sensitivity of the Area

- Step 2b of the assessment process requires the sensitivity of the area to be defined. The sensitivity of the area takes into account:
- The specific sensitivities that identified sensitive receptors have to dust deposition and human health impacts;
- The proximity and number of those receptors;

- In the case of PM_{10}, the local background concentration; and
- Other site-specific factors, such as whether there are natural shelters such as trees to reduce the risk of wind-blown dust.
- Individual receptors are classified as having *high*, *medium* or *low* sensitivity to dust deposition and human health impacts (ecological receptors are not addressed using this approach). The IAQM method provides guidance on the sensitivity of different receptor types to dust soiling and health effects as summarised in **Table A1**. It is noted that user expectations of amenity levels (dust soiling) is dependent on existing deposition levels.

According to the IAQM methods, the sensitivity of the identified individual receptors (as described above) is then used to assess the sensitivity of the area surrounding the active construction area, taking into account the proximity and number of those receptors, and the local background PM10 concentration (in the case of potential health impacts) and other site-specific factors. Additional factors to consider when determining the sensitivity of the area include:

- any history of dust generating activities in the area;
- the likelihood of concurrent dust generating activity on nearby sites;
- any pre-existing screening between the source and the receptors;
- any conclusions drawn from analysing local meteorological data which accurately represent the area and if relevant, the season during which the works will take place;
- any conclusions drawn from local topography;
- the duration of the potential impact (as a receptor may be willing to accept elevated dust levels for a known short duration, or may become more sensitive or less sensitive (acclimatised) over time for long-term impacts); and
- any known specific receptor sensitivities which go beyond the classifications given in the IAQM document.

The IAQM guidance for assessing the sensitivity of an area to dust soiling is shown in **Table A2**. The sensitivity of the area should be derived for each of activity relevant to the project (i.e. construction and earthworks).

Table A1 IAQM Guidance for Categorising Receptor Sensitivity

Value	High Sensitivity Receptor	Medium Sensitivity Receptor	Low Sensitivity Receptor
Dust soiling	Users can reasonably expect a high level of amenity; or The appearance, aesthetics or value of their property would be diminished by soiling, and the people or property would reasonably be expected to be present continuously, or at least regularly for extended periods as part of the normal pattern of use of the land.	Users would expect to enjoy a reasonable level of amenity, but would not reasonably expect to enjoy the same level of amenity as in their home; or The appearance, aesthetics or value of their property could be diminished by soiling; or The people or property wouldn't reasonably be expected to be present here continuously or regularly for extended periods as part of the normal pattern of use of the land.	The enjoyment of amenity would not reasonably be expected; or Property would not reasonably be expected to be diminished in appearance, aesthetics or value by soiling; or There is transient exposure, where the people or property would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land.
	Examples: Dwellings, museums, medium and long term car parks and car showrooms.	*Examples: Parks and places of work.*	*Examples: Playing fields, farmland (unless commercially-sensitive horticultural), footpaths, short term car parks and roads.*
Health effects	Locations where the public are exposed over a time period relevant to the air quality objective for PM_{10} (in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day).	Locations where the people exposed are workers, and exposure is over a time period relevant to the air quality objective for PM_{10} (in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day).	Locations where human exposure is transient.
	Examples: Residential properties, hospitals, schools and residential care homes.	*Examples: Office and shop workers, but will generally not include workers occupationally exposed to PM10.*	*Examples: Public footpaths, playing fields, parks and shopping street.*

Table A2 IAQM Guidance for Categorising the Sensitivity of an Area to Dust Soiling Effects

Receptor sensitivity	Number of receptors	Distance from the source (m)			
		<20	<50	<100	<350
High	>100	High	High	Medium	Low
	10-100	High	Medium	Low	Low
	1-10	Medium	Low	Low	Low
Medium	>1	Medium	Low	Low	Low
Low	>1	Low	Low	Low	Low

Note: Estimate the total number of receptors within the stated distance. Only the highest level of area sensitivity from the table needs to be considered. For example, if there are seven high sensitivity receptors < 20 m of the source and 95 high sensitivity receptors between 20 and 50 m, then the total of number of receptors < 50 m is 102. The sensitivity of the area in this case would be high.

A modified version of the IAQM guidance for assessing the sensitivity of an area to health impacts is shown in **Table A3**. For high sensitivity receptors, the IAQM methods takes the existing background concentrations of PM_{10} (as an annual average) experienced in the area of interest into account and is based on the air quality objectives for PM10 in the UK. As these objectives differ from the ambient air quality criteria adopted for use in this assessment (i.e. an annual average of 20 µg/m3 for PM_{10}) the IAQM method has been modified slightly.

- This approach is consistent with the IAQM guidance, which notes that in using the tables to define the sensitivity of an area, professional judgement may be used to determine alternative sensitivity categories, taking into account the following factors:
- any history of dust generating activities in the area;
- the likelihood of concurrent dust generating activity on nearby sites;
- any pre-existing screening between the source and the receptors;
- any conclusions drawn from analysing local meteorological data which accurately represent the area, and if relevant the season during which the works will take place;
- any conclusions drawn from local topography;
- duration of the potential impact; and
- any known specific receptor sensitivities which go beyond the classifications given in this document.

Table A3 IAQM Guidance for Categorising the Sensitivity of an Area to Dust Health Effects

Receptor sensitivity	Annual mean PM_{10} Concentration	Number of receptors [a,b]	Distance from the source (m)				
			<20	<50	<100	<200	<350
High	>25 µg/m^3	>100	High	High	High	Medium	Low
		10-100	High	High	Medium	Low	Low
		1-10	High	Medium	Low	Low	Low
	21-25 µg/m^3	>100	High	High	Medium	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	High	Medium	Low	Low	Low
	17-21 µg/m^3	>100	High	Medium	Low	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	<17 µg/m^3	>100	Medium	Low	Low	Low	Low
		10-100	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Medium	>25 µg/m^3	>10	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	21-25 µg/m^3	>10	Medium	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
	17-21 µg/m^3	>10	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
	<17 µg/m^3	>10	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Low	-	>1	Low	Low	Low	Low	Low

Notes:
(a) Estimate the total within the stated distance (e.g. the total within 350 m and not the number between 200 and 350 m); noting that only the highest level of area sensitivity from the table needs to be considered.
(b) In the case of high sensitivity receptors with high occupancy (such as schools or hospitals) approximate the number of people likely to be present. In the case of residential dwellings, just include the number of properties.

Risk Assessment

The dust emission magnitude from Step 2a and the receptor sensitivity from Step 2b are then used in the matrices shown in Table A5 (demolition), Table A5 (earthworks and construction) and Table A6 (track-out) to determine the risk category with no mitigation applied.

Table A4 Risk Category from Demolition Activities

Sensitivity of Area	Dust Emission Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Medium Risk
Medium	High Risk	Medium Risk	Low Risk
Low	Medium Risk	Low Risk	Negligible

Table A5 Risk Category from Earthworks and Construction Activities

Sensitivity of Area	Dust Emission Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Medium Risk	Low Risk
Low	Low Risk	Low Risk	Negligible

Table A6 Risk Category from Track-out Activities

Sensitivity of Area	Dust Emission Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Low Risk	Negligible
Low	Low Risk	Low Risk	Negligible

Step 3 - Site-Specific Mitigation

Once the risk categories are determined for each of the relevant activities, site-specific management measures can be identified based on whether the Site is a low, medium or high risk site.

Step 4 – Residual Impacts

Following Step 3, the residual impact is then determined after management measures have been considered.

APPENDIX B

COPERT Australia Input Parameters

Table B1 Long Term Average Ambient Temperature and Relative Humidity – Sydney Area

Month	Minimum Temperature (degrees Celsius)	Maximum Temperature (degrees Celsius)	Relative Humidity (percent)
January	19.8	27.1	71.3
February	20.0	27.4	73.1
March	18.7	25.7	71.5
April	16.2	23.9	71.9
May	11.5	20.9	61.6
June	9.9	19.6	58.4
July	9.1	17.6	66.8
August	10.4	19.2	63.1
September	11.9	21.1	67.9
October	14.6	22.7	67.5
November	16.3	24.9	65.9
December	17.9	25.2	71.1

Table B2 Estimated Distribution of Vehicles – Based on NSW Fleet Average

Vehicle Type	Percentage
Cars and motorcycles	82.9%
Light commercial vehicles	13.6%
Heavy vehicles	3.5%

Table B3 Distribution of Vehicles – Sectors and Subsectors

Sector	Subsector	Technology	Population (Annual)	Percentage
Passenger Cars	PC-S-petrol	ADR00-UNC	0	0.0%
Passenger Cars	PC-S-petrol	ADR27	35,732	0.7%
Passenger Cars	PC-S-petrol	ADR37-00	240,222	5.0%
Passenger Cars	PC-S-petrol	ADR37-01	242,850	5.1%
Passenger Cars	PC-S-petrol	ADR79-00	106,648	2.2%
Passenger Cars	PC-S-petrol	ADR79-01	244,203	5.1%

Sector	Subsector	Technology	Population (Annual)	Percentage
Passenger Cars	PC-S-petrol	ADR79-02	60,297	1.3%
Passenger Cars	PC-S-petrol	ADR79-03	0	0.0%
Passenger Cars	PC-S-petrol	ADR79-04	0	0.0%
Passenger Cars	PC-S-petrol	ADR79-05	0	0.0%
Passenger Cars	PC-M-petrol	ADR00-UNC	0	0.0%
Passenger Cars	PC-M-petrol	ADR27	50,017	1.0%
Passenger Cars	PC-M-petrol	ADR37-00	145,356	3.0%
Passenger Cars	PC-M-petrol	ADR37-01	97,929	2.0%
Passenger Cars	PC-M-petrol	ADR79-00	43,833	0.9%
Passenger Cars	PC-M-petrol	ADR79-01	77,585	1.6%
Passenger Cars	PC-M-petrol	ADR79-02	16,603	0.3%
Passenger Cars	PC-M-petrol	ADR79-03	0	0.0%
Passenger Cars	PC-M-petrol	ADR79-04	0	0.0%
Passenger Cars	PC-M-petrol	ADR79-05	0	0.0%
Passenger Cars	PC-L-petrol	ADR00-UNC	0	0.0%
Passenger Cars	PC-L-petrol	ADR27	56,971	1.2%
Passenger Cars	PC-L-petrol	ADR37-00	264,980	5.5%
Passenger Cars	PC-L-petrol	ADR37-01	210,427	4.4%
Passenger Cars	PC-L-petrol	ADR79-00	65,009	1.4%
Passenger Cars	PC-L-petrol	ADR79-01	73,277	1.5%
Passenger Cars	PC-L-petrol	ADR79-02	14,985	0.3%
Passenger Cars	PC-L-petrol	ADR79-03	0	0.0%
Passenger Cars	PC-L-petrol	ADR79-04	0	0.0%
Passenger Cars	PC-L-petrol	ADR79-05	0	0.0%
Passenger Cars	PC-S-diesel	ADR00-UNC	0	0.0%
Passenger Cars	PC-S-diesel	ADR30	32	0.0%
Passenger Cars	PC-S-diesel	ADR70-00	178	0.0%
Passenger Cars	PC-S-diesel	ADR79-00	3,769	0.1%
Passenger Cars	PC-S-diesel	ADR79-01	12,612	0.3%
Passenger Cars	PC-S-diesel	ADR79-02	5,803	0.1%
Passenger Cars	PC-S-diesel	ADR79-03	0	0.0%
Passenger Cars	PC-S-diesel	ADR79-04	0	0.0%
Passenger Cars	PC-S-diesel	ADR79-05	0	0.0%
Passenger Cars	PC-ML-diesel	ADR00-UNC	0	0.0%
Passenger Cars	PC-ML-diesel	ADR30	215	0.0%
Passenger Cars	PC-ML-diesel	ADR70-00	396	0.0%
Passenger Cars	PC-ML-diesel	ADR79-00	2,395	0.1%

