POD VOLUME 3
ATTACHMENT N:

AIR QUALITY ASSESSMENT

PREPARED BY:

ASK CONSULTING ENGINEERS

DESTINATION
BRISBANE
CONSORTIUM

QUEEN'S
WHARF
BRISBANE

PLANS AND DOCUMENTS
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Queens Wharf Brisbane Plan of Development

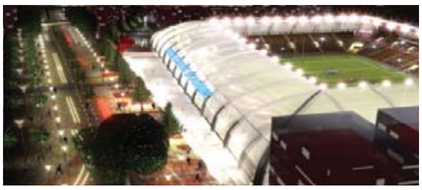
Air Quality Constraints Assessment

Report: PoD Volume 3, Attachment N.docx

Prepared for:

Destination Brisbane Consortium Integrated Resort Operations



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Executive Summary

Overview

ASK has been commissioned by DBC to provide air quality services for the Plan of Development for the Queens Wharf Brisbane Integrated Resort Development (QWBIRD) project proposed for the Brisbane City riverfront. This report provides a general assessment of air quality constraints associated with the site and likely development, especially the impacts of roads onto the development.

The broad scope includes:

- dispersion modelling of emissions from surrounding roadways for future scenarios with and without the development
- identification of constraints and criteria against which future development should be assessed
- recommending input for the Framework Environmental Management Plan.

Study Area

The proposed site of the QWBIRD project currently contains offices, a casino, a hotel, public open space and river transport. It is surrounded by offices, retail and entertainment areas of the central business district.

The terrain drops approximately 15 metres from the centre of the site to the Brisbane River.

There are three offsite apartments/hotels in George Street opposite the precinct, as well as the Treasury Hotel within the precinct.

Proposed Development

The QWBIRD project proposes to include a casino, entertainment facilities, hotels, retail and cultural uses over a 27 ha site. The general development form in the primary precinct (Resort Precinct) may potentially include four joined towers and public space.

Potential uses within the development that may be sensitive to air quality include:

- apartments
- hotel accommodation
- other resort facilities
- child care centre
- conference centre
- public recreation space.

Potential sources of air pollutants are demolition and construction activities, roads (vehicle emissions), power generators in the towers, carpark exhaust vents and cooking vents.

Air Quality Requirements

Acceptable levels of air pollution are defined by government authorities. Pollutants of concern include fine particles and gases.

The Queensland state government has set goals for acceptable air pollution levels and these are similar to the limits set by Brisbane City Council. There are also specific requirements for assessing roads as well as Australian Standard requirements for exhaust vents.

Existing Air Quality

Prevailing winds in Brisbane are most commonly from the south and east directions with near-calm conditions often associated with higher pollution levels. However monitoring data from South Brisbane shows a local prevalence of south-westerly winds. The state government has air pollution monitoring stations in Brisbane City, South Brisbane, Woolloongabba, Rocklea and Springwood. ASK has also undertaken monitoring at 1 William Street, Brisbane. Background levels of the pollutants of concern are within the accepted levels for air quality, but levels of fine particles are close to the limits, and additional sources including dust storms and bushfires sometimes cause high levels.

Impact of Road Network

Road vehicles will continue to contribute to fine particle and gas pollution in the area. Predicted levels at existing apartments and hotels are predicted to be within acceptable levels. However, fine particle levels are predicted to be higher than acceptable levels at some locations adjacent roads where there are currently no sensitive uses. These locations include William Street and Alice Street.

Constraints on Development

Carpark exhausts should be located at least 6 metres from sensitive uses, with a preferred distance of 15 metres. Cooking vents and cooling tower vents should be located at least 6 metres from sensitive uses. Emissions from power generators and boilers will require detailed assessment and planning to prevent high pollution levels at sensitive locations.

Development along William Street and Alice Street will require detailed planning to prevent new sensitive uses being exposed to high pollution levels from road traffic.

Recommendations for Design

Detailed design for the Casino Precinct is to include measures to address two issues identified by this assessment.

Air quality in the section of William Street covered by the development is to be managed by one or more of optimal sizing, mechanical ventilation, anti-pollution surface coating, restrictions on heavy diesel vehicles, or re-assessment with updated fleet data.

Air emissions from diesel generators are to be managed by one or more of exhaust controls, optimal location of exhaust points, separation of air intakes from exhausts. These measures are to be finalised following further modelling of detailed design.

Recommendations for Environmental Management

Detailed Environmental Management Plans are required to address:

- any asbestos during demolition
- silica monitoring during demolition
- detailed control measures to minimise dust impacts from concrete demolition
- maintenance of power generators and air pollution controls
- covered area (William Street) ventilation and other pollution reduction measures
- maintenance of filters on air intakes.

Outcomes

Air quality impacts due to development of the site can be mitigated to meet the technical criteria by planning within the spatial constraints identified, designing to meet the criteria, and good management practices.

1. Introduction

1.1 Overview

ASK Consulting Engineers Pty Ltd (ASK) was commissioned by Destination Brisbane Consortium Integrated Resort Operations (DBC) to provide air quality consultancy services as input into the Plan of Development (PoD) for the Queens Wharf Brisbane Integrated Resort Development (QWBIRD). The proposed location is on the Brisbane City riverfront to the south-west of the city centre as shown in **Figure 1.1**. Note that the area to the north of George Street is currently not included in the PoD.

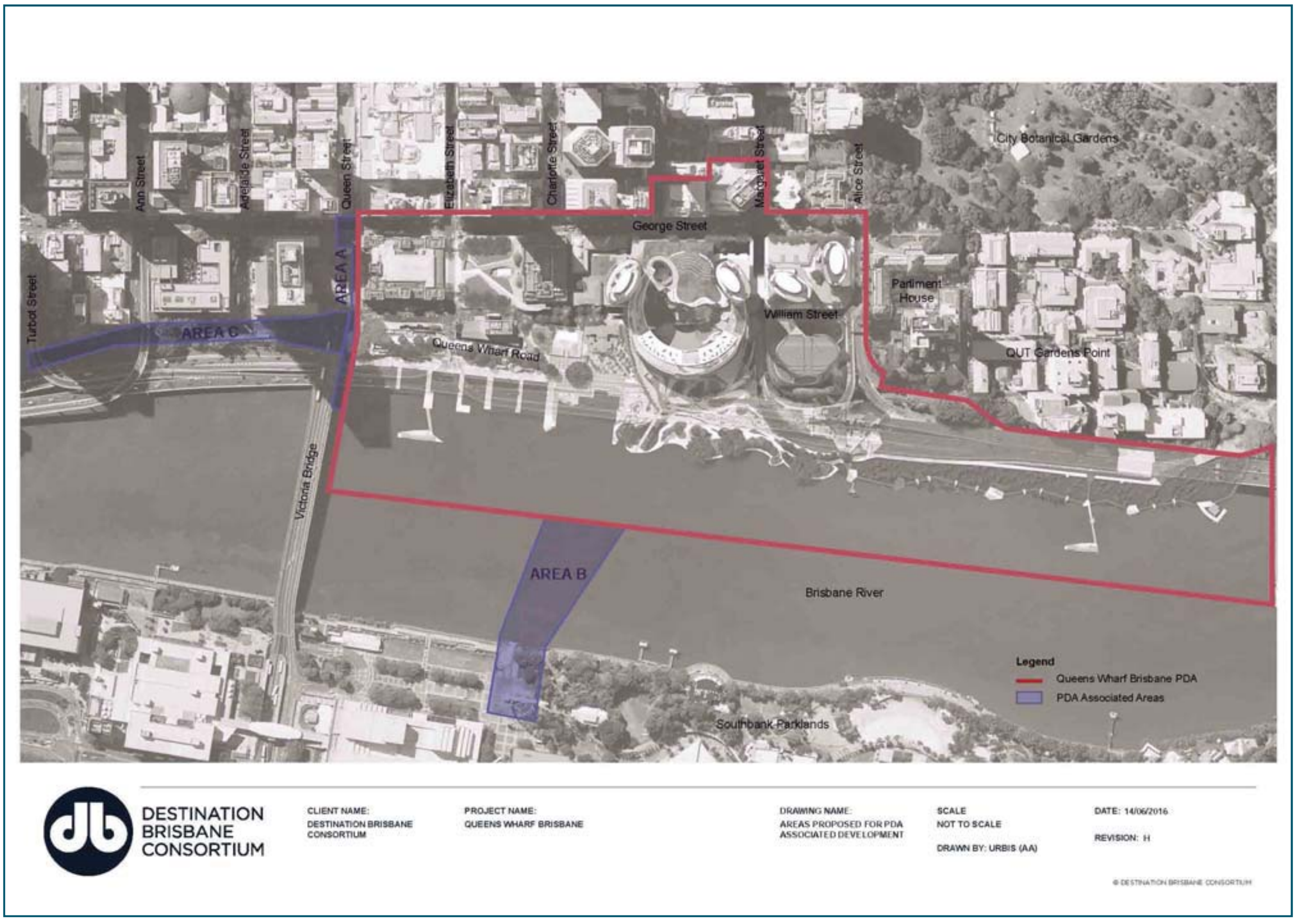

Figure 1.1 Location of QWBIRD (Supplied by DBC)

This report presents a general assessment of the air quality impacts associated with the QWBIRD development, sufficient for preparation of the PoD. Subsequent compliance assessment applications and associated technical reports will assess specific precincts of the QWBIRD development against the PoD.

The objective of this assessment is to advise on air quality impacts from transport routes onto the proposed development, the impact of the proposed buildings on the dispersion of transport emissions to existing sensitive uses, and to provide criteria including site specific buffers for assessing specific components of the QWBIRD development. Recommendations are made on site-specific issues that may arise during demolition, construction and operation.

To aid in the understanding of the terms in this report a glossary is included in **Appendix A**.

1.2 Broad Scope of Work

The purpose of the general assessment of the entire QWBIRD development is to provide guidance for specific precinct design elements such as design criteria, separation distances and/or any future monitoring or management requirements.

Air quality assessments can be based on monitoring, modelling, or a combination of the two. Air quality monitoring is best undertaken over a long time period to capture a range of weather and traffic conditions. However facilitating multiple monitoring locations over long time periods (i.e. 3 months to 1 year) is not considered practical or required at this stage of the project. Thus the assessment is to be based on existing monitoring data and computer modelling of the dispersion of air pollutants from the surrounding roads.

An air dispersion model such as Calpuff is most appropriate for simulating dispersion of emissions from roadways to nearby receptors. This type of model cannot accurately model the effect of buildings on air circulation and their influence on diffuse sources such as roads. However their influence has been estimated by including approximations of the building shape as sub-grid terrain features.

Modelling has been undertaken utilising a representative full year of meteorological data to predict future impacts. Two scenarios have been included: i) projected future baseline case without the development, and ii) future case with the development, so that the influence of traffic volume changes, and the proposed buildings on the air quality at existing residential uses could be ascertained.

The results of previous monitoring has been used to assist with estimation of existing air quality, including monitoring undertaken for the 1 William Street project and data from the DSITI air monitoring stations at Brisbane CBD (QUT) and Woolloongabba (identified as South Brisbane).

In addition to the assessment of transport emissions, recommendations have been included regarding suitable separation distances for cooking vents and carpark exhaust vents from air intakes and other sensitive uses. Recommendations also include input for the Framework Environmental Management Plan (EMP). This input is based on identification of any project-specific air quality issues, and the recommendation of non-generic requirements for construction and operation management plans.

1.3 Tasks

The assessment has been undertaken based on the following tasks:

(a) Review project and make preparations including data requests and review of legislative context.

(b) Liaise with DBC to identify existing sensitive locations including residential and hotel accommodation.

(c) Confirm the suitability of local meteorological data for inclusion in the modelling.

(d) Undertake meteorological modelling in the region and vicinity using TAPM with assimilation of local meteorological data.

(e) Fit the meteorological data to the terrain using Calmet.

(f) Establish the state of the local climate including seasonal rainfall temperatures, humidity, wind roses, and inversion heights.

(g) Identify expected regional background concentrations of pollutants considering monitoring data from the 1 William Street project, the Queensland Government air monitoring stations including Brisbane CBD (at QUT) and South Brisbane, and other available sources.

(h) Identify coordinates of road sections to be modelled, and choose suitable average vehicle speeds for each.

(i) Liaise with the project team to obtain projected traffic growth to future planning horizon 2031. This includes projections without the development project.

(j) Use 2010 vehicle fleet data and emission profiles for input into the emission model Copert Australia v1.2. Copert is the road traffic emission model used by the Queensland government.

(k) Develop an emission inventory for modelling (Year 2031) based on Copert. Air pollutants to be included are particulates less than 2.5 microns ($PM_{2.5}$), particulates less than 10 microns (PM_{10}), carbon monoxide, nitrogen oxides and benzene. The emission inventory has been developed using varying traffic volumes, traffic speeds and driving types (i.e. urban, highway, etc) to calculate emission rates according to time of day for each individual road.

(l) Undertake dispersion modelling of emissions based on the future traffic (Year 2031) data. The Calpuff dispersion model has been used to predict concentrations.

(m) Process results using Calpost and prepare tables of predicted concentrations at sensitive receptors.

(n) Update the road inventory with projected traffic for the development scenario as provided by the project team.

(o) Update and rerun the dispersion model.

(p) Prepare figures showing contours of predicted pollutants at ground level, including Waterline Park, on the ground level.

(q) Compare predicted concentrations from the baseline (no development) and with-development modelling scenarios, and discuss influence of proposed development on impacts at existing receptors.

(r) Rerun the model at three representative upper levels, and for pollutants whose concentrations are near the criteria. Prepare contour figures for these levels.

(s) Determine spatial constraints on the development, including separation from roads and exhaust vents.

(t) Prepare non-generic input for the Framework EMP including site-specific issues, strategies, specific control measures, requirements for monitoring and corrective actions. Highlight construction impacts on close receptors and nominate actions to take.

(u) Provide draft PoD report with:
   - EMP input including site-specific requirements for control of construction impacts based on proximity of receptors
   - generic guidelines on separation distances for cooking exhausts and carpark exhausts
   - assessment of the baseline scenario without the development
   - assessment of the with-development scenario
   - requirements for assessment of future substantial sources i.e. power generator exhausts
   - definition of which proposed land uses are considered sensitive receptors
   - mapping of contours defining acceptable locations for sensitive receptors.

(v) Attend meeting with project team to discuss draft report.

(w) Provide final report.

2. Study Area Description

2.1 Overview

The site for QWBIRD is currently occupied by government and commercial offices, a casino, a hotel, public open space and transport facilities. The surrounding land uses follow:

- To the north-west across the entrance to the Queen Street busway station are Brisbane City Council offices and library, as well as public open space.
- To the north-east are the Queen Street Mall, open space and shops.
- To the east across George Street are retail uses including food outlets, bars, commercial and government offices, accommodation hotels, apartments and a club venue.
- To the south-east across Alice Street is the state government parliament house.
- To the south-west underneath the REX are a bikeway/walkway and boat jetties.
- Further to the south-west and west are the Brisbane River and Victoria Bridge.

2.2 Terrain

The terrain slopes down from approximately 20 metres (AHD) in the centre of the site to approximately 5 metres (AHD) at the river as shown in **Figure 2.1**.

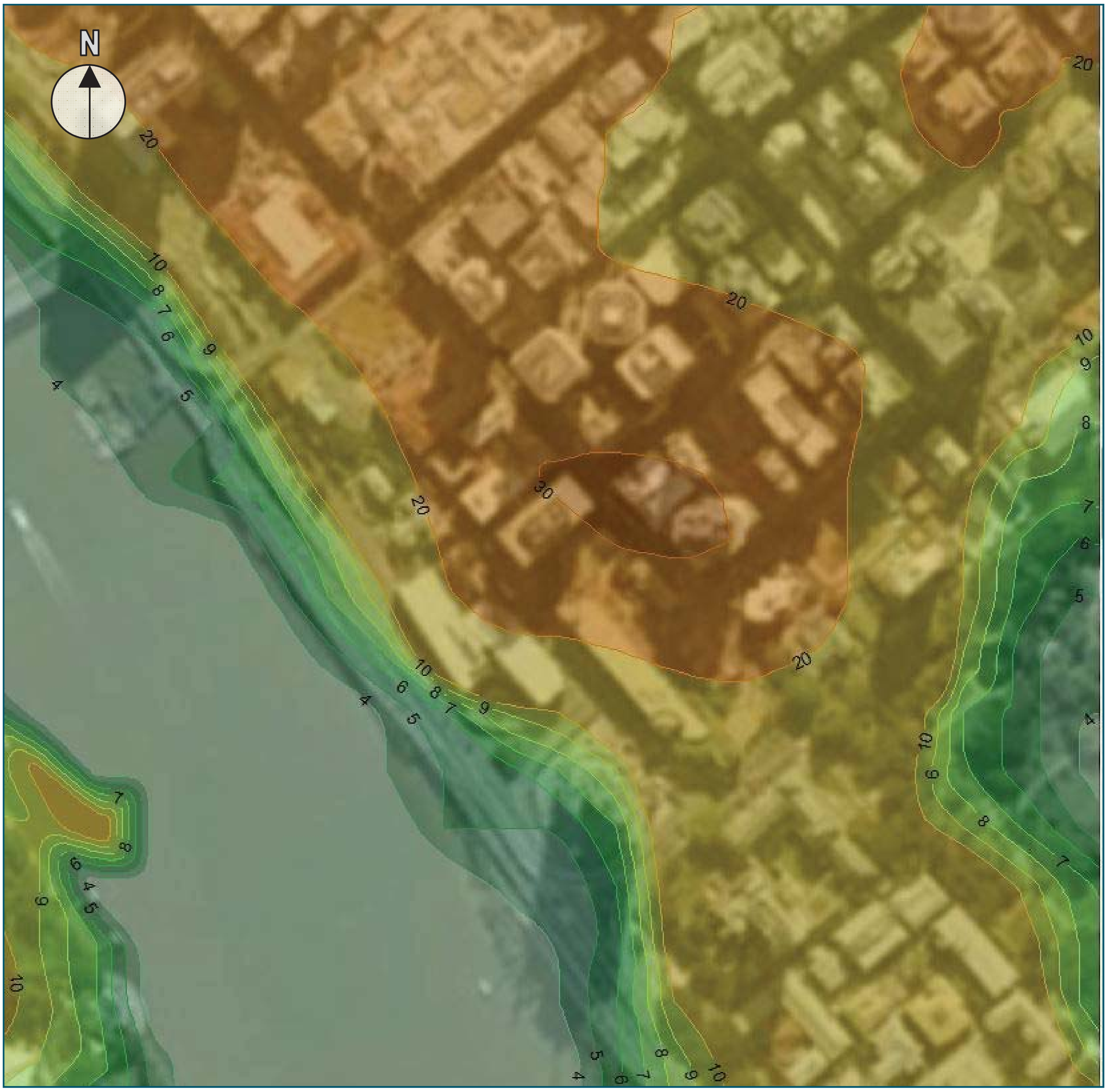

Figure 2.1 Approximate Topography in the Vicinity of Subject Site (m AHD)

2.3 Existing Buildings

The existing buildings located on the site are shown in **Figure 2.2** and listed in **Appendix B**.

Figure 2.2 Existing Buildings on the Site

2.4 Existing Sensitive Receptors

The definition of sensitive uses consistent with the State Planning Policy is discussed in detail in **Section 3.2**.

2.4.1 Sensitive Uses

The nearest sensitive receptors are summarised in **Table 2.1**, including their northing and easting UTM coordinates, and are shown in **Figure 2.3**. All of these sensitive receptors are accommodation uses. The receptor points (coordinates) chosen are at the middle of the site boundary facing the development, except for the Treasury Hotel, which is within the QWBIRD development area and is represented by three points on the eastern, southern and western corners of the building.

Table 2.1 List of Sensitive Receptors with UTM Coordinates (WGS84 Z56)

ID	Land Use	Name / Address	Real Property Description	Easting (m)	Northing (m)	Heights modelled above ground (m)
A	Apartments	29 George St	00000/BUP3797	502651	6961051	1.5, 35.0
B	Hotel accommodation	Rendezvous Studio Hotel, 103 George St	19/B118241	502527	6961187	1.5
C	Apartments and hotel accommodation	Oaks Casino Towers, 151 George St	0/SP148188	502456	6961267	1.5
De (east)	Hotel accommodation	Treasury Hotel, 142 George St	682/CP855445	502477	6961212	1.5
Ds (south)				502423	6961166	1.5
Dw (west)				502391	6961202	1.5

2.4.2 Other Uses

Although not considered sensitive uses under the State Planning Policy, other land uses such as public open space and air intakes into commercial buildings may also be affected by the development. Consideration of these locations is to be included in the design, demolition, construction and operation phases of the development. For example, construction of the south-western end of the foot bridge over the river has the potential to generate dust in the close vicinity of the construction site at Southbank.

Figure 2.3 Location of Site and Sensitive Receptors (Base Image from Google Earth Pro)

2.5 Road Network

The roads within and surrounding the development are shown in **Figure 2.4**.

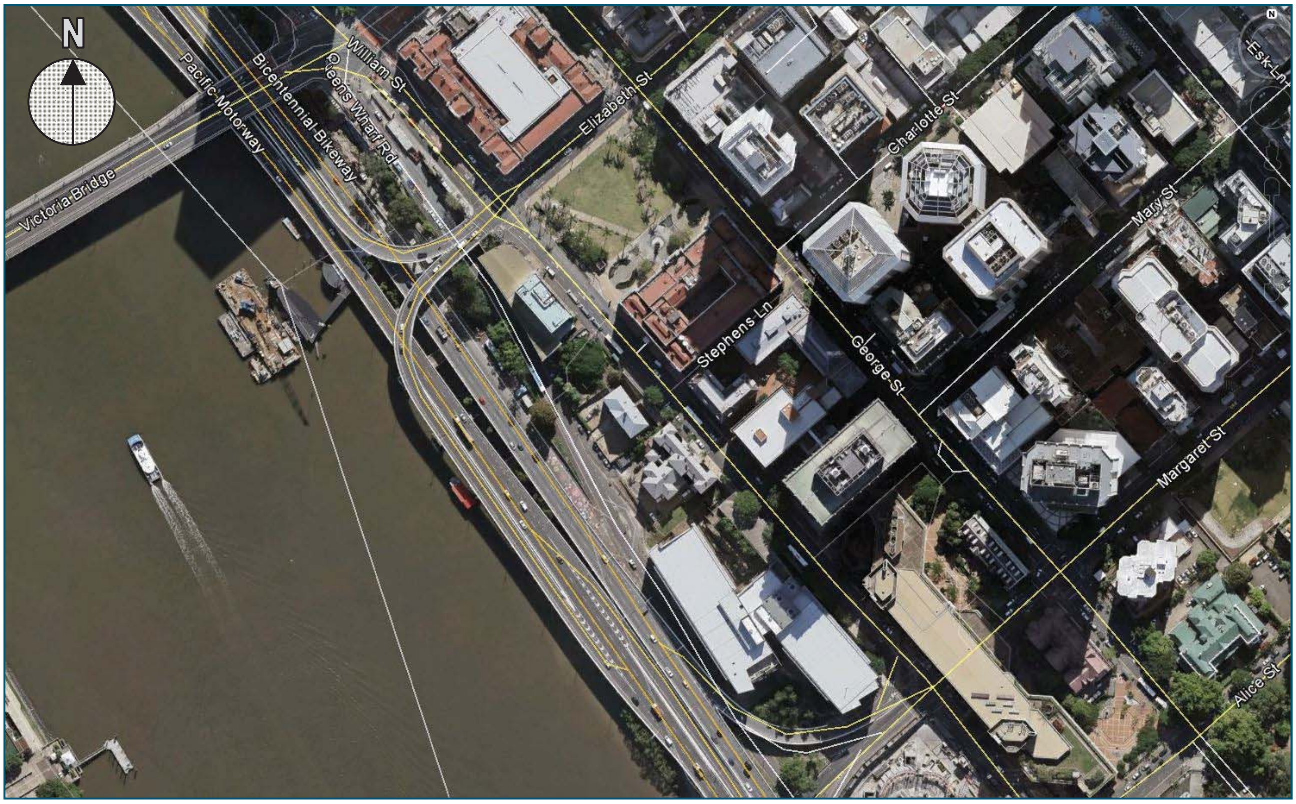

Figure 2.4 Location of Roads (Base Image from Google Earth Pro)

The roads to be included in the model include parts of:

- Riverside Expressway (REX) also known as Pacific Motorway
- William Street
- George Street
- Alice Street
- Margaret Street
- Mary Street
- Charlotte Street
- Elizabeth Street
- North Quay
- Victoria Bridge.

3. Proposed Development

3.1 Project Description

The QWBIRD development is proposed to include a casino, function and entertainment facilities, hotels, retail, tourist attractions, cultural facilities, convention facilities, residential development, landings and recreation uses as well as public space. It is to occur over approximately 27 ha including over parts of the Brisbane River.

The proposed development includes four precincts:

- IRD Precinct
- Treasury and Casino Repurposing Precinct
- Residential Precinct
- PDA Associated Development Precinct.

These are each made up of the sub-precincts shown in **Figure 3.1**.

Figure 3.1 Precinct Plan (Supplied by DBC)

The primary component of the project is the Resort Precinct (Precinct 1a). This may comprise hotels and apartments in four towers linked at lower levels. General elements that have relevance to air quality include:

- Parts of the Resort Precinct are in close proximity to the Riverside Expressway (REX), whilst other precincts extend underneath it.
- The proposed pedestrian bridge passes over the REX.

3.2 Potential Sensitive Uses

The potential land uses for QWBIRD are anticipated to be captured by the list of uses provided in **Table 3.1**. Those that are defined in State Development Assessment Provisions (SDAP) as sensitive are identified. Normally public open space is not considered sensitive to air pollution since people are not exposed for long periods of time. However one of the objectives of this project is to provide improved public recreational space adjacent to the river including the Waterline Park sub-precinct. Thus that area is also considered sensitive.

Table 3.1 Potential Sensitive Uses

Category	Use	Generic Planning Term	Air Quality Sensitive Use [1,2,3]
Residential			
	Apartments	Multiple Dwelling	Yes
	Hotel	Short-term Accommodation	Yes
	Serviced Apartment	Short-term Accommodation	Yes
	Retirement unit	Retirement Facility	Yes
	Caretakers accommodation for a non-residential use	Caretakers Accommodation	Yes
	Integrated Resort Development	Resort Complex	Yes
Commercial			
	Office	Office	No
	Hotel function space	Function Facility	Yes
	Casino	Tourist Attraction	Yes
	Gym	Indoor Sport and Recreation	Yes if part of IRD
	Cinema	Theatre	No
	Marina	Port Services	No
	Boat ramp, jetty	Landing	No
	Theatre	Theatre	No
	Resort	Resort Complex	Yes
	Sales office	Sales Office	No
	Child Care Centre	Child Care Centre	Yes including outdoor
	Museum	Community Use	No
	Art Gallery	Community Use	No
	Conference centre	Function Facility	Yes
	Convention/Exhibition Centre	Major sport, recreation and entertainment facility	Yes
	Bowling alley	Indoor Sport and Recreation	Yes if part of IRD
	Public/commercial car park	Parking Station	No
	Swimming pool, tennis courts	Outdoor Sport and Recreation	Yes if part of IRD

Category	Use	Generic Planning Term	Air Quality Sensitive Use [1,2,3]
Retail			
	Shop	Shop	No
	Shopping Centre	Shopping Centre	No
	Restaurant	Food and Drink Outlet	No
	Bar /pub	Hotel	No
	Café	Food and Drink Outlet	No
	Night Club	Nightclub Entertainment Facility	No
	Market e.g. farmers' market	Market	No
	Sports club	Club	No
	Car showroom	Showroom	No
Other			
	Park, plaza	Park	Yes, public recreational space adjacent to river [4]
	Fuel burning for standby power	Industry	No
	District energy facility	Utility Installation	No
	Substation	Substation	No
	Telecommunications Facility	Telecommunications Facility	No

Notes:

1. *SDAP defines sensitive development as including accommodation and child care uses. Accommodation includes caretaker's accommodation, multiple dwelling, resort complex, retirement facility, short-term accommodation. Resort complex includes integrated restaurants & bars, meeting & function facilities, sport & fitness facilities and staff accommodation.*
2. *For sensitive uses defined in **Table 3.1**, a sensitive location includes air intakes, doors, windows, and private outdoor recreational areas.*
3. *For non-sensitive uses, proposed building air intakes are considered sensitive in the context of air quality impacts associated with this development.*
4. *Public recreational space adjacent to the river is considered sensitive in the context of air quality impacts associated with this development.*

3.3 Potential Air Emission Sources

3.3.1 Roads

The QWBIRD development will influence traffic flows, and projected future (2031) traffic volumes with and without the QWBIRD development have been provided to ASK by TTM. The air quality impact from future traffic onto existing receptors and the proposed development, both with and without the influence of the QWBIRD development, is assessed in **Sections 6.6** and **7**.

3.3.2 Power Generators and Exhaust Vents

Emissions from power generators, diesel storage tank vents, hot water boilers, cooling towers, carpark exhaust vents, microbrewery and cooking exhaust vents will be addressed in the compliance assessments for detailed designs. ASK has been advised that the development will include generators powered by gas and diesel in the Resort Precinct and these are to be modelled as part of the compliance assessment. Power generators and boilers are substantial sources of hot combustion gases. Their location and appropriate treatment of exhaust gas in order to comply with criteria is to be determined during the design stage.

Appropriate separation distances for the other sources are discussed in **Section 7.5**.

4. Air Quality Criteria

4.1 Relevant Pollutants

4.1.1 Diesel Generators

Particulate fractions to be assessed include the following fractions:

- PM_{10} is the fraction of particulate matter with equivalent aerodynamic diameters of 10 μm or less.
- $PM_{2.5}$ is the fraction of particulate matter with equivalent aerodynamic diameters of 2.5 μm and less.

Gases produced from diesel combustion include:

- nitrogen oxides (NO_X)
- carbon monoxide (CO)
- volatile organic compounds (VOCs), in particular benzene.

4.1.2 Gas Generators

Gas generators emit NO_x, CO and VOCs, although emission rates of CO and VOCs are normally far less than emissions from diesel generators.

4.1.3 Roads

For road traffic, the pollutant species of interest include nitrogen dioxide (NO_2), which is assessed based on emissions of NO_x, as well as CO, VOCs, PM_{10} and $PM_{2.5}$. For the purpose of this investigation, the assessment of VOCs has been conducted based on the predicted concentration and criterion for benzene, which is the most likely compound to exceed criteria.