Sector	Subsector	Technology	Population (Annual)	Percentage
Passenger Cars	PC-ML-diesel	ADR79-01	11,557	0.2%
Passenger Cars	PC-ML-diesel	ADR79-02	4,423	0.1%
Passenger Cars	PC-ML-diesel	ADR79-03	0	0.0%
Passenger Cars	PC-ML-diesel	ADR79-04	0	0.0%
Passenger Cars	PC-ML-diesel	ADR79-05	0	0.0%
Passenger Cars	PC-S-E10	ADR00-UNC	0	0.0%
Passenger Cars	PC-S-E10	ADR27	0	0.0%
Passenger Cars	PC-S-E10	ADR37-00	78,212	1.6%
Passenger Cars	PC-S-E10	ADR37-01	106,426	2.2%
Passenger Cars	PC-S-E10	ADR79-00	66,758	1.4%
Passenger Cars	PC-S-E10	ADR79-01	166,391	3.5%
Passenger Cars	PC-S-E10	ADR79-02	41,084	0.9%
Passenger Cars	PC-S-E10	ADR79-03	0	0.0%
Passenger Cars	PC-S-E10	ADR79-04	0	0.0%
Passenger Cars	PC-S-E10	ADR79-05	0	0.0%
Passenger Cars	PC-M-E10	ADR00-UNC	0	0.0%
Passenger Cars	PC-M-E10	ADR27	0	0.0%
Passenger Cars	PC-M-E10	ADR37-00	43,101	0.9%
Passenger Cars	PC-M-E10	ADR37-01	43,046	0.9%
Passenger Cars	PC-M-E10	ADR79-00	27,438	0.6%
Passenger Cars	PC-M-E10	ADR79-01	52,864	1.1%
Passenger Cars	PC-M-E10	ADR79-02	11,313	0.2%
Passenger Cars	PC-M-E10	ADR79-03	0	0.0%
Passenger Cars	PC-M-E10	ADR79-04	0	0.0%
Passenger Cars	PC-M-E10	ADR79-05	0	0.0%
Passenger Cars	PC-L-E10	ADR00-UNC	0	0.0%
Passenger Cars	PC-L-E10	ADR27	0	0.0%
Passenger Cars	PC-L-E10	ADR37-00	84,509	1.8%
Passenger Cars	PC-L-E10	ADR37-01	92,093	1.9%
Passenger Cars	PC-L-E10	ADR79-00	40,693	0.9%
Passenger Cars	PC-L-E10	ADR79-01	49,928	1.0%
Passenger Cars	PC-L-E10	ADR79-02	10,211	0.2%
Passenger Cars	PC-L-E10	ADR79-03	0	0.0%
Passenger Cars	PC-L-E10	ADR79-04	0	0.0%
Passenger Cars	PC-L-E10	ADR79-05	0	0.0%
Passenger Cars	PC-LPG	ADR00-UNC	0	0.0%
Passenger Cars	PC-LPG	ADR27	7,152	0.1%

Sector	Subsector	Technology	Population (Annual)	Percentage
Passenger Cars	PC-LPG	ADR37-00	13,465	0.3%
Passenger Cars	PC-LPG	ADR37-01	25,951	0.5%
Passenger Cars	PC-LPG	ADR79-00	17,528	0.4%
Passenger Cars	PC-LPG	ADR79-01	86,947	1.8%
Passenger Cars	PC-LPG	ADR79-02	8,935	0.2%
Passenger Cars	PC-LPG	ADR79-03	0	0.0%
Passenger Cars	PC-LPG	ADR79-04	0	0.0%
Passenger Cars	PC-LPG	ADR79-05	0	0.0%
SUV	SUV-C-petrol	ADR00-UNC	1,529	0.0%
SUV	SUV-C-petrol	ADR37-00	22,064	0.5%
SUV	SUV-C-petrol	ADR37-01	48,013	1.0%
SUV	SUV-C-petrol	ADR79-00	26,171	0.5%
SUV	SUV-C-petrol	ADR79-01	47,376	1.0%
SUV	SUV-C-petrol	ADR79-02	17,394	0.4%
SUV	SUV-C-petrol	ADR79-03	0	0.0%
SUV	SUV-C-petrol	ADR79-04	0	0.0%
SUV	SUV-C-petrol	ADR79-05	0	0.0%
SUV	SUV-L-petrol	ADR00-UNC	1,561	0.0%
SUV	SUV-L-petrol	ADR36	41,700	0.9%
SUV	SUV-L-petrol	ADR37-00	14,309	0.3%
SUV	SUV-L-petrol	ADR37-01	27,391	0.6%
SUV	SUV-L-petrol	ADR79-00	26,603	0.6%
SUV	SUV-L-petrol	ADR79-01	38,774	0.8%
SUV	SUV-L-petrol	ADR79-02	9,264	0.2%
SUV	SUV-L-petrol	ADR79-03	0	0.0%
SUV	SUV-L-petrol	ADR79-04	0	0.0%
SUV	SUV-L-petrol	ADR79-05	0	0.0%
SUV	SUV-diesel	ADR00-UNC	2,205	0.0%
SUV	SUV-diesel	ADR30	9,727	0.2%
SUV	SUV-diesel	ADR70-00	26,202	0.5%
SUV	SUV-diesel	ADR79-00	31,054	0.6%
SUV	SUV-diesel	ADR79-01	36,982	0.8%
SUV	SUV-diesel	ADR79-02	17,519	0.4%
SUV	SUV-diesel	ADR79-03	0	0.0%
SUV	SUV-diesel	ADR79-04	0	0.0%
SUV	SUV-diesel	ADR79-05	0	0.0%
SUV	SUV-C-E10	ADR00-UNC	0	0.0%

Sector	Subsector	Technology	Population (Annual)	Percentage
SUV	SUV-C-E10	ADR37-00	7,458	0.2%
SUV	SUV-C-E10	ADR37-01	21,355	0.4%
SUV	SUV-C-E10	ADR79-00	16,383	0.3%
SUV	SUV-C-E10	ADR79-01	32,280	0.7%
SUV	SUV-C-E10	ADR79-02	11,851	0.2%
SUV	SUV-C-E10	ADR79-03	0	0.0%
SUV	SUV-C-E10	ADR79-04	0	0.0%
SUV	SUV-C-E10	ADR79-05	0	0.0%
SUV	SUV-L-E10	ADR00-UNC	0	0.0%
SUV	SUV-L-E10	ADR36	16,919	0.4%
SUV	SUV-L-E10	ADR37-00	4,926	0.1%
SUV	SUV-L-E10	ADR37-01	11,993	0.3%
SUV	SUV-L-E10	ADR79-00	16,652	0.3%
SUV	SUV-L-E10	ADR79-01	26,419	0.6%
SUV	SUV-L-E10	ADR79-02	6,312	0.1%
SUV	SUV-L-E10	ADR79-03	0	0.0%
SUV	SUV-L-E10	ADR79-04	0	0.0%
SUV	SUV-L-E10	ADR79-05	0	0.0%
Light Commercial Vehicles	LCV-petrol	ADR00-UNC	29,241	0.6%
Light Commercial Vehicles	LCV-petrol	ADR36	123,715	2.6%
Light Commercial Vehicles	LCV-petrol	ADR37-00	43,792	0.9%
Light Commercial Vehicles	LCV-petrol	ADR37-01	38,684	0.8%
Light Commercial Vehicles	LCV-petrol	ADR79-00	47,219	1.0%
Light Commercial Vehicles	LCV-petrol	ADR79-01	44,034	0.9%
Light Commercial Vehicles	LCV-petrol	ADR79-02	9,447	0.2%
Light Commercial Vehicles	LCV-petrol	ADR79-03	0	0.0%
Light Commercial Vehicles	LCV-petrol	ADR79-04	0	0.0%
Light Commercial Vehicles	LCV-petrol	ADR79-05	0	0.0%
Light Commercial Vehicles	LCV-diesel	ADR00-UNC	28,825	0.6%

Sector	Subsector	Technology	Population (Annual)	Percentage
Light Commercial Vehicles	LCV-diesel	ADR30	36,092	0.8%
Light Commercial Vehicles	LCV-diesel	ADR70-00	60,452	1.3%
Light Commercial Vehicles	LCV-diesel	ADR79-00	68,553	1.4%
Light Commercial Vehicles	LCV-diesel	ADR79-01	88,557	1.9%
Light Commercial Vehicles	LCV-diesel	ADR79-02	32,648	0.7%
Light Commercial Vehicles	LCV-diesel	ADR79-03	0	0.0%
Light Commercial Vehicles	LCV-diesel	ADR79-04	0	0.0%
Light Commercial Vehicles	LCV-diesel	ADR79-05	0	0.0%
Heavy Duty Trucks	MCV-petrol	ADR00-UNC	10,603	0.2%
Heavy Duty Trucks	MCV-diesel	ADR00-UNC	20,660	0.4%
Heavy Duty Trucks	MCV-diesel	ADR30	11,700	0.2%
Heavy Duty Trucks	MCV-diesel	ADR70-00	20,969	0.4%
Heavy Duty Trucks	MCV-diesel	ADR80-00	23,569	0.5%
Heavy Duty Trucks	MCV-diesel	ADR80-02	12,869	0.3%
Heavy Duty Trucks	MCV-diesel	ADR80-03	0	0.0%
Heavy Duty Trucks	MCV-diesel	ADR80-04	0	0.0%
Heavy Duty Trucks	MCV-diesel	ADR80-05	0	0.0%
Heavy Duty Trucks	HCV-diesel	ADR00-UNC	8,264	0.2%
Heavy Duty Trucks	HCV-diesel	ADR30	3,948	0.1%
Heavy Duty Trucks	HCV-diesel	ADR70-00	6,540	0.1%
Heavy Duty Trucks	HCV-diesel	ADR80-00	7,411	0.2%
Heavy Duty Trucks	HCV-diesel	ADR80-02	3,420	0.1%
Heavy Duty Trucks	HCV-diesel	ADR80-03	0	0.0%
Heavy Duty Trucks	HCV-diesel	ADR80-04	0	0.0%
Heavy Duty Trucks	HCV-diesel	ADR80-05	0	0.0%
Heavy Duty Trucks	AT-diesel	ADR00-UNC	3,142	0.1%
Heavy Duty Trucks	AT-diesel	ADR30	1,918	0.0%
Heavy Duty Trucks	AT-diesel	ADR70-00	4,115	0.1%
Heavy Duty Trucks	AT-diesel	ADR80-00	6,450	0.1%
Heavy Duty Trucks	AT-diesel	ADR80-02	2,803	0.1%
Heavy Duty Trucks	AT-diesel	ADR80-03	0	0.0%