4.2 State Legislative Requirements

4.2.1 QWBIRD Development Scheme

The development area has been declared a Priority Development Area (PDA) by the state government. The QWBIRD PDA development scheme is therefore the primary source of criteria, and this section specifies the associated requirements. How the development is to comply with these criteria is discussed in **Section 7.5** and **Section 8**, with necessary actions specified in **Section 9**.

The development scheme specifies the following relevant to air quality:

(1) Siting, design, construction and operation of the development is to have regard to constraints by:

  (a) "*avoiding, managing or mitigating adverse impacts on air quality from transport corridors including the Riverside Expressway"* including compliance with the requirements, standards and guidance in the State Planning Policy including the Environmental Protection (Air) Policy 2008

  (b) "avoiding, managing or mitigating adverse impacts on amenity .... during and after construction".

(2) The development is to "*provide adequate tower separation to allow ...... air circulation and ensure impacts on amenity ..... are minimised, particularly for residential buildings*."

4.2.2 State Planning Policy

The State Planning Policy (SPP) (2013) requires development to be assessed against the following requirements:

(1) It must be designed to avoid or minimise adverse impacts from emissions that will affect the health and safety, wellbeing and amenity of communities and individuals.

(2) It must support the achievement of the relevant objectives of the Environmental Protection (Air) Policy 2008 (which are reproduced in Appendix 5 of the SPP).

(3) It must not compromise the viability of existing or future industrial development.

4.2.3 State Development Requirements

Module 1 *Community amenity*, State Code 1.2 *Managing air and lighting impacts from transport corridors* of the State Development Assessment Provisions (version 1.8, 2016) contain performance outcomes and acceptable outcomes for sensitive development in the vicinity of transport operations and infrastructure. Essentially it requires developers to minimise or offset impacts.

Since the site is in the vicinity of a state-controlled road (REX), impacts from the road on the proposed development need to be considered. Performance Outcome PO1 requires that:

Development involving sensitive development achieves acceptable levels of air quality for occupiers or users of the development by mitigating adverse impacts on the development from air emissions generated by state transport infrastructure.

Sensitive development includes accommodation, educational establishments, childcares and hospitals. **Section 3.2** discusses sensitive uses further.

Acceptable Outcomes 1.1 and 1.2 of SDAP require that:

Every private open space and passive recreation area of an accommodation activity [AO1.1] and outdoor education area and passive recreation area of an educational establishment, childcare centre, and hospital [AO1.2] meet the air quality objectives in the Environmental Protection (Air) Policy 2008 for the following indicators:

(1) *carbon monoxide*

(2) *nitrogen dioxide*

(3) *sulphur dioxide*

(4) *photochemical oxidants*

(5) *respirable particulate matter (PM_{10})*

(6) *fine particulate matter ($PM_{2.5}$)*

(7) *lead*

(8) *toluene*

(9) *formaldehyde*

(10) *xylenes.*

Note that this definition of “respirable” particulate matter is a different size fraction than that referred to in the field of occupational health and safety.

The potential for impact from emission of sulfur dioxide and lead have been significantly reduced in recent years due to unleaded petrol and low sulfur fuels and therefore these pollutant species have not been considered in this assessment.

The main VOC species of concern is considered to be benzene. In ASK's experience, predicted concentration levels of toluene, formaldehyde and xylene from road transport vehicles are significantly lower compared to criteria than predicted levels of benzene. Therefore if predicted concentrations of benzene comply with the relevant criterion, concentration levels of other VOC species are also expected to be compliant.

Photochemical smog is considered to be a regional issue, and this development will not emit substantial quantities of precursors (VOCs and NO_x) compared to regional levels. Therefore the assessment of photochemical oxidants is not considered to be a constraint for this development.

A summary of the assessment against SDAP is included in **Appendix D** of this report.

4.2.4 TMR Requirements

More specific guidance on criteria and methodology for assessment of roads and tunnels is contained in the Department of Transport and Main Roads Road Traffic Air Quality Management Manual (TMR 2014). Table 3.3.1 of this manual lists guideline levels, including those discussed in **Section 4.2.5**, as well as some tunnel-specific criteria that allow higher concentrations of pollutants. However these tunnel-specific criteria are not intended for tunnels containing sensitive uses so are not considered relevant to the section of William Street that is to be covered by the IRD.

Chapter 5 of TMR manual (2014) and the associated *Air Quality Management Report – Form 1* provide screening thresholds below which an air quality assessment is not required. For roads carrying more than 50,000 vehicles per day, a separation of 40 metres is required between a habitable room and the edge of the road. For roads with 20,000 – 50,000 vehicles per day, the separation is 20 metres. For roads with less than 20,000 vehicles per day, an assessment is not triggered. Note that the manual specifies the lower threshold as being 25,000 whilst the form specifies 20,000. The lower number is assumed to prevail.

Appendix B of the TMR manual (2014) includes the following requirements:

- Covered roadways in excess of 90 metres in length are to be considered as tunnels for the purpose of ambient air quality assessment.
- Traffic volumes considered should be those predicted 10 years from the opening.
- 10% to 20% of emitted NO_x is to be assumed in the form of NO_2. This is discussed further in **Section 6.9** of this report.
- A 90^{th} percentile regional background concentration should be included in the gas concentration predictions. This is discussed further in **Section 5** of this report.
- A method is provided for calculating maximum pollutant concentrations within tunnels based on emission rates, tunnel dimensions and air movement.

4.2.5 Queensland Environmental Protection Policy

The Environmental Protection (Air) Policy 2008 (EPP(Air)) provides objectives for air quality indicators (pollutants). The objectives relevant to this project and human health and wellbeing have been summarised in **Table 4.1**.

The EPP(Air) incorporates the goals nominated within the National Environmental Protection (Ambient Air Quality) Measure (NEPM). The 2016 amended NEPM includes a new annual PM_{10} standard. It also includes a 2025 goal of reducing annual average $PM_{2.5}$ concentrations to 7 μg/m3. These changes are not yet incorporated into Queensland legislation. However further assessment will be undertaken to guide the detailed design of the QWBIRD to endeavour to meet these new criteria.

Table 4.1 Air Quality Criteria (EPP Air) for Health and Wellbeing

Air Quality Indicator	Period	Criteria (µg/m^3)
Benzene	1 year	10
CO	8 hours	11,000 [2]
NO_2	1 hour	250 [2]
	1 year	62
$PM_{2.5}$	24 hours	25
	1 year	8
TSP	1 year	90
PM_{10}	24 hours	50 [1]

Notes:

1. The intent of the five allowable exceedances in the NEPM is to cater for regional events. However EHP has permitted these exceedances to be used in assessment of the impact of major developments.
2. Allowance is made to exclude one day but this is intended for bushfires.

4.3 Other Relevant Guides

The above state government requirements provide the ambient air criteria that need to be met. However, with the exception of the TMR Manual (2014) for assessing road impacts, they do not provide any guidance on how to predict whether or not the criteria will be met. Therefore other relevant guides have been reviewed to assist with developing more detailed site-specific criteria for designing the development to meet the state requirements. These include an Australian Standard and current Brisbane City Plan requirements as discussed in this section.

4.3.1 AS1668.2 Mechanical Ventilation in Buildings

Section 3.10.2 of Australian Standard AS1668.2-2012 specifies a minimum separation distance of 6 metres from discharges greater than 1000L/s. Refer to Table 3.4 of AS1668.2 for other flow rates.

4.3.2 Brisbane City Plan 2014 - Centre or Mixed Use Development Code

This code has an acceptable outcome for exhausts being a separation from sensitive uses of 15 metres from carpark exhausts, and 6 metres from cooking exhausts.

4.3.3 Brisbane City Plan 2014 - Multiple Dwelling Development Code

This code has the same requirements as the Centre or Mixed Use Code for separation from exhausts.

4.3.4 Brisbane City Plan 2014 - Transport Air Quality Corridor Overlay Code

The Transport Air Quality Corridor Overlay Code assesses the suitability of sensitive land uses within the vicinity of a transport corridor or tunnel vent stack. It includes State-controlled and other roads where traffic volumes are moderate to high.

Table 8.2.23.3.B of the code provides minimum separation distances for development within air quality corridors. The separation distances for sensitive uses are presented in **Table 4.2**. These separation distances are acceptable outcomes. Mechanical ventilation with appropriately filtered air or air intakes outside the separation distance are also acceptable outcomes. A site-specific air quality assessment may also confirm other appropriate measures.

Table 4.2 Minimum Separation Distances (Table 8.2.23.3.B)

Route Type	Minimum Separation Distance Measured from the Kerb	
	Transport air quality corridor A sub-category (for residences)	Transport air quality corridor B sub-category (for childcare centres)
Motorway route	30m	80m
High-volume traffic route	20m	80m
Intermediate-volume traffic route	10m	40m
Moderate-volume traffic route	-	40m
High-volume intersection	30m	60m

The REX is identified as a high volume traffic route and has corresponding corridor A and B separation distances. Alice Street between the REX and George Street, and Margaret Street between the REX and William Street are both identified as moderate volume traffic routes and have a corresponding corridor B separation distance.

4.3.5 Brisbane City Plan 2014 Air Quality Planning Criteria

The air quality criteria prescribed within City Plan 2014 are consistent across the development and overlay codes. Those relevant to this project are presented in **Table 4.3**. Unless otherwise indicated, they are intended to protect human health.

For pollutants with averaging times of 1 hour or less, the 99.9th percentile predicted concentration including background is to be compared to the criterion. Where one year had been modelled, this corresponds to the 9th highest hour. Averaging times of greater than 1 hour are to be presented using the maximum concentration.

Table 4.3 Air Quality Criteria (City Plan 2014)

Pollutant	Averaging Time	Criteria (µg/m^3)
NO_2	1 hour	250
	1 year	62
PM_{10}	24 hours	50
$PM_{2.5}$	24 hours	25
	1 year	8
CO	8 hours	11,000
Benzene	1 year	10

4.3.6 Dust Deposition

Whilst there are no quantitative limits specified in legislation, there are guidelines designed to avoid nuisance caused by dust deposition fallout onto near horizontal surfaces.

The Department of Environment and Heritage Protection (EHP 2013) suggests the guideline that deposited matter averaged over one month should not exceed 120 mg/m^2/day (3.6 g/m^2/month). For extractive industries, it is the insoluble component of analysed dust that is used.

4.4 Criteria Recommended for QWBIRD Plan of Development

The key criteria for this development are those from the EPP(Air), except that the allowable exceedences should not be used to accommodate emissions from the proposed development, since they are intended to allow for regional events. Although the EPP(Air) itself only sets goals for ambient air quality, the QWBIRD Plan of Development, State Development and TMR requirements are that ambient concentrations arising from all sources meet the EPP(Air) goals as planning criteria.

The Brisbane City Plan 2014 criteria are numerically consistent with the EPP(Air), although they do allow for the 99.9th percentile to be used for comparison with the one hour criteria, which is relevant in this case for NO_2. This is appropriate to use for point sources such as generators, since the influence of meteorology on this type of source produces highly variable modelling results at the 100th percentile level. It is not appropriate to use for transport emission sources.

Table 4.4 Air Quality Criteria Recommended for QWBIRD

Pollutant	Averaging Time	Criteria (µg/m^3)
NO_2	1 hour	250
	1 year	62
TSP	1 year	90
PM_{10}	24 hours	50
$PM_{2.5}$	24 hours	25
	1 year	8
CO	8 hours	11,000
Benzene	1 year	10
Dust deposition	1 month	120 mg/m^2/day

Note: The criteria are to be compared to the maximum predicted concentrations with the exception that at locations where the most influential source(s) are point sources such as generators, then the 99.9th percentile one hour concentration of NO_2 may be used. Where the most influential source is transport, the maximum is to be used.

5. Existing Climate and Air Quality

The development is to be located on the Brisbane City riverfront, to the south-west of the city centre. This section provides an overview of the existing climate and air quality for the local area.

5.1 Weather Stations

A search of the Bureau of Meteorology's (BOM) weather station directory has revealed that the nearest current BOM weather station (Brisbane City station) to the subject site is located approximately 1.5 kilometres to the east-south-east of the subject site at Wolloongabba. Temperature, rainfall and humidity data from this station is presented in **Section 5.3**.

In addition to the BOM Brisbane City station, wind speed and direction data from the Department of Science, Information Technology and Innovation (DSITI) Brisbane CBD monitoring station is also presented within **Section 5.2**. The DSITI monitoring station for the Brisbane CBD is located approximately 300 metres to the south-east of Alice Street with the inlets on the top of a building at the Queensland University of Technology (QUT), and is the closest monitoring station to the subject site.

5.2 Wind Data

Wind speed and direction plots (wind roses) from the DSITI Brisbane CBD monitoring station for the years 2012, 2013 and 2014 are presented in **Figure 5.1** to **Figure 5.3**. The wind roses for these recent years show a similar pattern, with easterly winds dominating the plots, and a large proportion of calm conditions.