Sector	Subsector	Technology	Population (Annual)	Percentage
Heavy Duty Trucks	AT-diesel	ADR80-04	0	0.0%
Heavy Duty Trucks	AT-diesel	ADR80-05	0	0.0%
Heavy Duty Trucks	Autogas Trucks	ADR30	643	0.0%
Heavy Duty Trucks	Autogas Trucks	ADR70-00	455	0.0%
Heavy Duty Trucks	Autogas Trucks	ADR80-00	461	0.0%
Heavy Duty Trucks	Autogas Trucks	ADR80-02	282	0.0%
Heavy Duty Trucks	Autogas Trucks	ADR80-03	0	0.0%
Heavy Duty Trucks	Autogas Trucks	ADR80-04	0	0.0%
Heavy Duty Trucks	Autogas Trucks	ADR80-05	0	0.0%
Buses	BUS-L-diesel	ADR00-UNC	1,961	0.0%
Buses	BUS-L-diesel	ADR30	2,065	0.0%
Buses	BUS-L-diesel	ADR70-00	3,352	0.1%
Buses	BUS-L-diesel	ADR80-00	2,582	0.1%
Buses	BUS-L-diesel	ADR80-02	2,126	0.0%
Buses	BUS-L-diesel	ADR80-03	0	0.0%
Buses	BUS-L-diesel	ADR80-04	0	0.0%
Buses	BUS-L-diesel	ADR80-05	0	0.0%
Buses	BUS-H-diesel	ADR00-UNC	527	0.0%
Buses	BUS-H-diesel	ADR30	708	0.0%
Buses	BUS-H-diesel	ADR70-00	1,095	0.0%
Buses	BUS-H-diesel	ADR80-00	852	0.0%
Buses	BUS-H-diesel	ADR80-02	746	0.0%
Buses	BUS-H-diesel	ADR80-03	0	0.0%
Buses	BUS-H-diesel	ADR80-04	0	0.0%
Buses	BUS-H-diesel	ADR80-05	0	0.0%
Mopeds	2-stroke <50 cm^3	Conventional	0	0.0%
Mopeds	2-stroke <50 cm^3	Mop - Euro I	0	0.0%
Mopeds	2-stroke <50 cm^3	Mop - Euro II	0	0.0%
Mopeds	2-stroke <50 cm^3	Mop - Euro III	0	0.0%
Mopeds	4-stroke <50 cm^3	Conventional	0	0.0%
Mopeds	4-stroke <50 cm^3	Mop - Euro I	0	0.0%
Mopeds	4-stroke <50 cm^3	Mop - Euro II	0	0.0%
Mopeds	4-stroke <50 cm^3	Mop - Euro III	0	0.0%
Motorcycles	2-stroke >50 cm^3	Conventional	0	0.0%
Motorcycles	2-stroke >50 cm^3	Mot - Euro I	0	0.0%
Motorcycles	2-stroke >50 cm^3	Mot - Euro II	0	0.0%
Motorcycles	2-stroke >50 cm^3	Mot - Euro III	0	0.0%

Sector	Subsector	Technology	Population (Annual)	Percentage
Motorcycles	4-stroke <250 cm^3	Conventional	0	0.0%
Motorcycles	4-stroke <250 cm^3	Mot - Euro I	0	0.0%
Motorcycles	4-stroke <250 cm^3	Mot - Euro II	0	0.0%
Motorcycles	4-stroke <250 cm^3	Mot - Euro III	0	0.0%
Motorcycles	4-stroke 250 - 750 cm^3	Conventional	180,979	3.8%
Motorcycles	4-stroke 250 - 750 cm^3	Mot - Euro I	0	0.0%
Motorcycles	4-stroke 250 - 750 cm^3	Mot - Euro II	0	0.0%
Motorcycles	4-stroke 250 - 750 cm^3	Mot - Euro III	0	0.0%
Motorcycles	4-stroke >750 cm^3	Conventional	0	0.0%
Motorcycles	4-stroke >750 cm^3	Mot - Euro I	0	0.0%
Motorcycles	4-stroke >750 cm^3	Mot - Euro II	0	0.0%
Motorcycles	4-stroke >750 cm^3	Mot - Euro III	0	0.0%

Table B4 Other Parameters

Parameter	Input
Road share percentage	100% urban
Canister size	(DSITIA, 2014)
Fuel tank size	
Fuel injection percentage	
RVP	
Sulphur and metal content in fuel	

Appendix C

Qualitative Assessment Methodology

The risk-based assessment takes account of a range of impact descriptors, including the following:

- **Nature of Impact**: does the impact result in an adverse or beneficial environment?
- **Sensitivity**: how sensitive is the receiving environment to the anticipated impacts? This may be applied to the sensitivity of the environment in a regional context or specific receptor locations.
- **Magnitude**: what is the anticipated scale of the impact?

The integration of receptor sensitivity with impact magnitude is used to derive the predicted significance of that change.

Nature of Impact

Predicted impacts may be described in terms of the overall effect upon the environment:

- **Beneficial**: the predicted impact will cause a beneficial effect on the receiving environment.
- **Neutral**: the predicted impact will cause neither a beneficial nor adverse effect.
- **Adverse**: the predicted impact will cause an adverse effect on the receiving environment.

Receptor Sensitivity

Sensitivity may vary with the anticipated impact or effect. A receptor may be determined to have varying sensitivity to different environmental changes, for example, a high sensitivity to changes in air quality, but low sensitivity to noise impacts. Sensitivity may also be derived from statutory designation which is designed to protect the receptor from such impacts.

Sensitivity terminology may vary depending upon the environmental effect, but generally this may be described in accordance with the broad categories outlined in **Table C1**, which has been used in this assessment to define the sensitivity of receptors to air quality impacts.

Table C1 Methodology for Assessing Sensitivity of a Receptor to Air Quality Impacts

Sensitivity	Criteria
Very High	Receptors of very high sensitivity to air pollution (e.g. dust or odour) such as: hospitals and clinics, retirement homes, painting and furnishing businesses, hi-tech industries and food processing.
High	Receptors of high sensitivity to air pollution, such as: schools, residential areas, food retailers, glasshouses and nurseries, horticultural land and offices.
Medium	Receptors of medium sensitivity to air pollution, such as: farms, outdoor storage, light and heavy industry.
Low	All other air quality sensitive receptors not identified above.

Magnitude of Impact

Magnitude describes the anticipated scale of the anticipated environmental change in terms of how that impact may cause a change to baseline conditions. **Table C2** outlines the methodology used in this assessment to define the magnitude of the identified potential air quality impacts.

Table C2 Methodology for Assessing Magnitude of Impacts

Magnitude	Description
Substantial	Impact is predicted to cause significant consequences on the receiving environment (may be adverse or beneficial)
Moderate	Impact is predicted to possibly cause statutory objectives/standards to be exceeded (may be adverse)
Slight	Predicted impact may be tolerated.
Negligible	Impact is predicted to cause no significant consequences.

Significance of Impact

The risk-based matrix provided below illustrates how the definition of the sensitivity and magnitude interact to produce impact significance.

Table C3 Impact Significance Matrix

Magnitude / Sensitivity		[Defined by Table C2]			
		Substantial Magnitude	Moderate Magnitude	Slight Magnitude	Negligible Magnitude
[Defined by Table C1]	**Very High Sensitivity**	Major Significance	Major/ Intermediate Significance	Intermediate Significance	Neutral Significance
	High Sensitivity	Major/ Intermediate Significance	Intermediate Significance	Intermediate/Minor Significance	Neutral Significance
	Medium Sensitivity	Intermediate Significance	Intermediate/Minor Significance	Minor Significance	Neutral Significance
	Low Sensitivity	Intermediate/Minor Significance	Minor Significance	Minor/Neutral Significance	Neutral Significance

APPENDIX D

Predicted Pollutant Isopleth Plots – Incremental Concentrations

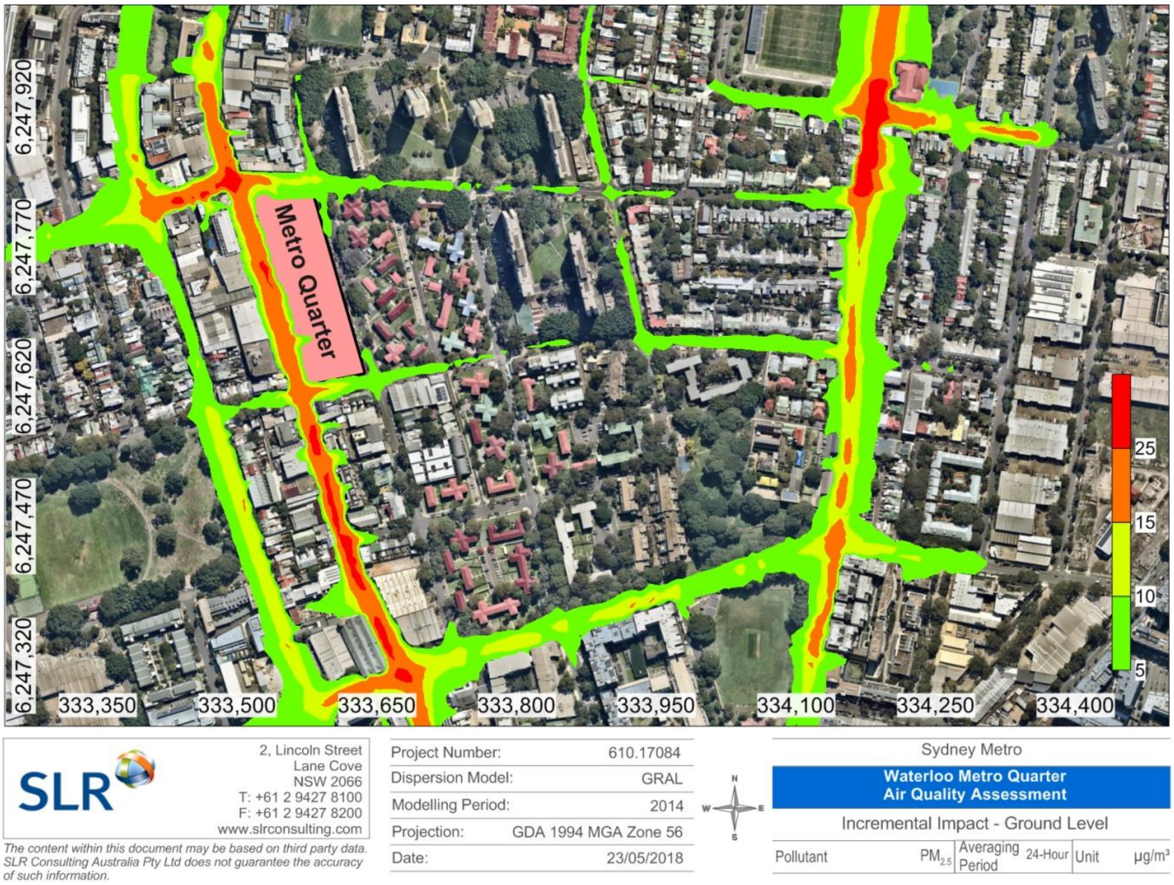

Figure D1 Maximum predicted incremental 24-hour average $PM_{2.5}$ – Ground Level