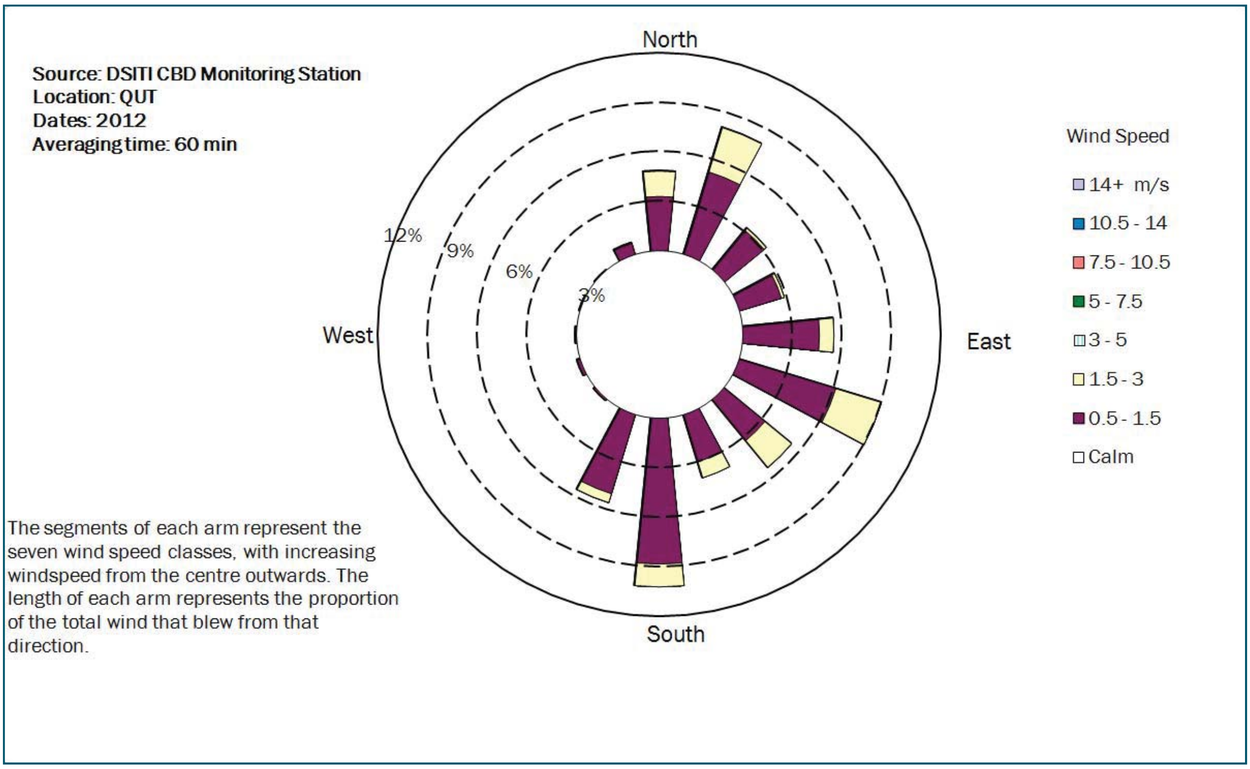

Figure 5.1 Wind Rose for DSITI Brisbane CBD Monitoring Station for Year 2012

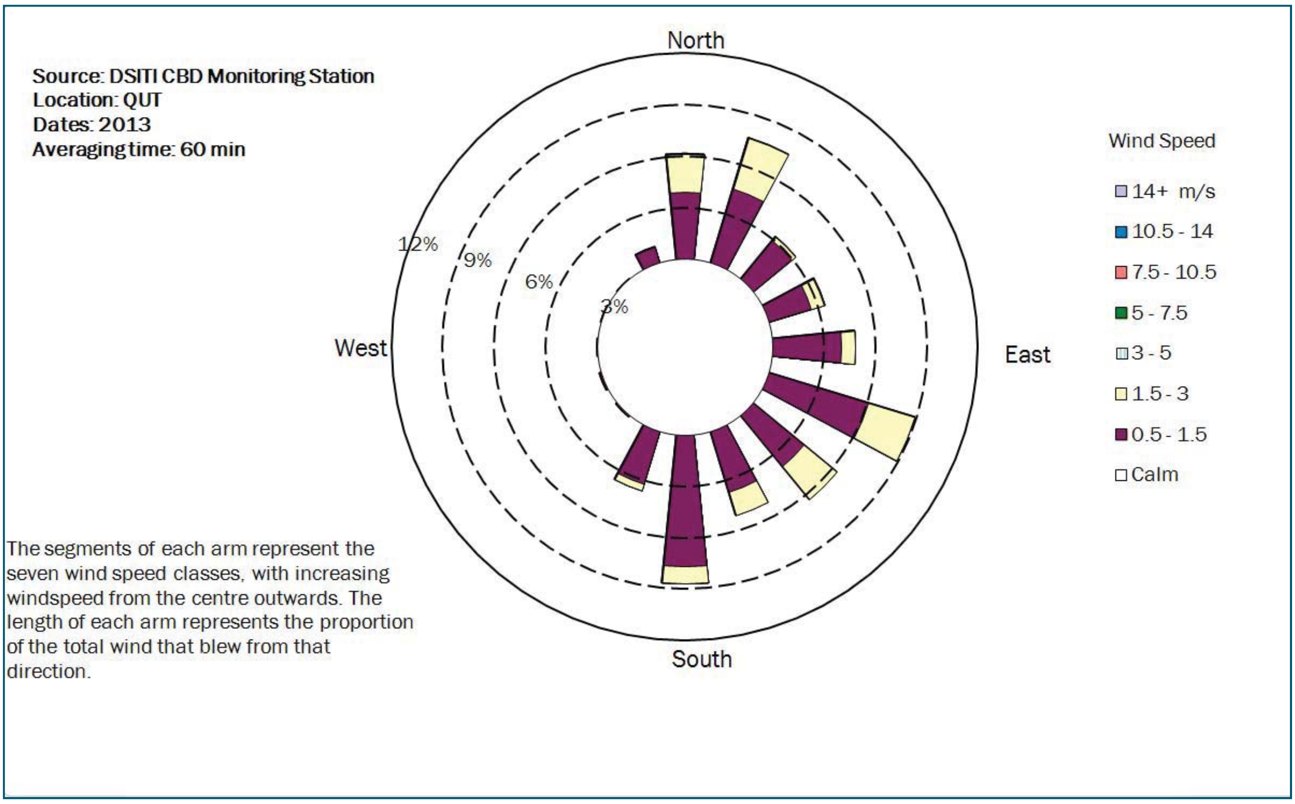

Figure 5.2 Wind Rose for DSITI Brisbane CBD Monitoring Station for Year 2013

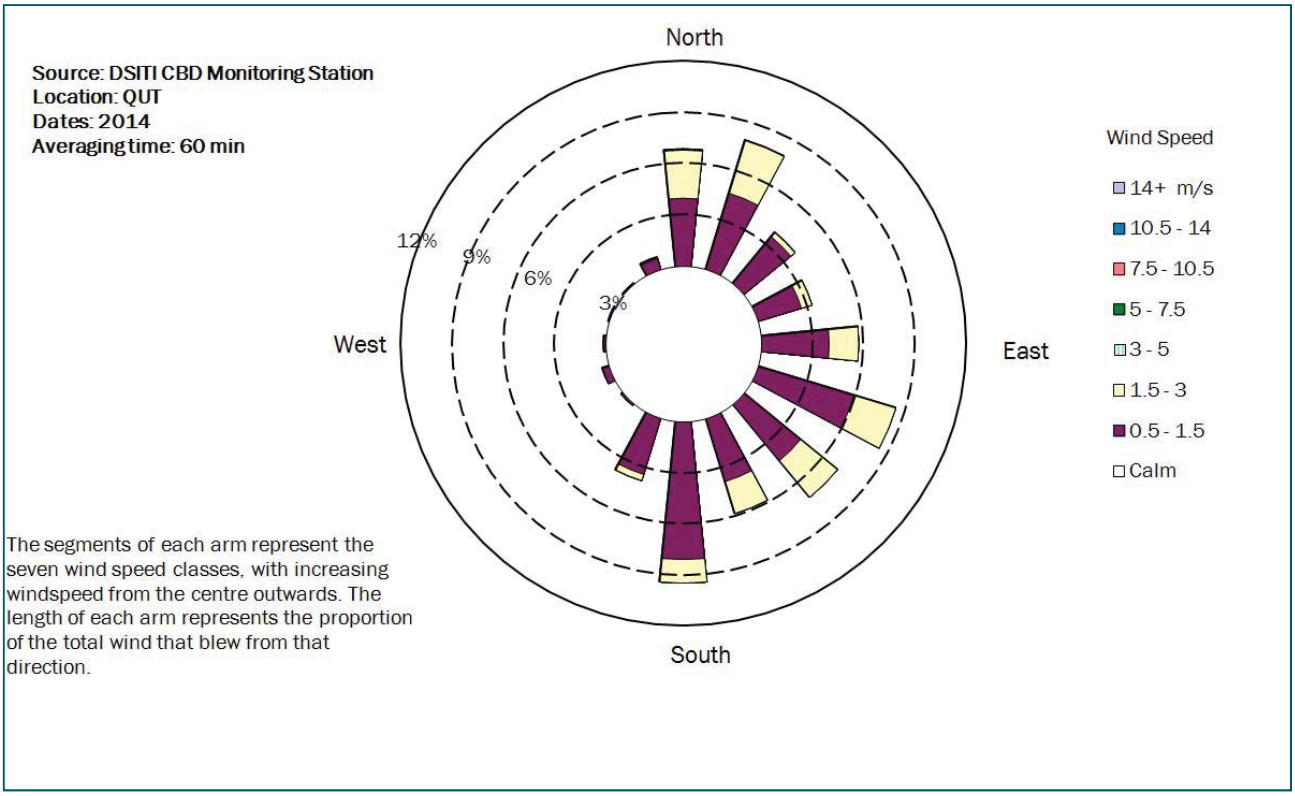

Figure 5.3 Wind Rose for DSITI Brisbane CBD Monitoring Station for Year 2014

5.3 Temperature, Rain and Humidity (BOM Brisbane City)

Long-term weather and climate data from the BOM Brisbane City weather station are summarised in **Table 5.1.**

Table 5.1 Climate Statistics for Brisbane City (1999 to 2016 for Temperature and Rainfall, 1999 to 2010 for Humidity)

Month	Mean Daily Maximum Temperature (°C)	Mean Daily Minimum Temperature (°C)	Mean Monthly Rainfall (mm)	Highest Monthly Rainfall (mm)	Lowest Monthly Rainfall (mm)	Mean 9am Relative Humidity (%)	Mean 3pm Relative Humidity (%)
Jan	30	21	148	343	5	63	57
Feb	30	21	143	275	16	66	59
Mar	29	20	110	247	12	66	57
Apr	27	17	67	195	3	67	54
May	24	14	70	249	10	66	49
Jun	22	12	56	122	6	70	52
Jul	22	10	24	91	0	64	44
Aug	23	11	41	108	0	59	43
Sep	26	14	30	104	1	58	48
Oct	27	16	71	306	6	56	51
Nov	28	19	105	327	16	59	56
Dec	29	20	133	480	19	60	57
Mean	26	16	83	237	8	63	52

5.4 Overview of Ambient Air Quality Data

Monitoring data from similar locations have been used to represent the existing background. The estimated background concentrations have not been included in the modelling runs but are provided with the results so that the cumulative impact can be compared to criteria. In the absence of site-specific continuous monitoring data, a single value is normally used to represent background. For averaging periods of 24 hours or less, the 70th percentile is typically used (refer Brisbane City Plan 2014 Air Quality Planning Scheme Policy).

The Department of Science, Information Technology and Innovation (DSITI) operates numerous ambient air monitoring stations in the vicinity. For the purposes of this assessment, air quality data from three of these stations (Brisbane CBD, Rocklea and Springwood) have been applied as background concentrations. The Brisbane CBD station is elevated on a building (at Queensland University of Technology), and the Rocklea station has a large buffer from local sources, so these are considered relevant to background. Due to its proximity, the Brisbane CBD station is preferred over Rocklea, and therefore Rocklea data has only been used for those pollutants not measured at the CBD station. The Springwood station has been used for pollutants not measured at the other stations.

The South Brisbane and Woolloongabba stations are in close proximity to major roads. This assessment uses modelling of the roads in the vicinity of QWBIRD to predict the impacts of those roads. The background levels that are to be added to those predictions should therefore not be influenced by nearby roads. Thus data from these two stations is not appropriate for use in this assessment.

Discussion of the ambient air quality monitoring data available from the nearby DSITI monitoring stations is contained within the following sections. Historical reports of DSITI data do not provide the 70th percentile so it is necessary to analyse raw data purchased from DSITI to obtain that. Recently, data from the DSITI monitoring stations has become freely available on the Queensland Government data website (https://data.qld.gov.au), with this data including 70th percentile concentrations. For the purposes of the assessment, for years when 70th percentile data is unavailable, the higher 75th percentile data has been used.

ASK has previously undertaken ambient air quality monitoring at 1 William Street (adjacent Riverside Expressway). In addition to the DSITI monitoring station data, data obtained from this monitoring is also discussed in **Section 5.10**.

5.5 DSITIA Brisbane CBD Monitoring Station

The DSITI monitoring station for the Brisbane CBD is located at the Queensland University of Technology (QUT). This station is the closest monitoring station to the subject site. Data from this monitoring station is presented in **Table 5.2.**

Table 5.2 shows measured concentrations of CO and NO_2 over the available period (1999 to 2004), and concentrations of PM_{10} particulates over a longer period (1999 to 2014). The averaged 75th percentile 1-hour NO_2 background concentration is 32 μg/m^3, and the annual average background concentration is 23 μg/m^3. The averaged maximum 8-hour background concentration of CO is 3875 μg/m^3. The averaged 75th percentile 24-hour PM_{10} background concentration between 1999 - 2005 is 20 μg/m^3, the averaged 70th percentile 24-hour PM_{10} background concentration between 2007 - 2014 is 19 μg/m^3.

The 90th percentile 1-hour NO_2 background concentration is included to address TMR requirements for assessment of roads and is recommended for assessment of the ground level across the QWBIRD development.

Table 5.2 Concentrations Recorded by DSITI Air Quality Monitoring Station in the Brisbane CBD.

Year	75th percentile 1-hour average NO_2 concentration (µg/m^3)	90th percentile 1-hour average NO_2 concentration (µg/m^3)	Annual average NO_2 concentration (µg/m^3)	Maximum 8-hour average CO (µg/m^3)	75th percentile 24-hour average PM_{10} concentration (µg/m^3)	70th percentile 24-hour average PM_{10} concentration (µg/m^3)
1999	26	36	19	6642	18	-
2000	28	40	21	3092	21	-
2001	36	51	26	3779	21	-
2002	32	47	23	2863	23	-
2003	34	47	24	3092	19	-
2004	34	49	24	3779	20	-
2005	-		-	-	19	-
2006	-		-	-	-	-
2007	-		-	-	-	18
2008	-		-	-	-	18
2009	-		-	-	-	20
2010	-		-	-	-	-
2011	-		-	-	-	17
2012	-		-	-	-	17
2013	-		-	-	-	24
2014	-		-	-	-	16
Average	32	45	23	3875	20	19

5.6 DSITI Rocklea Monitoring Station

The DSITI monitoring station at Rocklea is located in the grounds of the Oxley Creek Common, and is located approximately 1.6 kilometres from the Ipswich Motorway and 600 metres from light industry. Data from this monitoring station is presented in **Table 5.3**.

Table 5.3 shows measured concentrations of $PM_{2.5}$ (24 hour average and annual average) over the available period (1999 to 2014). The averaged 75th percentile 24 hour $PM_{2.5}$ background concentration is 8 µg/m^3, and the annual average background concentration is 5.5 µg/m^3.

Table 5.3 Concentrations Recorded by Queensland DSITI Air Quality Monitoring Station at Rocklea

Year	75th percentile 24-hour average $PM_{2.5}$ concentration (µg/m^3)	Annual Average $PM_{2.5}$ concentration (µg/m^3)
1999	10	3.5
2000	10	5.0
2001	7	5.8
2002	8	5.5
2003	7	6.1
2004	10	5.1
2005	8	6.5
2006	5	4.6
2007	6	4.1
2008	8	4.4
2009	8	10.9 [1]
2010	7	8.2
2011	8	-
2012	9	-
2013	8	6.6
2014	7	5.8
Average	8	5.5

Note: 1. This measured concentration was not included in the calculation of the average as it was noted in the DSITI monitoring report that dust storms significantly influenced measured particulate concentrations.

5.7 DSITI Springwood Monitoring Station

The Springwood DSITI monitoring station has been located on the grounds of Springwood State High School since 1999. It is relevant to this project in undertaking monitoring of VOCs including benzene. The Springwood site would be expected to be affected by nearby road traffic sources and petroleum distribution activities and thus would represent a conservatively high background concentration. **Table 5.4** shows the annual average concentrations at Springwood over the period 2001 - 2013.

Table 5.4 Concentrations Recorded by Queensland DSITI Air Quality Monitoring Station at Springwood

Year	Annual average benzene (µg/m^3)
2001	2.6
2002	1.9
2003	2.6
2004	2.6
2005	2.6
2006	2.2
2007	2.9
2008	3.5
2009	1.3
2010	2.2
2011	3.5
2012	2.9
2013	2.6
Average	2.6

5.8 DSITI South Brisbane Monitoring Station

The DSITI South Brisbane monitoring station is located between the south-east freeway and the Stanley St/Vulture St off-ramp at Woolloongabba and was established in 2001. Although it is located in Woolloongabba it is identified as the South Brisbane site to avoid confusion with the Woolloongabba site located within the grounds of the Princess Alexandria Hospital. The pollutants measured on a continuous basis include:

- meteorological data
- carbon monoxide
- nitrogen oxides
- PM_{10}
- $PM_{2.5.}$

Due to its location between the south-east freeway and the Stanley St/Vulture St off-ramp, the South Brisbane site is expected to be heavily affected by road transport vehicles. As this assessment is assessing air emissions from transport vehicles, applying the measured pollutant levels from the South Brisbane station as background levels would over-estimate pollutant concentrations. Therefore the monitoring data available for the South Brisbane station has not been applied in this assessment.