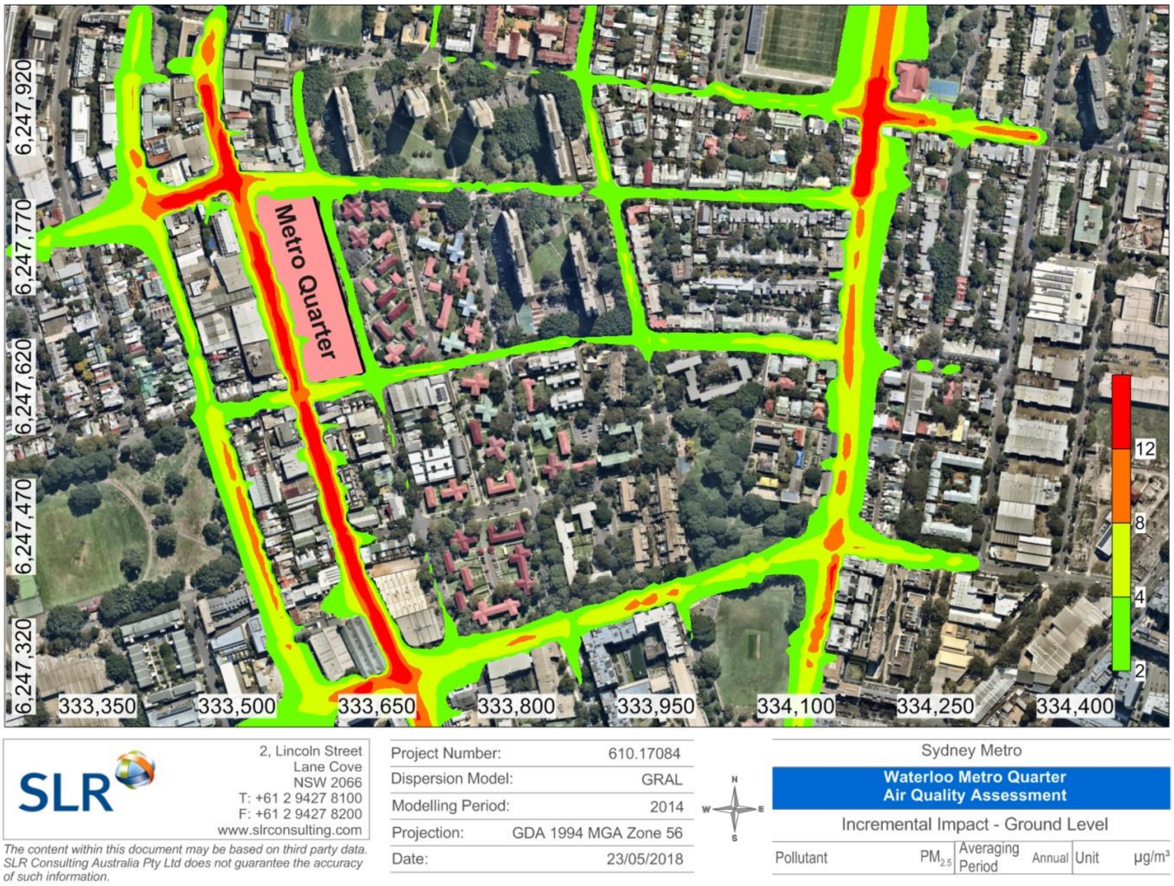

Figure D2 Maximum predicted incremental annual average $PM_{2.5}$ – Ground Level

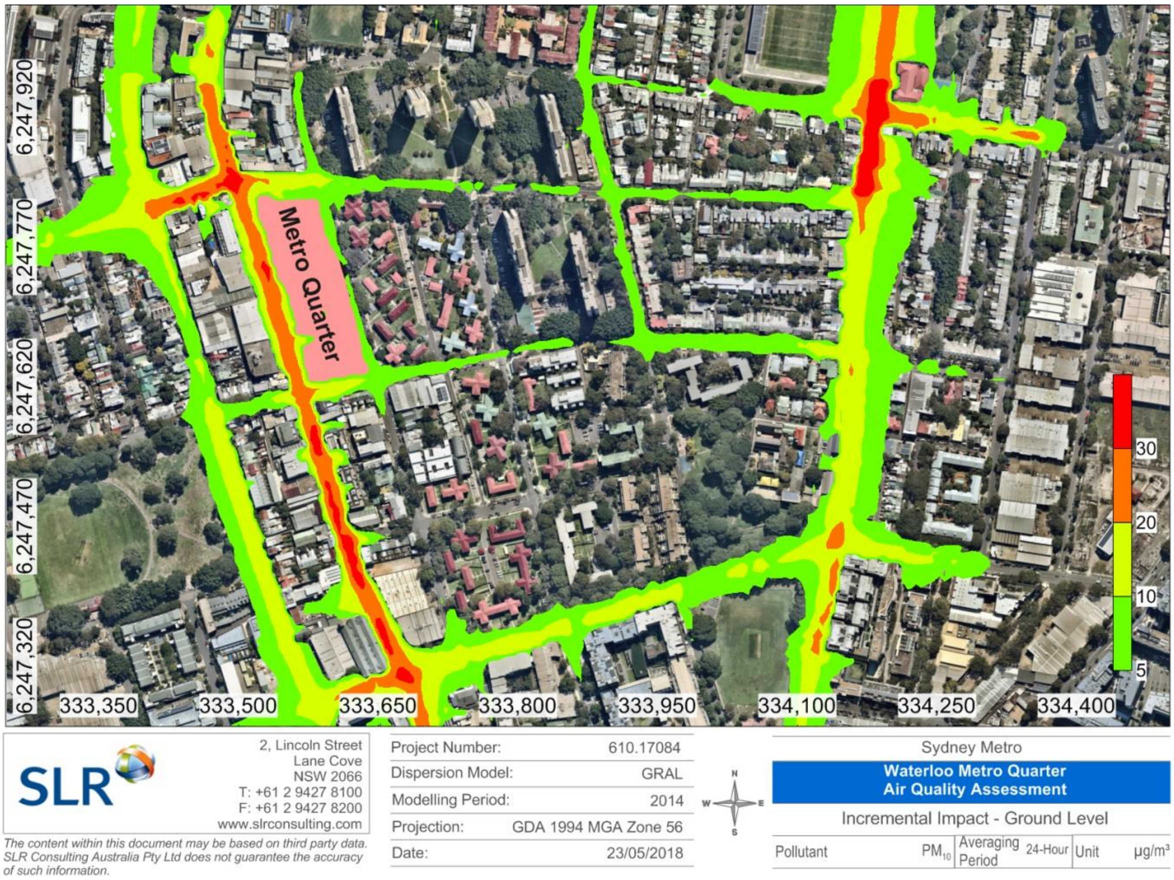

Figure D3 Maximum predicted incremental 24-hour average PM_{10} – Ground Level

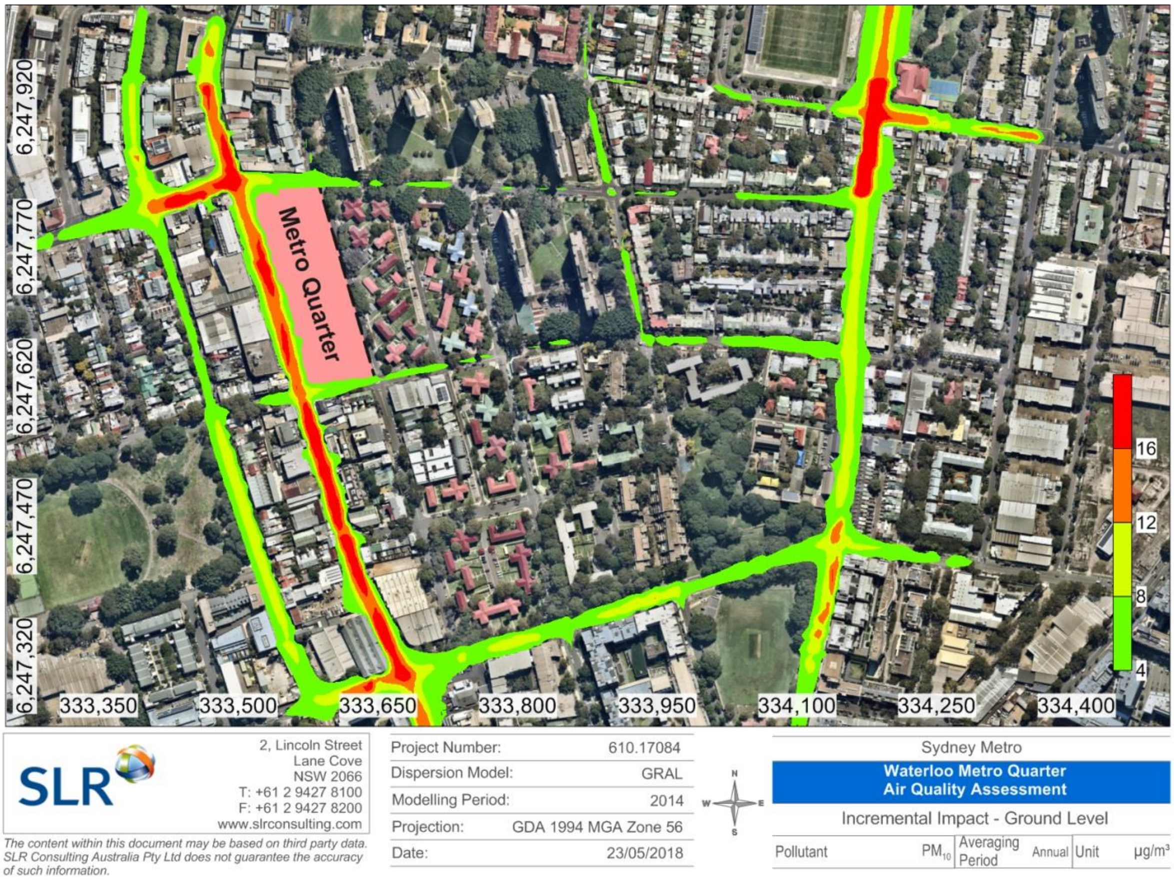

Figure D4 Maximum predicted incremental annual average PM_{10} – Ground Level

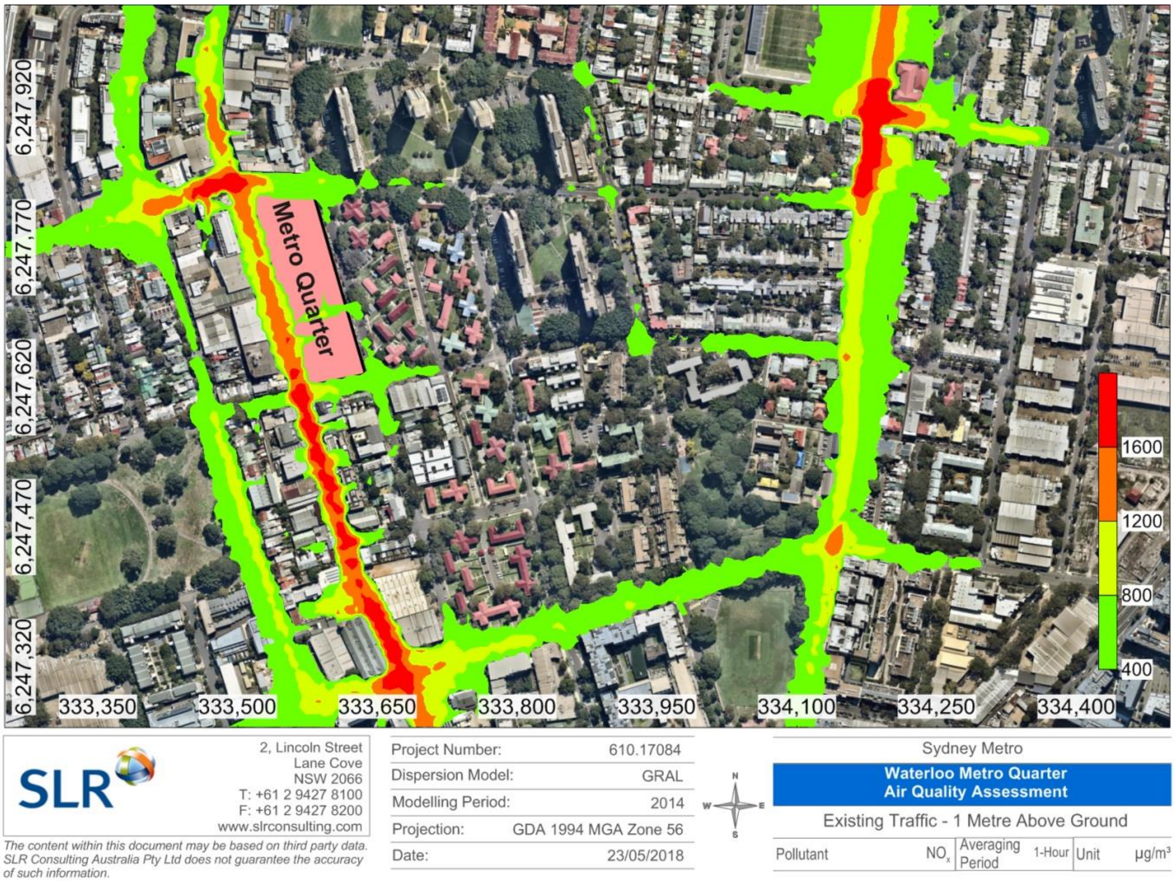

Figure D5 Maximum predicted incremental 1-hour average NO_x – Ground Level

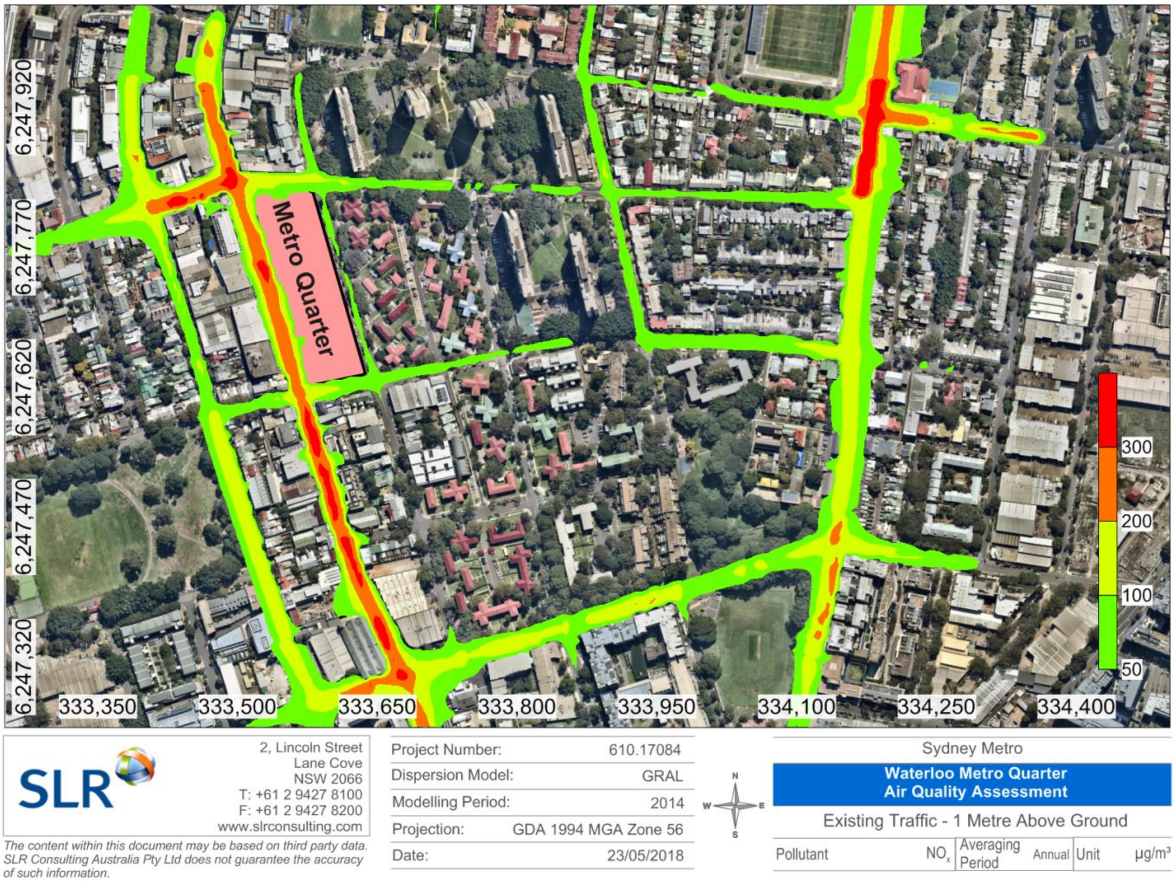

Figure D6 Maximum predicted incremental annual average NO_x – Ground Level

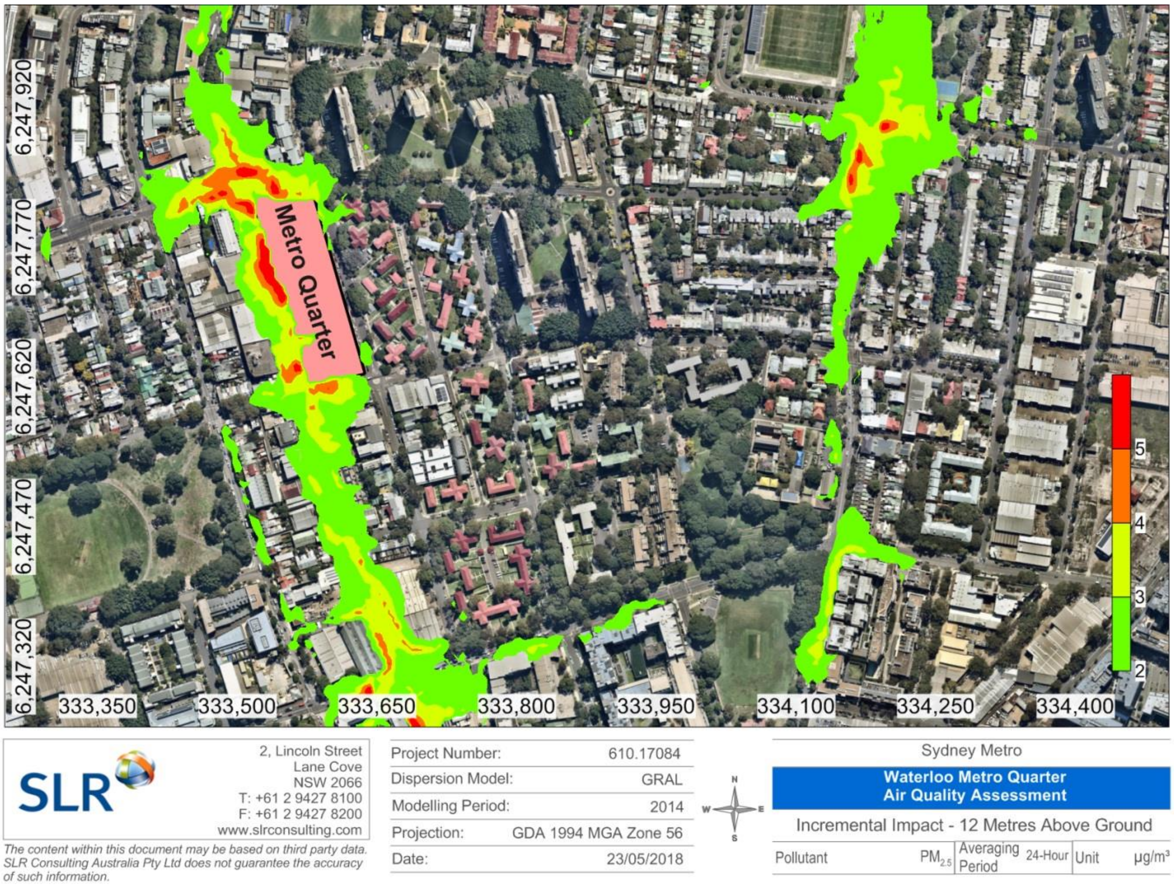

Figure D7 Maximum predicted incremental 24-hour average $PM_{2.5}$ – 12 m Elevation

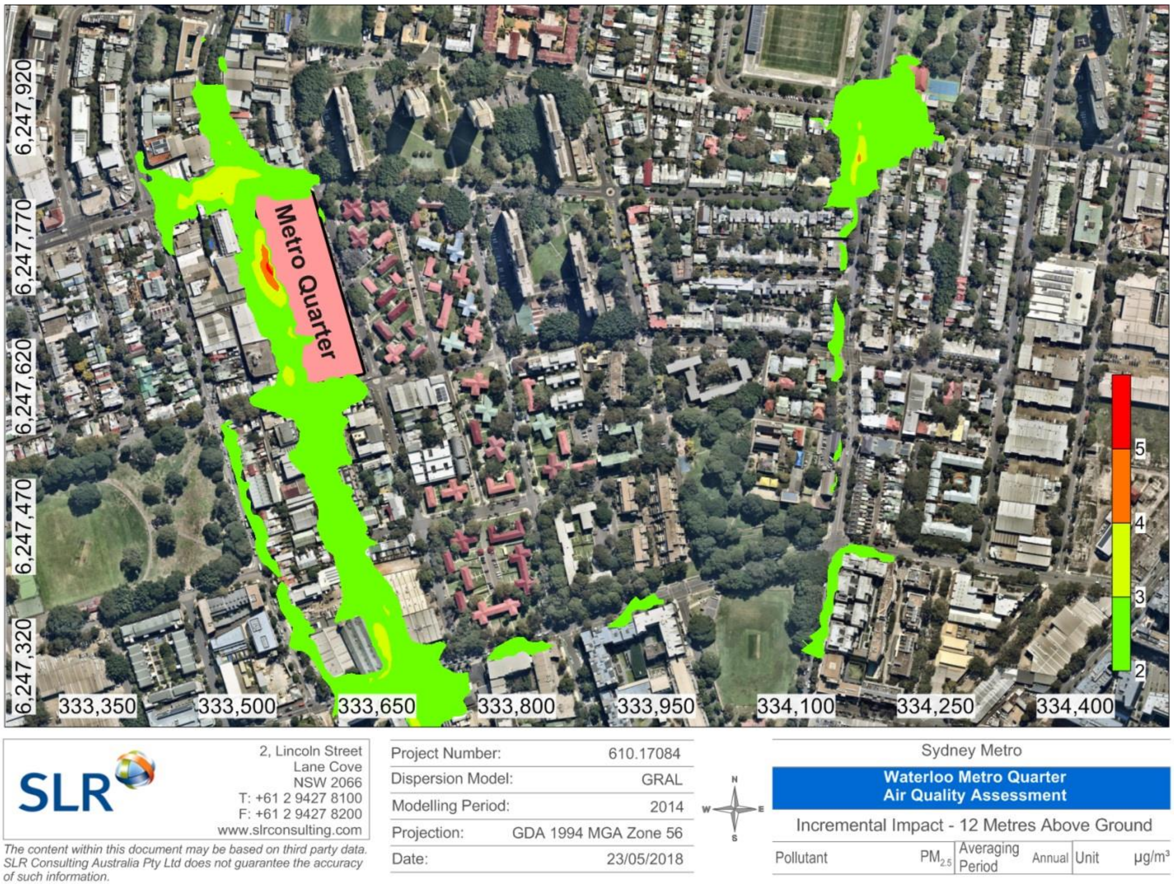

Figure D8 Maximum predicted incremental annual average $PM_{2.5}$ – 12 m Elevation