5.9 DSITI Woolloongabba Monitoring Station

The DSITI Woolloongabba monitoring station is located in the grounds of the Princess Alexandria Hospital and was established in 1998. It is located close to the kerb of the busy Ipswich Road and hence is suited to peak traffic monitoring. It is located approximately seven metres from a large taller building, so the meteorological data is not suitable for dispersion modelling. The pollutants measured on a continuous basis include:

- meteorological data
- carbon monoxide
- nitrogen oxides
- PM_{10}

- $PM_{2.5}$.

As per the South Brisbane station, due to the Woolloongabba station's location adjacent to a busy road, monitoring data available for the Woolloongabba station has not been applied in this assessment.

5.10 1 William Street Monitoring

ASK has previously undertaken ambient air quality monitoring at both the DSITI South Brisbane air monitoring site and on-site at 1 William Street (ASK 2013). The monitoring data obtained at 1 William Street is influenced by traffic on the REX and other local roads and therefore is not suitable to represent background concentrations, but can be used as a broad comparison with the results of the modelling.

Initially, two Osiris dust monitors were placed at the South Brisbane site from 2pm on 21 March 2013 until 3pm on 22 March 2013. The purpose of this was to compare the two Osiris monitors directly with the DSITI TEOM used to measure $PM_{2.5}$. The Osiris monitors showed similar $PM_{2.5}$ results with each other and were comparable with the South Brisbane TEOM, although 17% higher.

At 1 William Street, monitoring was undertaken at two different heights: ground level and 18 metres above ground level. At each height an Osiris dust monitor was setup to measure particulates less than 2.5 microns ($PM_{2.5}$) with a passive Radiello sampler also installed for the measurement of nitrogen dioxide (NO_2). A boom lift was used to hold the Osiris monitor at 18 metres above ground level for the duration of the 7 day monitoring period. A third Radiello sampler was left at the South Brisbane air monitoring site for the same seven-day period to provide a comparison of the passive method compared to the DSITI chemiluminescence analyser.

The monitoring results and correlation analysis results are presented in **Table 5.5**. These are similar to the monitoring results from Rocklea and include the contribution from the local road network.

Table 5.5 Summary of Particulate Monitoring Results

Parameter	Osiris 2118 (Later setup at ground level at 1 William St)	Osiris 2387 (Later setup at 18 metres above ground at 1 William St)	DSITI TEOM monitor South Brisbane site
Average of 24-hr average measured $PM_{2.5}$	5.4 $\mu g/m^3$	6.6 $\mu g/m^3$	6.1 $\mu g/m^3$
Pearson's Correlation Coefficient against the TEOM 3-hr averages	0.50	0.43	1
Paired t-test against TEOM: probability of equal means	0.074	0.081	1
$PM_{2.5}$ concentration corrected to DSITI method	6.3 $\mu g/m^3$	7.7 $\mu g/m^3$	-

The Osiris monitors are well correlated with each other and reasonably correlated with the South Brisbane TEOM, indicating that they are responding to similar particulate events.

The maximum 24 hour $PM_{2.5}$ concentration measured was 11 $\mu g/m^3$ at 18 metres above ground on 30/3/13. The average at 18 metres above ground was 6.6 $\mu g/m^3$, at ground level 5.4 $\mu g/m^3$, and at South Brisbane was 6.1 $\mu g/m^3$.

The average measured value at 18 metres above ground is slightly higher (11% which is only just significant $p<0.1$) than the TEOM and at ground level slightly lower (9%) than the TEOM. The difference may be due to the relative height of exhausts on the freeway ramps. Thus, based on the particulate monitoring, concentrations at 18 metres may be 11% higher than those at the South Brisbane site.

The average measured NO_2 concentrations are provided in **Table 5.6**. **Table 5.6** shows that the concentrations measured by the Radiello passive sampler at the DSITI site was approximately half that measured by the DSITI NO_2 monitor. This difference is greater than observed in other studies of the method and is not considered as representative due to the short monitoring duration (7 days). However to be conservative, the results provided by the Radiellos at 1 William Street have been scaled up in **Table 5.6** by the ratio of the DSITI NO_2 monitor to Radiello result at the South Brisbane site. The higher concentration at 1 William Street is 0.011 ppm (21 µg/m^3). This is lower than the Brisbane CBD monitoring station results.

Table 5.6 Summary of NO_2 (ppm) Monitoring Results

Parameter	Radiello at Ground level at 1 William St	Radiello 18 metres above ground at 1 William St	Radiello at DSITI site	DSITI NO_2 monitor permanently installed at DSITI site
Average measured NO_2	0.005	0.004	0.006	0.013
NO_2 concentration normalised (based on DSITI NO_2 Monitor)	0.011	0.008	0.013	0.013

5.11 Summary of Estimated Background Levels

Based on the discussions in the preceding sections, the expected background air quality for key pollutants has been summarised with the estimated concentrations listed in **Table 5.7**. The existing air quality in the area is considered to be generally acceptable with occasional peaks in particulate concentrations due to bushfires, hazard reduction burning or dust storms.

Table 5.7 Background Air Quality

Pollutant	Averaging Time	Estimated Background Concentration (µg/m^3)
NO_2	1 hour	45 (ground level) 32 (elevated above ground level)
	1 year	23
PM_{10}	24 hours	19
$PM_{2.5}$	24 hours	8
	1 year	5.5
CO	8 hours	3875
Benzene	1 year	2.6

6. Assessment Methodology

6.1 Overview

In order to predict what happens to the pollutants after they are emitted to air, a mathematical model is used to simulate their dispersion and deposition. It is accepted by regulatory agencies that this type of modelling has associated uncertainties. These are normally addressed by using statistics over long simulation times, and deriving emission rates based on published emission factors or data representing high emission conditions.

With sources close to ground level such as roads, the critical wind conditions tend to be near-calm i.e. low wind speeds. Gaussian plume models such as Ausplume and Aermod cannot model calm conditions and have low accuracy in light winds, especially in valleys where katabatic flows are present and where drainage flows turn to follow the valley. Calpuff, being a non-steady-state Lagrangian puff model, is able to simulate stagnation over time, which is critical in near-calm conditions. Its meteorological pre-processor Calmet performs diagnostic simulation of terrain effects on the wind field. It has a specific slope flow algorithm that predicts katabatic flows (Scire, J.S. & Robe, F.R., 1997).

The predictions undertaken for the assessment of road traffic emissions are based on the following method:

- The modelling scenarios for the assessment were derived based on road traffic volume information provided by TTM.
- Emission estimates were based on the vehicle emission model Copert and fleet configuration data provided by DSITI as described in **Section 6.6**.
- Prediction of input meteorology was completed using TAPM v4 developed by the CSIRO Division of Atmospheric Research. TAPM has a prognostic 3 dimensional meteorological component which can be used to generate hourly meteorological data for input into dispersion models. Calmet was used to fit the windfields to the local terrain.
- Prediction of particulate and gas concentrations was undertaken using Calpuff.

6.2 Modelling Scenarios

There are two relevant scenarios for this assessment of the development:

- A projected baseline scenario is used in this report for the Plan of Development to assess anticipated air quality ten years into the future (nominally 2031), without the development proceeding. Thus any future development can be compared to this scenario without presumption of development details.
- A future development scenario has been developed based on traffic modelling by TTM and the potential broad structural form of the IRD buildings. This has allowed assessment of the impacts of the QWBIRD on dispersion of traffic emissions by comparison against the baseline scenario and criteria. It also provides the basis for modelling of proposed point sources in individual precincts for subsequent compliance assessments.

6.3 TAPM Meteorological Modelling Configuration

6.3.1 TAPM Fundamentals

The meteorological component of The Air Pollution Model (TAPM) was used to provide wind fields over the region. Wind speed and direction has been monitored at the nearby DSITI South Brisbane monitoring station and this data was assimilated into the modelling. Wind data from the Brisbane City BoM station has been found to be not representative of winds outside its immediate vicinity and so has not been used.

The databases required to run TAPM are provided by CSIRO and include global and Australian terrain height data, vegetation and soil type datasets, sea surface temperature datasets and synoptic scale meteorological datasets.

The Australian terrain data is in the form of 9-second grid spacing (approximately 0.3 kilometres) and is based on data available from Geosciences Australia. Australian vegetation and soil type data is on a longitude/latitude grid at 3-minute grid spacing (approximately 5 kilometres) and is public domain data provided by CSIRO Wildlife and Ecology.

The synoptic scale meteorology dataset used is a six-hourly synoptic scale analysis on a longitude/latitude grid at 0.75 or 1.0-degree grid spacing (approximately 75 kilometres or 100 kilometres). The database is derived from US NCEP reanalysis synoptic product.

TAPM dynamically fits the gridded data for the selected region to finer grids taking into account terrain, surface type and surface moisture conditions. It produces detailed fields of hourly estimated temperature, winds, pressure, turbulence, cloud cover and humidity at various levels in the atmosphere as well as surface solar radiation and rainfall.

6.3.2 TAPM Configuration

The year 2007 has been used for the meteorological simulation as it experienced typical weather conditions, unlike more recent years which experienced unusually high rainfall periods, and less stable conditions.

TAPM was setup using four nested 30 x 30 grids, centred on latitude 27°28.5' south, longitude 153°0.5' east, which are coordinates at West End not far from the centre of Brisbane. The four nested grids were as follows:

- 420 km x 420 km with 30 km resolution
- 105 km x 105 km with 10 km resolution
- 30 km x 30 km with 3 km resolution
- 9 km x 9 km with 1 km resolution.

Thirty (30) vertical levels were used with lower level steps at 10, 25, 50, 75 and 100 metres up to 8 kilometres in altitude. This is greater than normal number of vertical layers in order to provide better resolution of vertical layers. Boundary conditions on the outer grid were derived from the synoptic analysis. Non-hydrostatic pressures were ignored due to the gentle terrain and moderate resolution.

TAPM land use data was updated using the latest aerial photography available being May 2015 from the Queensland Globe overlay for Google Earth from the Department of Natural Resources & Mines.

Meteorological data from the DSITI South Brisbane monitoring station was available for assimilation into the model run. A wind rose of this data is shown in **Figure 6.1**. TAPM was run without assimilation of this data and the wind rose for the same period is shown in **Figure 6.2**. The two wind roses show a similar pattern except TAPM predicted a lower proportion of calm conditions (which is typical) and low wind speeds from the south-west.