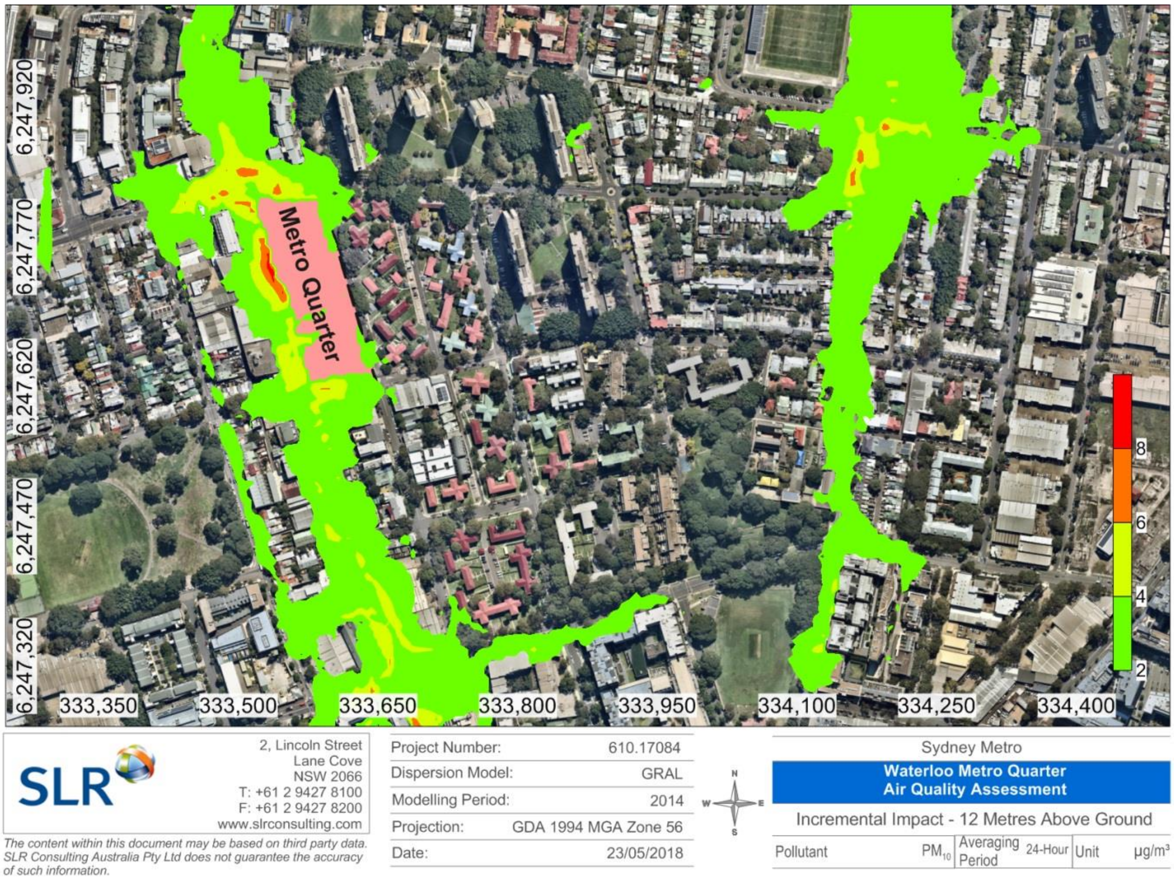

Figure D9 Maximum predicted incremental 24-hour average PM_{10} – 12 m Elevation

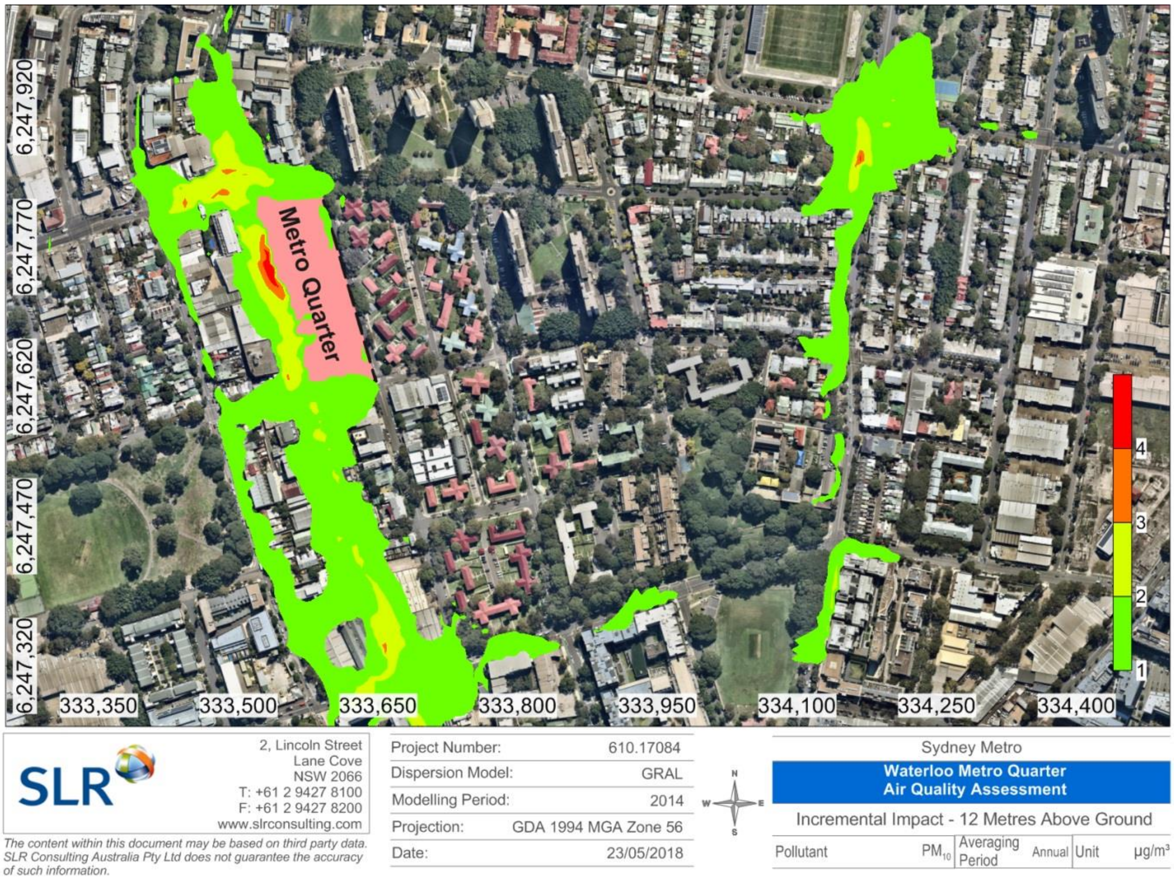

Figure D10 Maximum predicted incremental annual average PM_{10} – 12 m Elevation

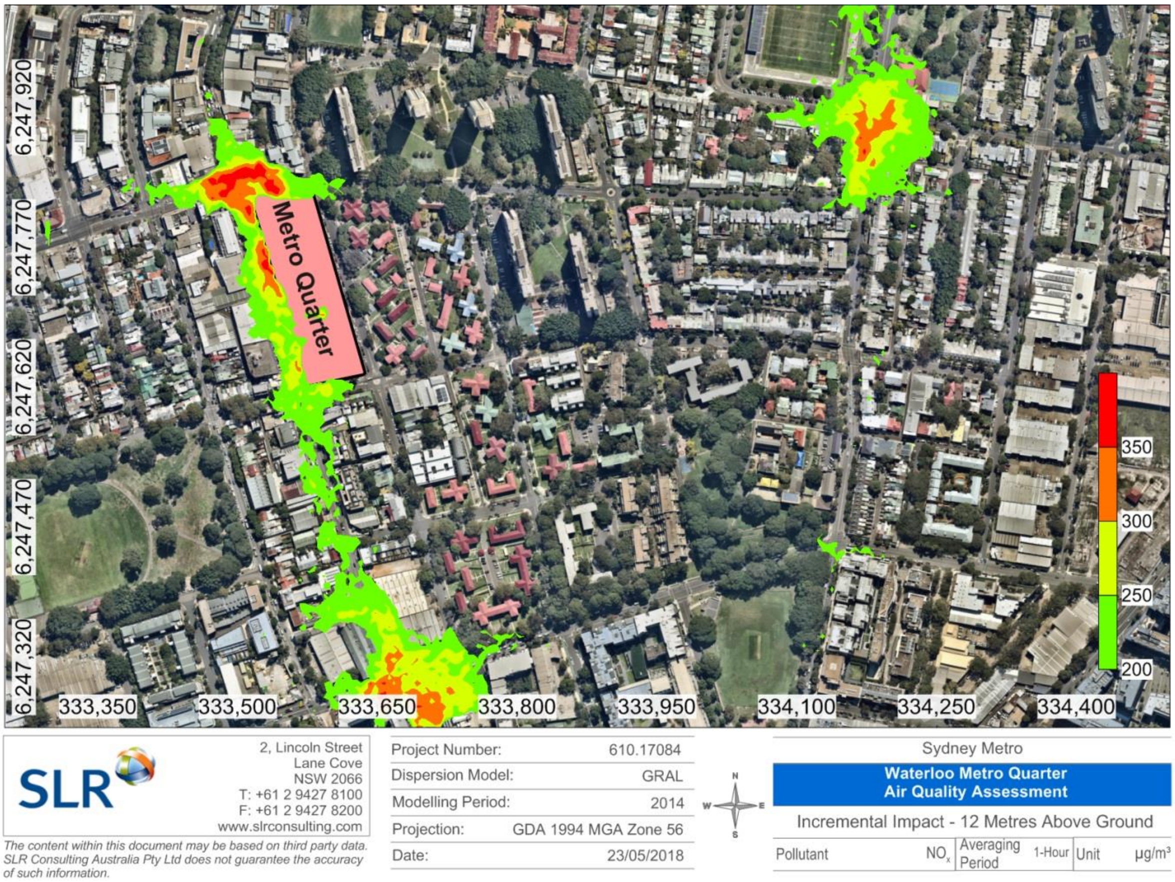

Figure D11 Maximum predicted incremental 1-hour average NO_x – 12 m Elevation

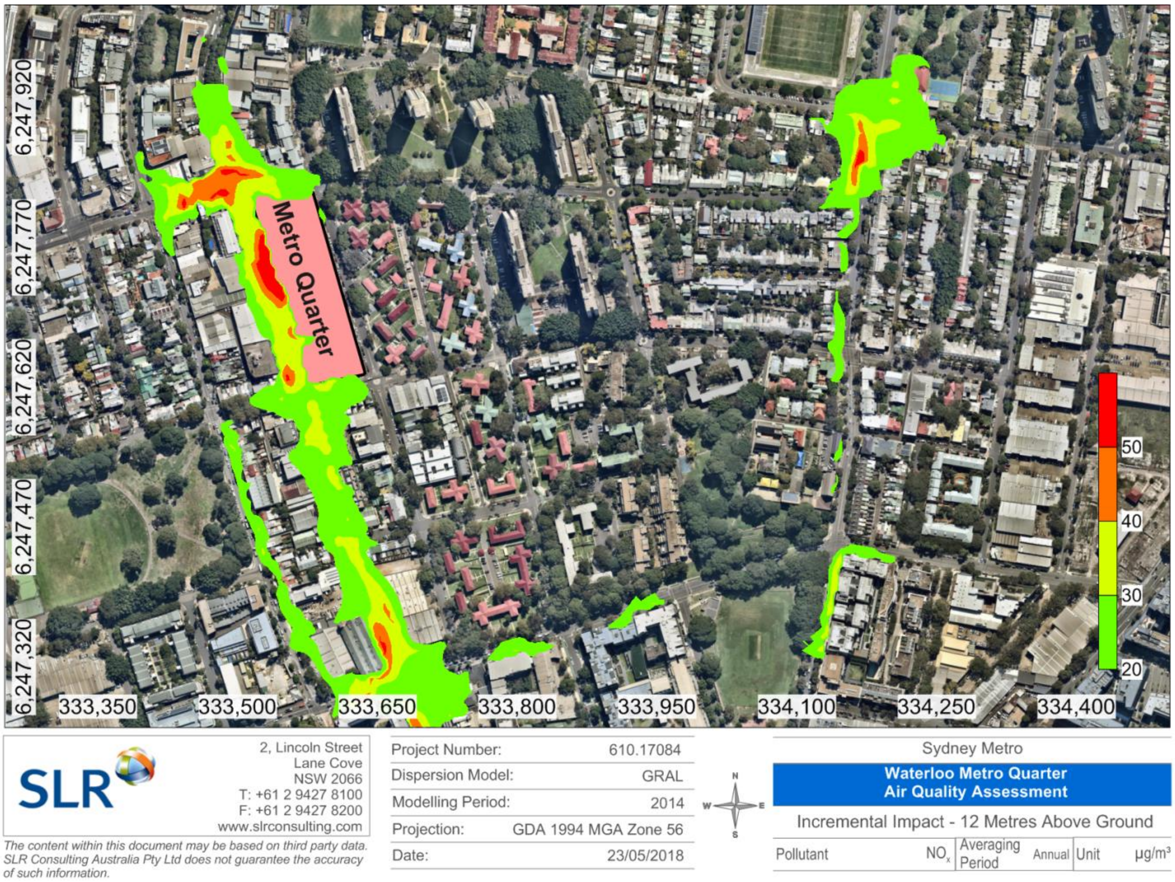

Figure D12 Maximum predicted incremental annual average NO_x – 12 m Elevation

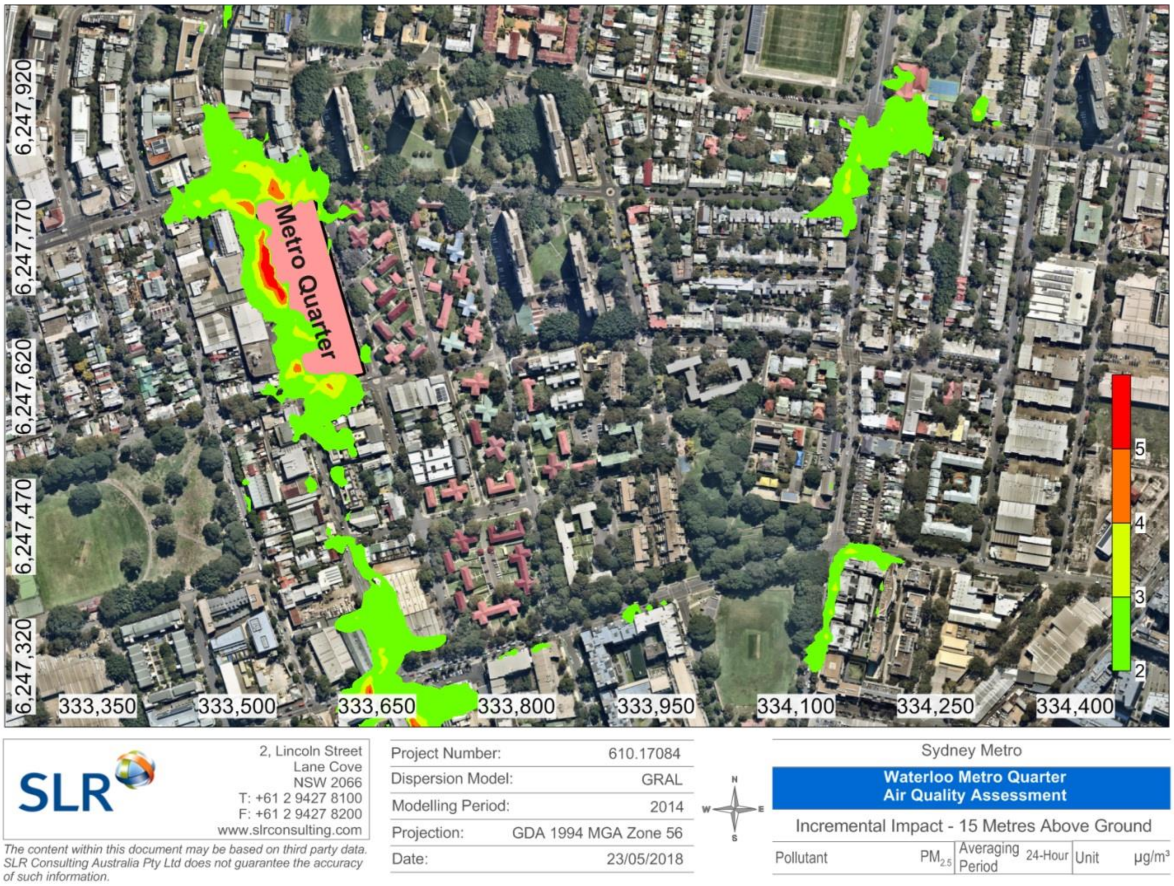

Figure D13 Maximum predicted incremental 24-hour average $PM_{2.5}$ – 15 m Elevation

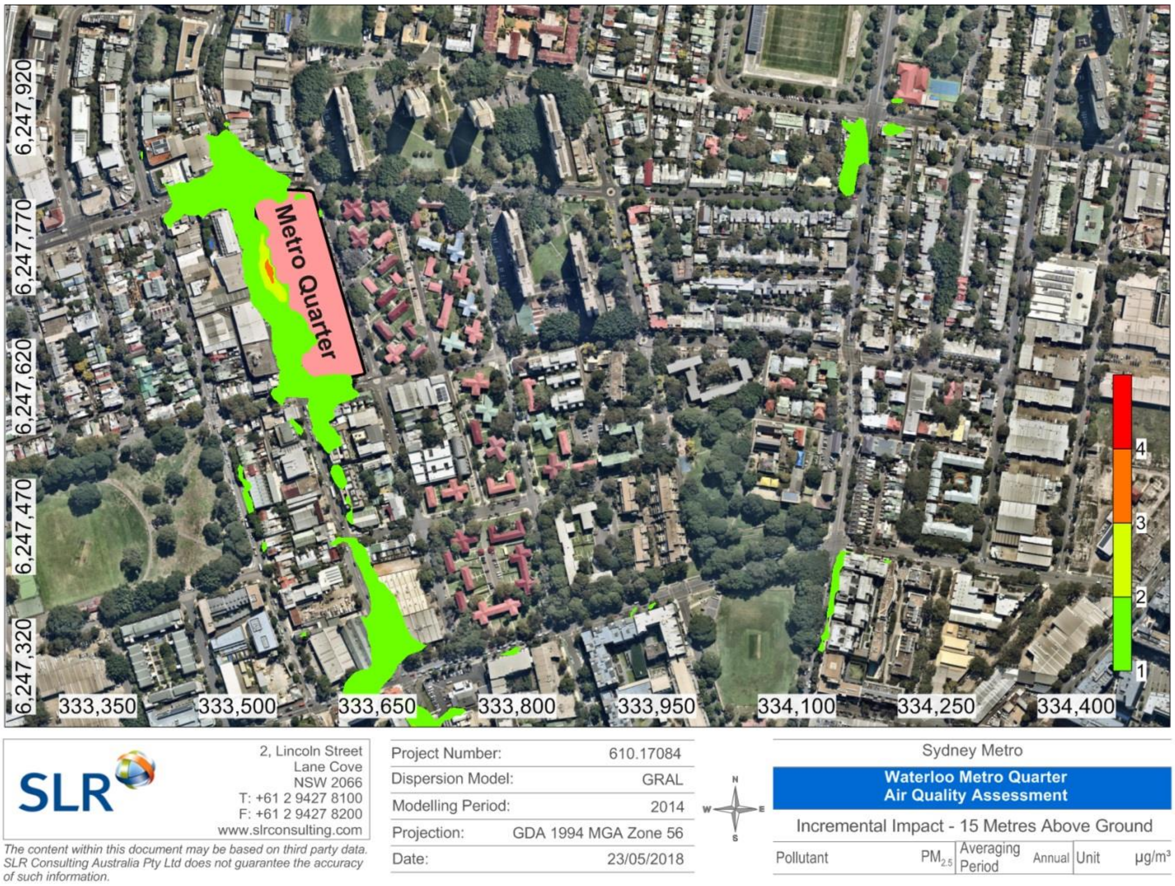

Figure D14 Maximum predicted incremental annual average $PM_{2.5}$ – 15 m Elevation

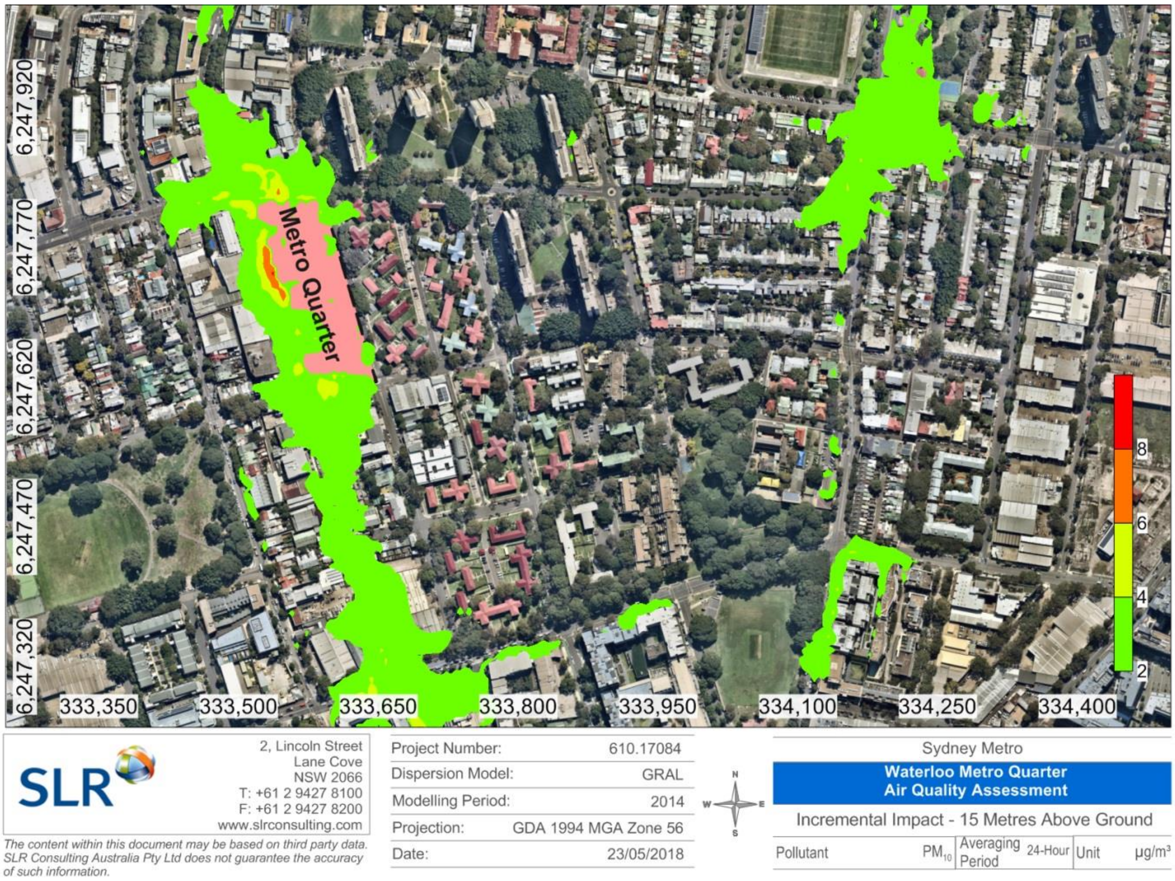

Figure D15 Maximum predicted incremental 24-hour average PM_{10} – 15 m Elevation