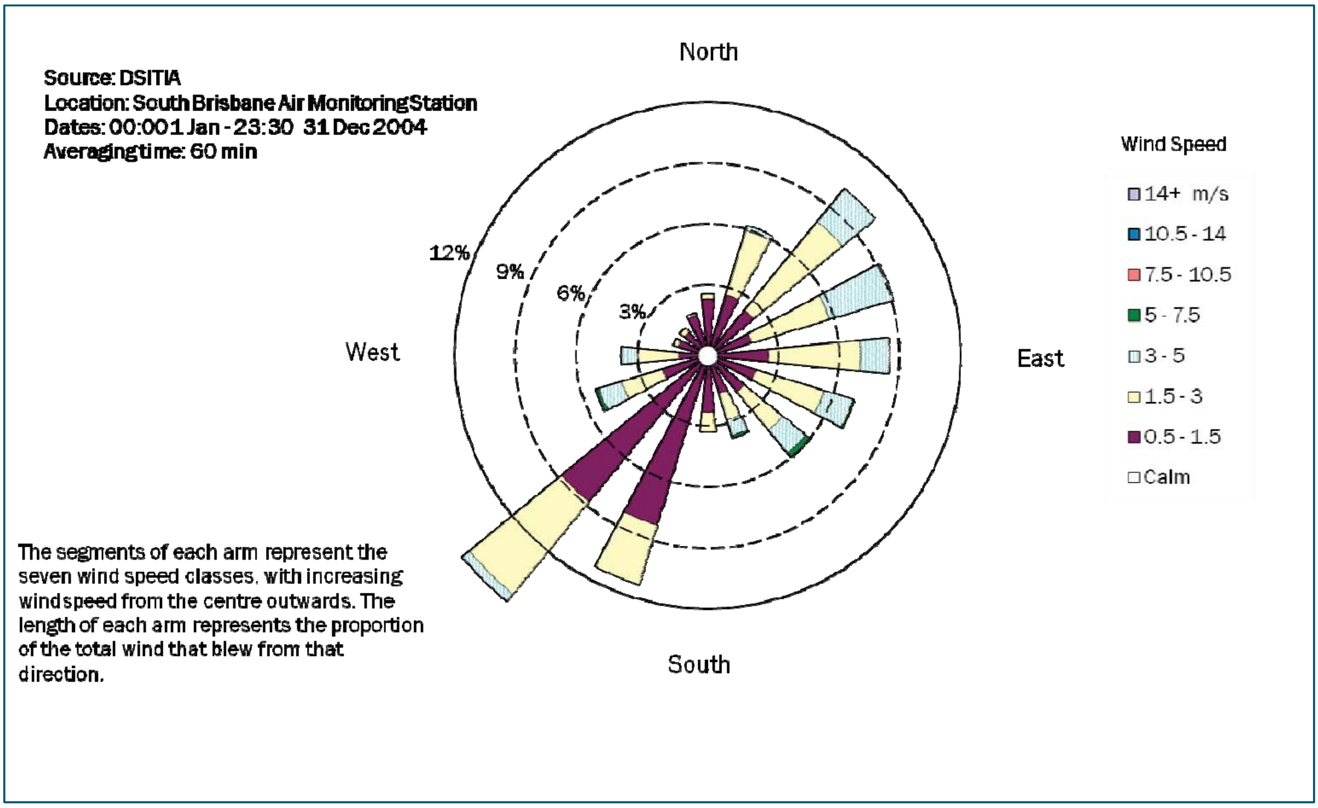

Figure 6.1 Wind Rose of DSITI South Brisbane Air Monitoring Station 2007 Data

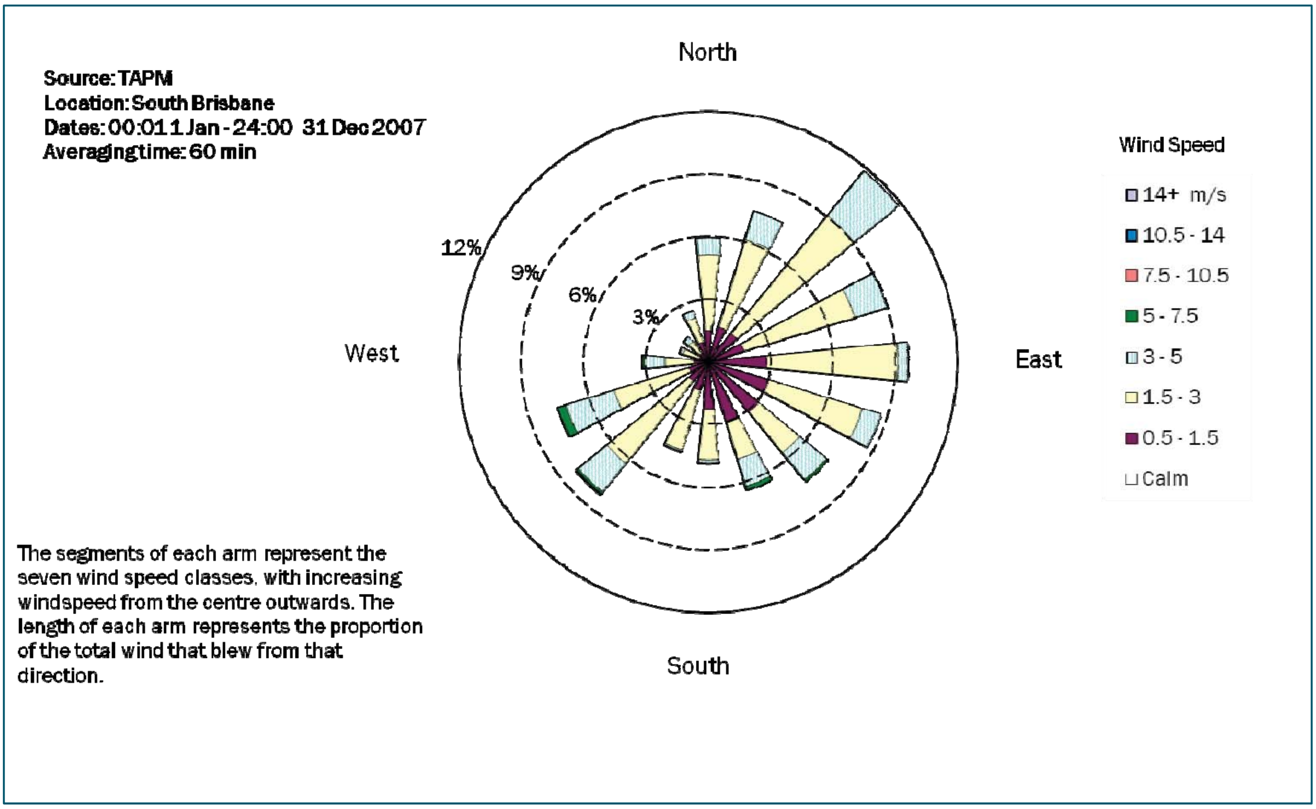

Figure 6.2 Wind Rose from TAPM for 2007 without Assimilation of DSITI Data

6.3.3 TAPM Validation

The TAPM GIS visualisation tool was used to examine the final windfields generated by the model. The last few hours of the year were reviewed to ensure the model completed the run correctly. The windfields in the inner grid throughout the month of June were examined in detail to understand the local wind patterns, influence of topography, and to ensure that the data assimilation had progressed smoothly. The following patterns were observed:

- Topography did not substantially influence wind conditions.
- Wind in the vicinity of the South Brisbane observational station (near the centre of the domain) was mostly consistent with the remainder of the inner grid. Wind speed near the centre was typically higher in the day time and wind direction had slightly more fluctuations, but directions and speed both had consistent phase.
- Morning winds were mostly calm or light south-westerlies.
- Afternoon winds were moderate to strong south to south-westerlies.
- Night winds were mostly calm or light southerlies.
- At times of the year other than winter, south-easterlies were more common.

6.4 Graphical Information System

For the purpose of providing topographic data for the detailed modelling, the coordinates of a rectangular grid representative of the area around the proposed site were derived using WGS84 coordinates from Google Earth Professional. The south-west corner coordinates were (501300, 6959800), north-east corner coordinates were (503700, 6962200) and the grid interval was 40 metres.

The WGS84 and GDA94 grids are identical to an accuracy of less than one metre. All coordinates in this report are rounded off to the nearest metre and are valid for both coordinate grids.

Gridded topographic data for Calmet was created using Global Mapper to process data from Geosciences Australia using the Kriging method. The Geosciences Australia data used was Shuttle Radar Topography Mission (SRTM) elevations on a 1-second grid (approximately 30 metre spacing). There are three versions of this data available to the public:

- Digital Elevation Model (DEM) 1.0 is the raw data.
- DEM-S is smoothed to remove artefacts like trees, and has better vertical accuracy and should be the best version for most applications.
- DEM-H is smoothed with overlayed hydrological channels to ensure flow connectivity and may be better in steep terrain. However it may have horizontal errors up to 200 metres in flat terrain.

The three data sets were all loaded into the Global Mapper software to determine which was best for this location. The DEM-S data was chosen in order to minimise the influence of buildings (which were included separately in the model as sub-grid terrain features).

6.5 Calmet Meteorological Modelling

6.5.1 Calmet Configuration

The model was run over the full year of 2007 based on a 3-dimensional grid produced using the Caltapm utility program to convert TAPM data to MM5 format suitable for Calmet to read. The Calmet grid was set to a grid spacing of 60 metres and 40 by 40 grid points. Twelve vertical layers were modelled with cell face heights of 0, 20, 40, 80, 160, 300, 450, 650, 900, 1200, 1700, 2300, and 3200 metres. This is greater than normal number of vertical layers in order to provide better resolution of vertical layers.

Mixing height calculation parameters were set to default values including a minimum overland mixing height of 50 metres and a maximum mixing height of 3000 metres. Temperature prediction parameters were set to default.

Divergence minimisation was used. The critical Froude number was set to 1. Slope flow effects were included. The radius of influence of terrain features was set to 1 kilometres being approximately half the distance between ridges.

The output from Calmet was a three dimensional grid of wind-field data for incorporation into Calpuff.

6.5.2 Calmet Results

The frequency distributions of occurrences of winds for each direction sector and for each wind class (wind rose) as generated by Calmet are illustrated in **Figure 6.3**. **Figure 6.3** shows a predominance in winds from the south-west and the north-east, similar to the wind rose produced by TAPM and the DSITI observations.

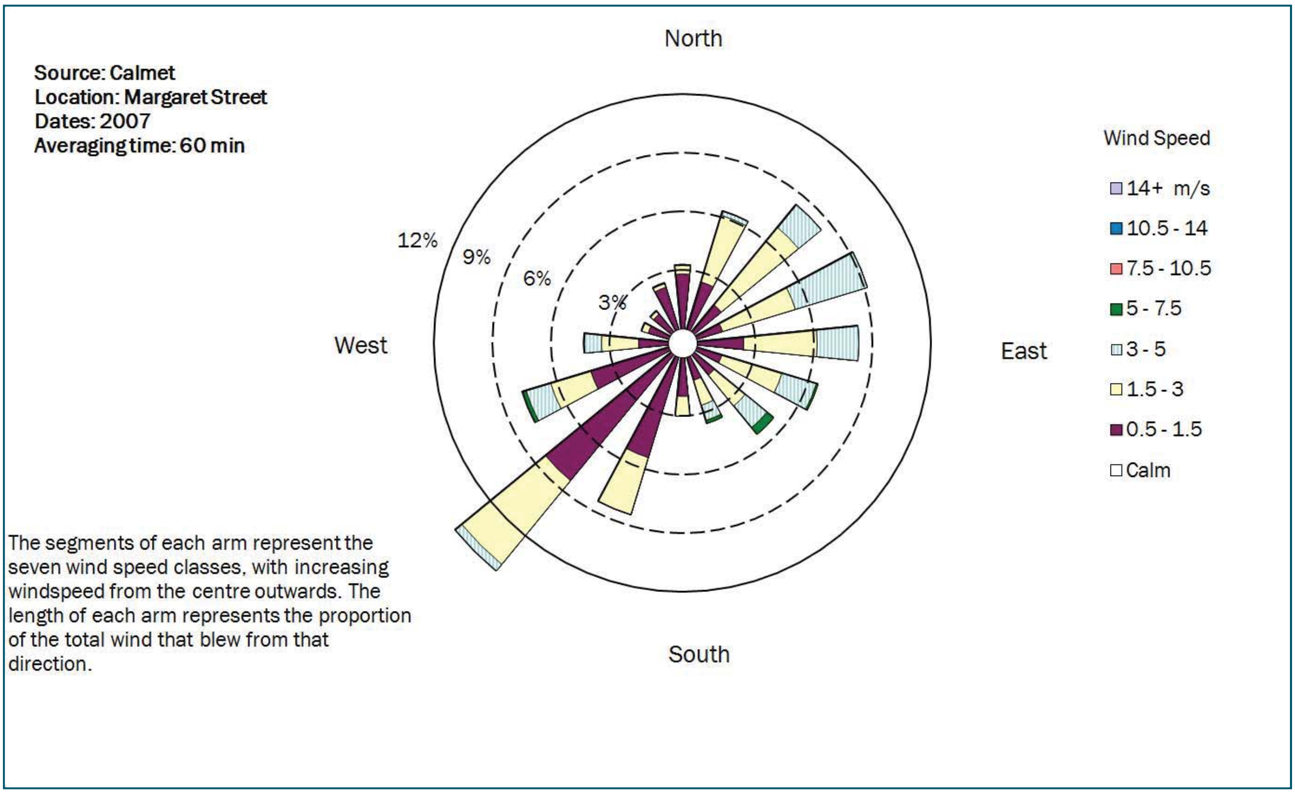

Figure 6.3 Wind Rose for 2007 from Calmet

Figure 6.4 and **Figure 6.5** show, respectively, the frequency of stable conditions throughout the day, and the variation of mixing height throughout the day. Day time conditions are either neutral or unstable.

In the morning the mixing height rises up gradually reaching an average of approximately 1.2 kilometres by the afternoon, then reforming at ground level again at nightfall.

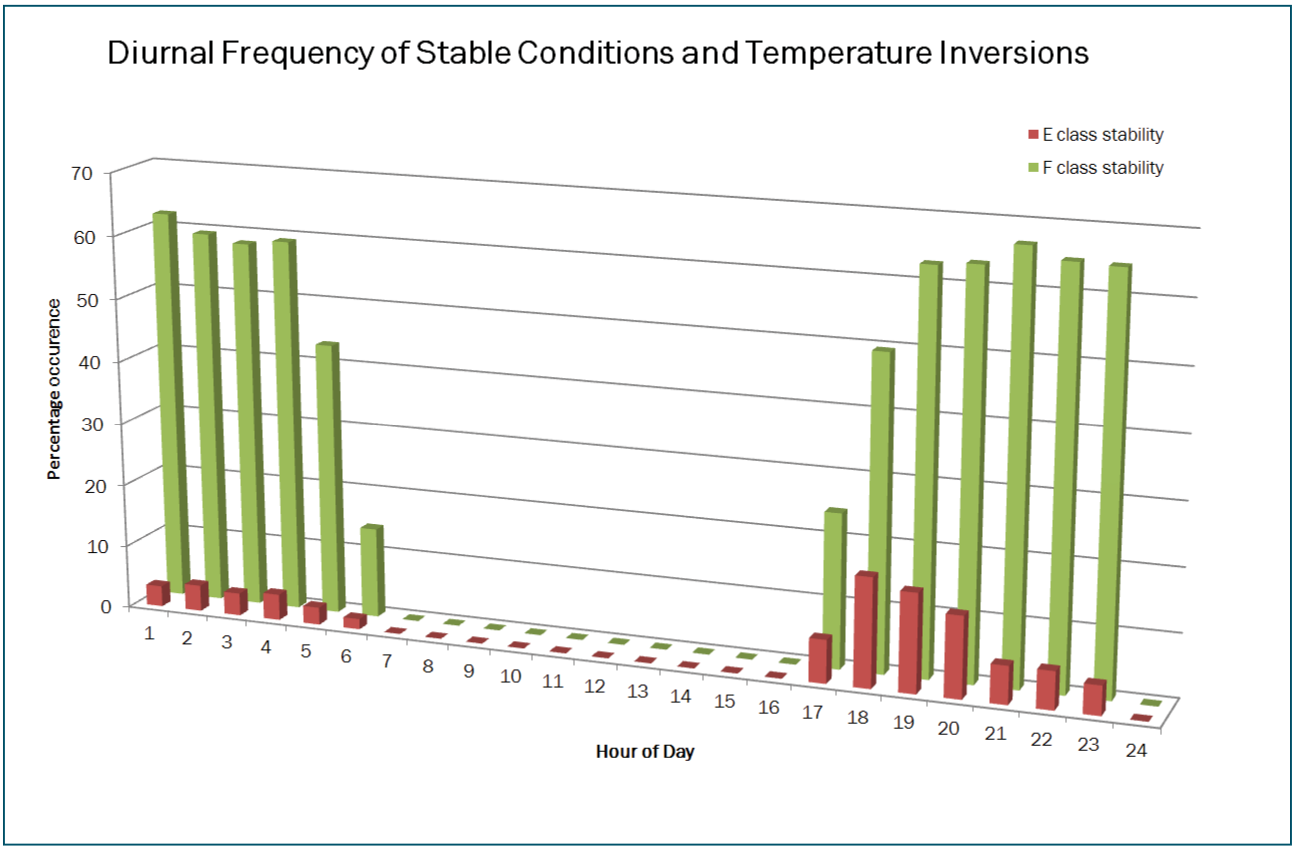

Figure 6.4 Diurnal Frequency of Stable Conditions

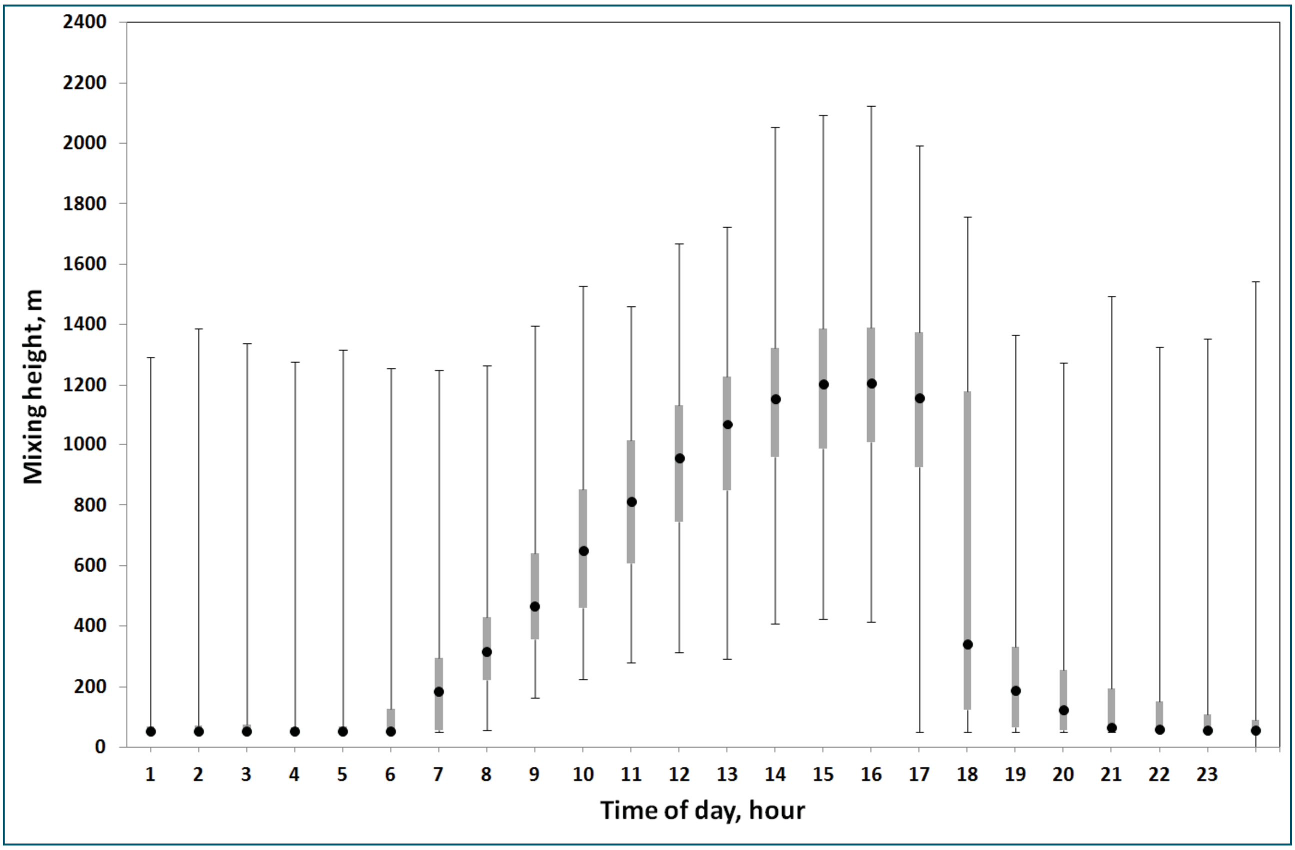

Figure 6.5 Prediction of Mixing Height from Calmet Model

6.6 Road Traffic Emission Inventory

6.6.1 Roads Included

An air quality assessment of roads is triggered by the proximity of the REX to the development site since it carries more than 50,000 vehicles per day and is less than 40 metres from the site and potential sensitive use locations. In addition, Alice Street and Victoria Bridge also carry more than 20,000 vehicles per day and are within 20 metres of the site. Since cumulative impacts from other sources need to be considered, other local roads in the vicinity have also been included (with the exception of Stephens Lane which carries very few vehicles). Roads included are:

- Riverside Expressway (REX) also known as Pacific Motorway
- William Street
- George Street
- Alice Street
- Margaret Street
- Mary Street
- Charlotte Street
- Elizabeth Street
- North Quay
- Victoria Bridge.

6.6.2 Inventory

Modelling of road traffic emissions has been undertaken using traffic data provided by TTM. An emission inventory for emissions from vehicle traffic has been developed using the emission calculation software COPERT Australia. To ensure the emission factors determined by the COPERT software were accurate, ASK has obtained vehicle population and activity data for Queensland from DSITI. The data provided by DSITI included the following information based on the year 2010:

- motor vehicle population
- annual travel (km/year) per individual vehicle and per vehicle type
- total fuel use
- fuel data and fuel quantity.

Emission calculations considered fuel evaporation, mileage degradation, fuel effect and the influence of air-conditioning on emissions (i.e. increase in emissions due to engine workload). The calculated emission factors include both hot and cold engine emissions. The fuel quality specification was based on the year 2009, which is the most recent year available in the software.

COPERT calculates emission rates for pollutant species based on vehicle type and total kilometres travelled. However, the heavy vehicle percentage (or commercial vehicle percentage) included in COPERT is not consistent with heavy vehicle percentage in the CBD. Therefore, to determine the emission factors, emissions from light vehicles and heavy vehicles were determined separately and then combined based on the relative percentages.

6.6.3 Input Data

The traffic volumes used in the model were based on the afternoon peak hour volumes as presented in **Appendix C**. The approach assumed the diurnal distribution as shown in **Table 6.1**, which is that provided by TTM for the REX.

Table 6.1 Assumed Diurnal Distribution of Traffic (percentage per hour)

Night (12–6am)	Morning day (6–7am)	Morning peak (7–9am)	Day (9am–4pm)	Evening peak (4–6pm)	Evening (6pm–8pm)	Night (8pm–12am)
2	4	9	4	9	4	2

Heavy vehicle percentages and average speeds were taken from afternoon peak hour surveys as listed in **Appendix C**.

6.6.4 Road Source Configuration

The "road" source type is a new feature of Calpuff v7 and was used in this assessment. The mixing zone width for each road segment was based on the standard lane width of 3.5 metres, plus 3 metres either side. Sigma y is then calculated as the mixing zone width divided by 4.3. Sigma z is the average vehicle height (assumed to be 2 metres due to the large number of buses) divided by 2.15.

6.6.5 Gradients

The road gradient correction factors were derived from a TMR calculation spreadsheet using the following categories:

- 0 to 0.5%
- 0.5 to 4%
- 4 to 6%.

The Queens Wharf Road gradient was calculated to be 1.9 % (averaged over its length). Some ramps to the REX were also assumed to have a gradient in the 0.5 to 4% category as listed in **Appendix C**. All other roads were assumed to have gradients from 0 to 0.5%.

6.7 Building Influence

Building downwash is routinely used in dispersion modelling to calculate the influence of building wake on point source emissions. However, this is not appropriate for instances where the receptors and sources are both in close proximity to the building, as it does not simulate the influence of the building on the wind vectors.

Buildings were approximated in the Calpuff model as sub-grid terrain features using the OPTHILL pre-processor. This takes a symmetric representation of the building along two axes and fits an inverse polynomial function to approximate the building shape. This data is then use by Calpuff to estimate concentrations around the building profile according to the methods of the Complex Terrain Dispersion Model (CTDM).

6.8 Calpuff Configuration

The three dimensional wind fields from Calmet were entered into Calpuff for the full year 2007. Calpuff was run over a smaller computational grid (780 metres x 720 metres) with spacing of 60 metres, and with receptors gridded over a smaller grid of 480 metres by 600 metres. Nested grid receptors were used to provide more detailed resolution (20 metres) over a 280 metre by 280 metre grid.

Chemical transformation was not included in the modelling which causes an over-prediction of airborne concentrations. Deposition was not modelled which will tend to over predict slightly.

Wind speed profile was set to the Industrial Source Complex (ISC) Urban-2 exponents. Calm conditions were not invoked until the wind speed dropped below 0.2 m/s. Transitional plume rise, stack tip downwash and partial penetration of boundary layers were included. Briggs rise algorithm was used.

The emissions were modelled as puffs (not slugs) since there are no area sources. Puff-splitting was turned off and the maximum number of puffs released per time step was set to 60.

Dispersion coefficients were derived by the model using turbulence generated by micrometeorology. The Heffter curve was used to compute time-dependent dispersion beyond 550 metres. The partial plume height adjustment method was used to allow winds to approach hills as terrain increases. Coefficients were set to 0.5 for unstable and neutral conditions, and 0.35 for stable conditions allowing the plume to approach the ground faster in stable conditions.

The minimum turbulence velocity, sigma v, was set to 0.2 m/s.

6.9 Nitrogen Dioxide Modelling

6.9.1 Overview

Most of the NO_x emitted by combustion engines are in the form of nitric oxide (NO). This reacts with other gases in the atmosphere to form NO_2. Because the fraction of NO_2 emitted by vehicles is highly dependent on the configuration of each individual vehicle, emission factors are only available as NO_x.

A typical proportion of NO_2 in urban airsheds during peak concentration events is 20%. This includes both regional sources and local sources. The contribution from regional sources would have built up over a longer time period i.e. NO emissions would have had substantial time to react to form NO_2. In a rural environment, the proportion would be lower.

The rate of conversion from NO to NO_2 is related to a large number of factors. The most critical are ozone concentration, hydrocarbon concentration and the amount of sunlight, which increases the rate of the reverse reaction. Both hydrocarbons and ozone can be responsible for oxidising NO to form NO_2. Generally, the conditions that favour NO_2 formation are when ozone concentrations are high and sunlight low. This scenario could occur in the late afternoons following a clear day. In rural areas, ozone concentrations are low, so NO_2 formation is not favoured.

As a guide, under worst conditions, ozone can oxidise approximately 5% of NO in 10 minutes. Oxidation by hydrocarbons is more dependent on pre-existing quantities of different species. Over time periods longer than 10 minutes, polluted air will be substantially mixed with the regional background air.

6.9.2 Janssen Method

The Janssen Method (Middleton et al 2007) is a popular technique for estimating conversion of nitrogen oxides to NO_2 downwind of a source. It is based on aircraft-based measurements taken downwind of power stations. A plot of NO_2/NO_x ratios against distance for different ozone concentrations is provided as Figure 1 in Middleton et al (2007), allowing application for a wide range of distances from the source. Brisbane City Council (BCC) has requested that this method be used for air quality assessments in Brisbane, and it has been applied to a range of different urban air emission sources.

6.9.3 Conversion Relevant to this Study

The distance from the nearby road network to the development is less than 200 metres. Typical ozone concentrations in Brisbane are 20 ppb. Based on the Middleton et al (2007) plot, the ratio of nitrogen dioxide is less than 10% inside 200 metres and therefore a conversion rate of 10% has been adopted. This is within the range recommended by TMR (2014).

6.10 Calpost Processing

Following dispersion modelling, contours of pollution concentrations were generated using the GIS software Surfer 13. Surfer was then used to overlay the model outputs onto a scan of a rectified aerial photograph of the area. Contours shown in this report were generated using the Kriging method with a grid spacing of 3.6 metres and contours were created with smoothing set to high.

7. Road Network Dispersion Modelling Results

7.1 Limitations

The uncertainties associated with this type of assessment are normally only dealt with in a qualitative manner, but include:

- emission inventory estimation techniques
- source strength variability
- variability in emission rates and traffic over time
- meteorological data variability
- inherent uncertainty in dispersion modelling.

Typically 95% confidence intervals are estimated to require a multiplicative factor of 2 or 3. In this case, the uncertainty is mostly due to assumptions regarding the vehicle fleet. This has been addressed by utilising vehicle emission data for the 2010 fleet, using the afternoon peak traffic speed throughout the day and other conservative modelling assumptions.

Note that it would be appropriate for future assessments to utilise updated fleet data and projections to future years.

7.2 Suspended Particulate Results

The predicted concentrations at sensitive receptors from road traffic are shown in **Table 7.1** along with the criterion and the estimated background levels. The estimated background levels are shown in the tables separately and have not been added to the predicted concentrations shown. The cumulative impact is assessed by adding the background to the predicted values provided in the data tables.

Table 7.1 Predicted Suspended Particulate Concentrations

Receptor ID#	Height above ground (m)	Maximum 24 hour Average PM_{10} (µg/m^3)		Maximum 24 hour Average $PM_{2.5}$ (µg/m^3)		Annual Average $PM_{2.5}$ (µg/m^3)	
Criterion		50		25		8	
Background		19		8		5.5	
Scenario		Baseline	QWBIRD	Baseline	QWBIRD	Baseline	QWBIRD
Ground floor at 29 George St	1.5	6	6	5	5	1.5	1.4
Top of 29 George St	35	1	1	0	0	0.1	0.1
Rendezvous Studio Hotel, 103 George St	1.5	6	5	4	4	1.4	1.4
Oaks Casino Towers, 151 George St	1.5	6	6	4	5	1.6	1.5
East Corner, Treasury Hotel, 142 George St	1.5	6	6	4	4	1.8	1.7
South Corner, Treasury Hotel, 142 George St	1.5	9	8	7	6	2.2	2.1
West Corner, Treasury Hotel, 142 George St	1.5	9	8	7	7	2.3	2.2

Receptor ID#	Height above ground (m)	Maximum 24 hour Average PM_{10} (µg/m^3)		Maximum 24 hour Average $PM_{2.5}$ (µg/m^3)		Annual Average $PM_{2.5}$ (µg/m^3)	
William Street at proposed site of Tower 1	0	-	5	-	4	-	1.2
William Street at proposed site of Tower 4	0	-	5	-	4	-	1.4

From the results presented in **Table 7.1** it is evident that the predicted maximum 24 hour average PM_{10} and $PM_{2.5}$ concentrations with the inclusion of background are comfortably compliant with the criteria for all receptors. The predicted annual average concentrations for $PM_{2.5}$ including background are also compliant with the criteria for all receptors, but the predicted concentration at the west corner of the Treasury Hotel is 7.8 µg/m^3, close to the criterion of 8 µg/m^3 listed in **Table 4.4** This result is consistent with the monitoring undertaken at 1 William Street.

Based on these predictions, development in the nearby Miller Park and IRD Heritage precincts is to be designed such that detailed modelling does not predict exceedances at the Treasury Hotel.

The 24 hour and annual average $PM_{2.5}$ concentration contours across the site without the development, at ground level, including background, are presented in **Figure 7.1** and **Figure 7.2**. The annual average $PM_{2.5}$ contours with the QWBIRD development at ground level are presented in **Figure 7.3**.

The 24 hour average $PM_{2.5}$ concentration complies with the criterion. However the annual average exceeds the criterion at the Alice Street end of the precinct and at locations along William Street. It is noted that concentrations provided in tabular form are more accurate than the contours as they provide a prediction at a point in space, rather than a graphical interpolation.

For development within the areas indicated by red shading on **Figure 7.2** and **Figure 7.3** (exceeding criteria), the compliance assessment is to demonstrate meeting the criterion by appropriate separation distances, updated modelling data or sufficient treatment of air intakes to sensitive receptors.

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Queens Wharf Brisbane Baseline Scenario
Maximum 24hr Average Ground Level
PM2.5 Concentrations including Background (ug/m3)

N

0.0km 0.1km 0.2km 0.3km

MGA94 Z56

This figure should be read in conjunction with the data disclaimer at the front of this report.

Client
Destination Brisbane Consortium
(Image from Google Earth Pro)

Figure 7.1

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Queens Wharf Brisbane Baseline Scenario
Annual Average Ground Level
PM2.5 Concentrations including Background (ug/m3)

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Figure 7.2

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Queens Wharf Brisbane Development Scenario
Annual Average Ground Level
PM2.5 Concentrations including Background (ug/m3)

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Figure 7.3

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0.0km 0.1km 0.2km 0.3km

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7.3 Gas Concentration Results

The predicted gas concentrations at sensitive receptors are shown in **Table 7.2** along with the criterion and the estimated background levels. The estimated background levels are shown in the tables separately and have not been added to the predicted concentrations shown. The cumulative impact is assessed by adding the background to the predicted values provided in the data tables.

As shown in **Table 7.2** the worst affected receptor for all pollutant species is the west corner of the Treasury Hotel. The predicted cumulative (including background) 8 hour average carbon monoxide concentration at this receptor for the with-development scenario is 4,832 $\mu g/m^3$, well within the criterion of 11,000 $\mu g/m^3$. Ground level contours of the 8 hour average carbon monoxide concentrations are shown in **Figure 7.4**. The cumulative annual average benzene concentrationfor the same location and scenario is 3.5 $\mu g/m^3$, well within the criterion of 10 $\mu g/m^3$.

The cumulative maximum 1 hour NO_2 concentration at the Treasury Hotel for the with-development scenario is 145 $\mu g/m^3$, well within the criterion of 250 $\mu g/m^3$. The cumulative annual average NO_2 concentration for this location and scenario is 28 $\mu g/m^3$, well within the criterion of 62 $\mu g/m^3$. Ground level contours of the 1 hour NO_2 concentrations are also shown in **Figure 7.5**.

Annual average concentration contours have not been included as the predicted levels for both NO_2 and benzene are well within the criteria.