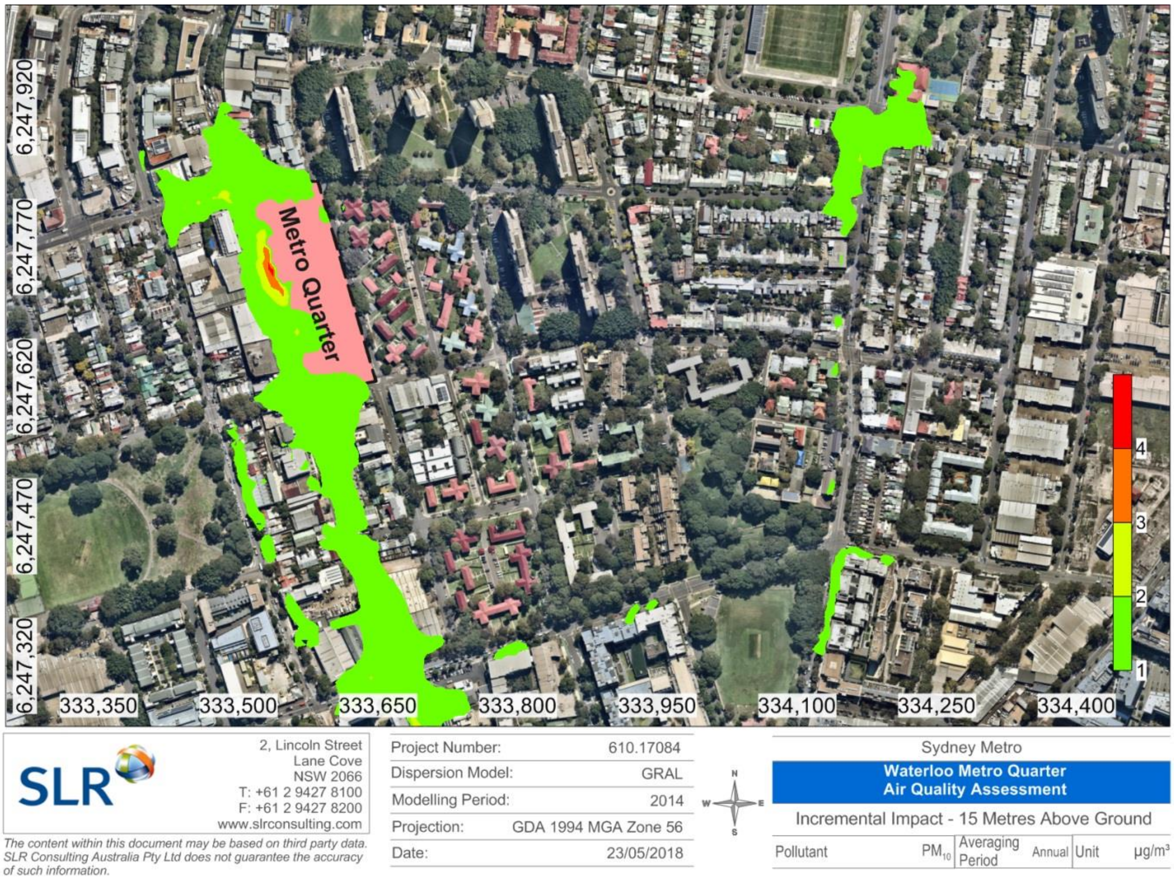

Figure D16 Maximum predicted incremental annual average PM_{10} – 15 m Elevation

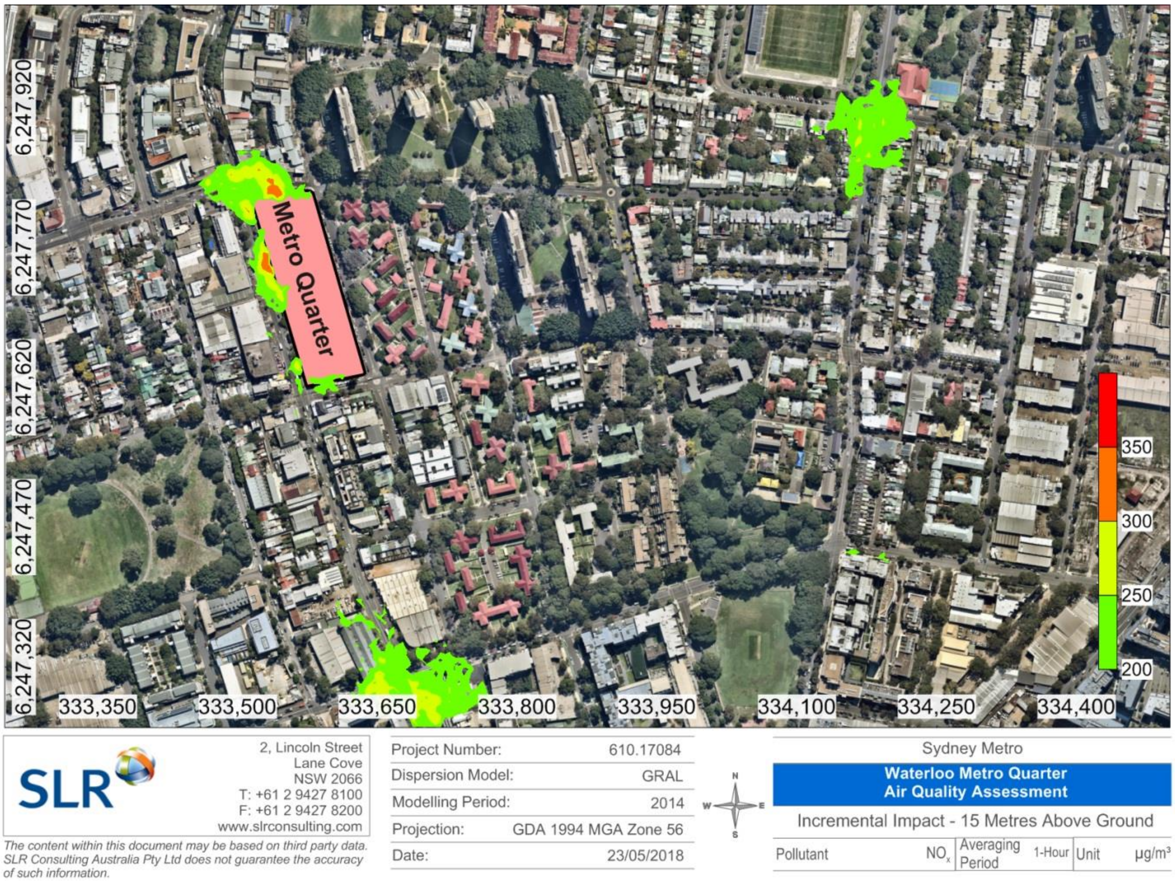

Figure D17 Maximum predicted incremental 1-hour average NO_x – 15 m Elevation

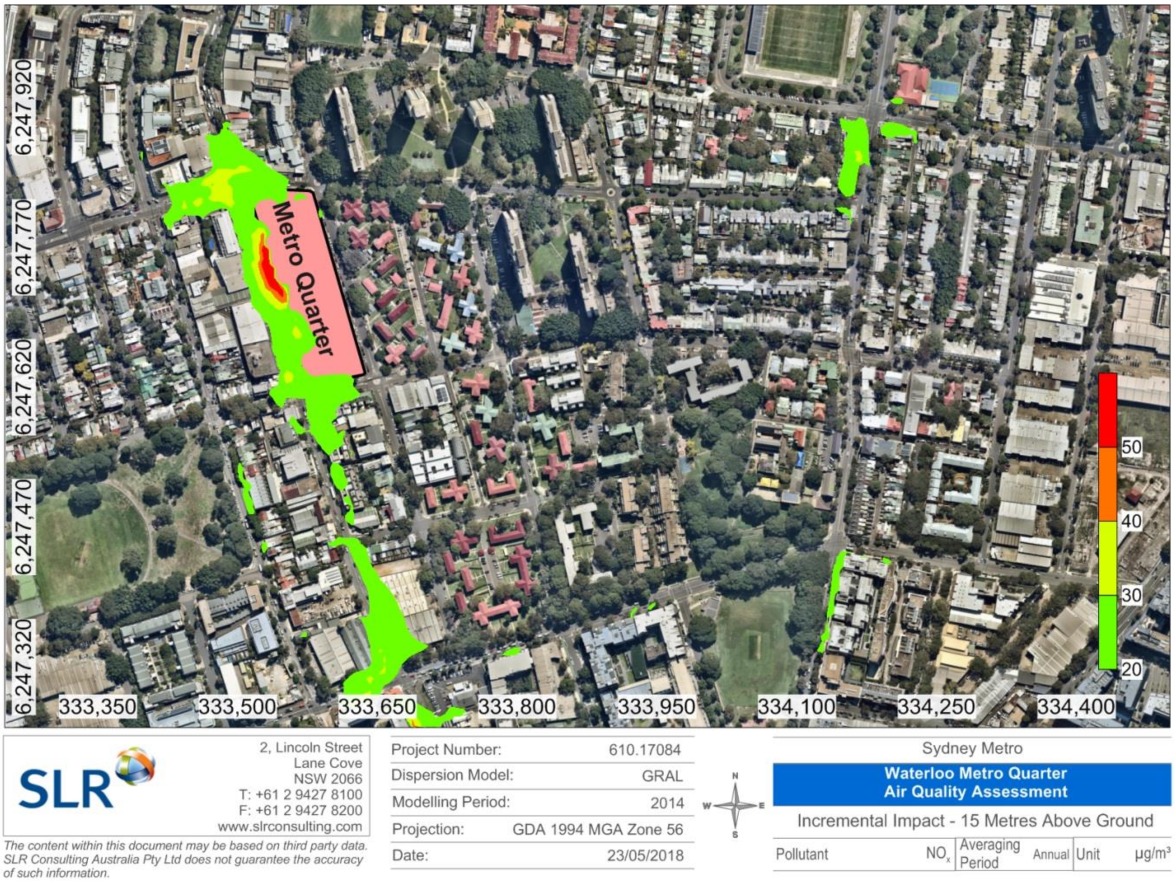

Figure D18 Maximum predicted incremental annual average NO_x – 15 m Elevation