Table 7.2 Predicted Gaseous Concentration Levels

Receptor ID#	Height above ground (m)	Maximum 1 hour average NO_2 ($\mu g/m^3$)		Annual average NO_2 ($\mu g/m^3$)		Maximum 8 hour average CO ($\mu g/m^3$)		Annual average benzene ($\mu g/m^3$)	
Criterion		250		62		11,000		10	
Background		45 (ground level) 32 (elevated)		23		3,875		2.6	
Scenario		Baseline	QWBIRD	Baseline	QWBIRD	Baseline	QWBIRD	Baseline	QWBIRD
Ground floor at 29 George St	1.5	67	66	4	3	973	908	0.8	0.8
Top of 29 George St	35	8	8	0	0	66	67	0.1	0.1
Rendezvous Studio Hotel, 103 George St	1.5	63	60	3	3	846	726	0.8	0.7
Oaks Casino Towers, 151 George St	1.5	70	69	4	4	895	829	0.9	0.8
East Corner, Treasury Hotel, 142 George St	1.5	72	68	4	4	866	746	1.0	0.8

Receptor ID#	Height above ground (m)	Maximum 1 hour average NO_2 ($\mu g/m^3$)		Annual average NO_2 ($\mu g/m^3$)		Maximum 8 hour average CO ($\mu g/m^3$)		Annual average benzene ($\mu g/m^3$)	
South Corner, Treasury Hotel, 142 George St	1.5	97	97	5	5	1065	944	1.1	0.9
West Corner, Treasury Hotel, 142 George St	1.5	100	100	5	5	1086	957	1.1	0.9
William Street at proposed site of Tower 1	0	-	42	-	3	-	536	-	0.5
William Street at proposed site of Tower 4	0	-	42	-	3	-	572	-	0.7

7.4 Particulate Concentrations at Elevated Locations

The constraining criterion for impacts of the road network is the annual average $PM_{2.5}$ criterion. Therefore this criterion has been used to assess impacts at different heights above ground.

The model has been run at 10 metres above ground near the southern portion of the REX, which has a greater impact than the northern portion, to determine a suitable separation distance for sensitive uses from the REX. The resultant contours are shown in **Figure 7.6**. The predicted $PM_{2.5}$ concentrations at this height are well within the criterion in this vicinity and hence no specific separation distance is required from the REX.

To illustrate the predicted air quality at outdoor areas of the development, the dispersion model has also been run at 20 metres above ground, the height of the pedestrian bridge and River View Plaza. The resultant contours are shown in **Figure 7.7**. The predicted $PM_{2.5}$ concentrations at this height are well within the criterion across the development area and hence air quality is anticipated to be within the criteria.

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Queens Wharf Brisbane Baseline Scenario
Maximum 8 hr Average Ground Level
CO Concentrations including Background (ug/m3)

Client
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(Image from Google Earth Pro)

Figure 7.4

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0.0km 0.1km 0.2km 0.3km

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Queens Wharf Brisbane Baseline Scenario
Maximum 1 hr Average Ground Level
NO2 Concentrations including Background (ug/m3)

Figure 7.5

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Queens Wharf Brisbane Development Scenario
Annual Average 10 metres above Ground
PM2.5 Concentrations including Background (ug/m3)

Figure 7.6

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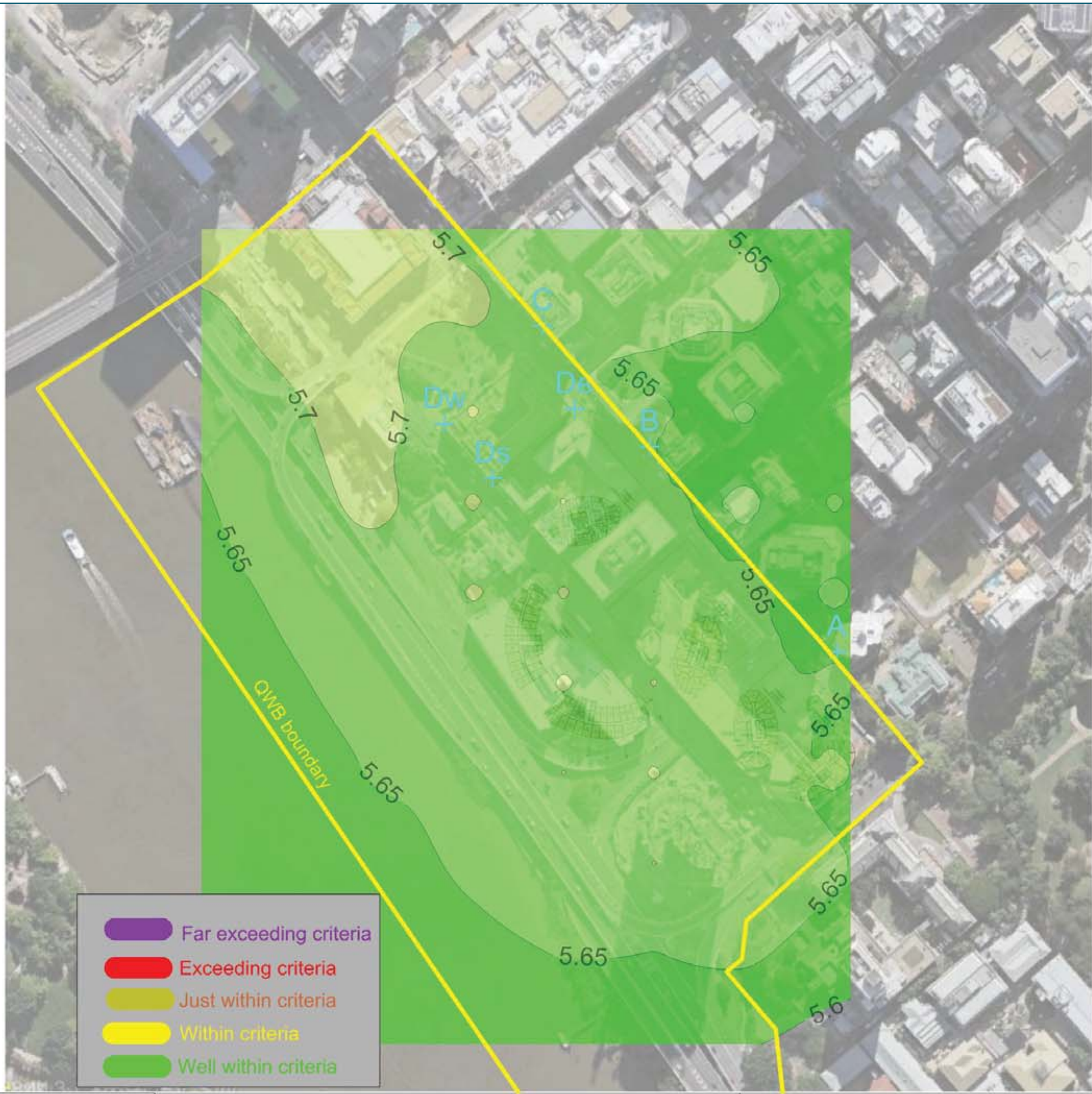

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Queens Wharf Brisbane Development Scenario
Annual Average at 20 metres above Ground
PM2.5 Concentrations including Background (ug/m3)

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Figure 7.7

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7.5 Summary of Impacts on Sensitive Receptors

7.5.1 Existing Accommodation Uses

Comparison of predicted concentrations from the road network without (baseline scenario) and with (development scenario) the QWBIRD are provided in **Table 7.1** and **Table 7.2**. There are small increases and decreases in concentrations of pollutants due most likely to changes in traffic volumes.

7.5.2 Future Development Uses

Predicted concentrations at the base of proposed towers on William Street for the development scenario are slightly lower than at other locations in the vicinity for the baseline scenario. Thus the building forms included in the development scenario are not causing a significant impact on air circulation.

7.5.3 Sensitive Public Recreation Space

Figure 7.1 to **Figure 7.5** show that ground level concentrations are within with the criteria near the river including the location for Waterline Park.

The Goodwill Extension Precinct extends beyond the southern end of the modelling domain and it is not envisaged that there will be sensitive uses there as its purpose is primarily transport and travel. However the river area to the south-west of the REX is within the criteria, so it is anticipated that the remainder of the Goodwill Extension Precinct will also be within the criteria.

8. Discussion of Constraints

8.1 Sensitive Uses

Four existing accommodation uses have been identified in the immediate vicinity of the development as listed in **Table 2.1**. Other sensitive uses that are part of the proposed development will be identified during the design phase based on the definitions in **Table 3.1** and their locations are to be managed to comply with the criteria.

Air emission sources proposed as part of the development will need to address impacts onto both existing and proposed sensitive uses. Sources to be considered may include:

- demolition
- construction
- roads
- generators
- diesel storage tank fill vents
- boiler vents
- cooling tower vents
- carpark exhausts
- cooking vent exhausts
- operational management.

8.2 Impacts of Future Generators

Detailed modelling of generator emissions (including at least NO_x, CO, $PM_{2.5}$ and PM_{10}) is to be undertaken using a dispersion model such as Calpuff or Aermod to assess potential impacts at sensitive receivers and determine any requirements for relocation or mitigation measures such as filters and catalytic converters. It is anticipated that a combination of appropriate location and appropriate treatment should lead to compliance with the air quality criteria in **Section 9.1** and hence the State Planning Policy referenced in **Section 4.2.3**.

When underground diesel storage tanks are filled, air from the tanks will be displaced requiring a vent. Diesel is not as volatile as petrol, and vapour recovery is not normally installed on diesel tank vents at service stations. However it still produces vapour that can potentially lead to health effects and/or odour nuisance. Six metres is considered an adequate separation from sensitive uses.

8.3 Impacts of Future Exhaust Vents

As discussed in **Section 4.3**, carpark exhaust vent points must be separated at least 6 metres from sensitive uses, and where practical should be separated by 15 metres. Cooling tower vents must be separated at least 6 metres from sensitive uses. Cooking exhaust vent points should be separated at least 6 metres from sensitive uses. Unless boiler vents are located on tower rooftops, the location of these is to be determined based on dispersion modelling such that predicted concentrations comply with the criteria.

8.4 Impacts of Road Network

The air quality impacts arising from the future road network, with and without the development, have been predicted and are detailed in **Section 7**. Predicted concentrations of pollutant species are predicted to comply with the nominated criterion, with the exception of annual average $PM_{2.5}$ concentrations, which are predicted to exceed the criterion at some locations in the QWBIRD development site as shown in **Figure 7.2**. At the time of compliance assessment for locations that exceed criteria, the detailed design is to include measures such as separation from the road, mechanical air supply with remote or filtered intakes, such that the $PM_{2.5}$ criterion is met at sensitive uses. This will meet the requirements of the State Planning Policy and TMR Manual (2014) discussed in **Section 4.2.4**.

8.5 Air Quality Issues for Environmental Management Plans

8.5.1 Generic Requirements

Environmental Management Plans for demolition, construction and operation of the development will be developed subsequent to the PoD. The objective of these plans will be to meet the ambient air criteria specified in **Section 9.1.** The performance criteria should include:

- no visible dust leaving the boundary during demolition or construction
- machinery to be maintained according to manufactures recommendations
- no complaints from neighbours.

It is anticipated that these plans will include standard practices such as:

- dust barriers on the sides of buildings being demolished
- ceasing dust-generating activities during high wind conditions
- water spraying of dust generating activities
- enclosed chutes for demolition materials
- watering of exposed surfaces
- asbestos management plan for demolition
- switching off machinery when not in use
- limiting generator usage
- daily visual inspections
- incident and complaints reporting
- procedure for corrective actions to be implemented should incidents occur.

8.5.2 Site-Specific Requirements

The QWBIRD precinct is unique for many reasons including the following relevant to air quality:

- Public open space is not normally defined as a sensitive use, since people are not present in those areas for long periods of the day. However in the context of this development, the public space in the vicinity of the river is considered sufficiently important to the vitality of the community, that good air quality at this location has been identified as an objective of the development.
- There are a large number of heritage buildings that are to be retained on site, which presents the opportunity to avoid street canyons by having diverse structural elements. A large number of buildings including high-rise buildings are to be demolished in the vicinity of existing sensitive receptors. Demolition and construction of buildings adjacent to sensitive uses and building air intakes are to be carried out according to construction management plans that include measures to comply with particulate criteria at sensitive uses in these buildings.
- The resort development proposes building over part of William Street, which is also likely to cover the main entrance to the casino, a sensitive use. The building form will restrict air flow and mixing, allowing accumulation of pollutants from road traffic. Potential measures to comply with criteria include mechanical air extraction, remote air intakes, and surface coating to reduce nitrogen oxides. These would all require ongoing maintenance.

- Backup power generators may be proposed in the vicinity of private outdoor areas and tall accommodation towers. Exhaust treatment measures and location of exhaust vents are to be designed and maintained to meet ambient air quality criteria at sensitive uses.

These issues need to be managed through appropriate design, but also good practice during demolition, construction and operation of the development. Specific recommendations to address these issues are provided in **Section 9.3** to **Section 9.5**.

9. Recommendations

9.1 Ambient Air Criteria

The ambient air criteria adopted for the QWBIRD Plan of Development are listed in **Table 9.1**.

Table 9.1 Air Quality Criteria Recommended for QWBIRD

Pollutant	Averaging Time	Criteria (µg/m^3)
NO_2	1 hour	250
	1 year	62
TSP	1 year	90
PM_{10}	24 hours	50
$PM_{2.5}$	24 hours	25
	1 year	8
CO	8 hours	11,000
Benzene	1 year	10
Dust deposition	1 month	120 mg/m^2/day

Note: The criteria are to be compared to the maximum predicted concentrations with the exception that at locations where the most influential source(s) are point sources such as generators, then the 99.9th percentile one hour concentration of NO_2 may be used. Where the most influential source is transport, the maximum is to be used.

Separation distances for emission sources are listed in **Table 9.2**. The origin of these is discussed in **Section 4** of this report. Where criteria cannot be met in the outdoor air, appropriate filtration of air intakes is to be designed to meet criteria.

Table 9.2 Separation Distances and Controls

Emission Source	Separation Distance from Sensitive Uses [1]	Other Controls [2]
Power generators	Subject to dispersion modelling	Catalytic converters and, for diesel, fabric filters.
Water heater boilers	On rooftop or subject to dispersion modelling	
Carpark exhausts	6m minimum, 15m where practical	
Cooling tower vents	6m minimum, 10m where practical	
microbrewery	6m	Carbon filters
Cooking exhaust vents	6m	Grease filters
William Street kerb	13m	Air intake treatment
Alice Street kerb	15m	“
Margaret Street kerb	10m	“
Elizabeth Street kerb near William Street	30m	“
REX traffic lane edge	10m	“

Notes:

1. *Distances from roads are based on **Figure 7.3**. The separation from the REX is based on the resolution of the model. These should be applied in three dimensions unless further modelling demonstrates a lesser separation is suitable.*
2. *Updated modelling with improved data may show compliance without the need for treatment.*

9.2 Requirements for Detailed Design and Compliance Assessments

9.2.1 Portion of William Street Covered by Building

TMR (2014) requires that roadways covered by more than 90 metres of their length are to be considered as tunnels for air quality assessment purposes. If this occurs, concentrations within the tunnel are to be calculated using the same emission inventory data used in the dispersion model, but fed into a box model according to the TMR (2014) box model method.

Potential solutions to comply with air quality criteria within the William Street covered area may include:

- restrict of diesel heavy vehicle access
- increasing the cross-sectional dimensions or reducing the length
- mechanical ventilation
- surface coating for reduction of nitrogen oxides
- updating emission factors.

9.2.2 Diesel Generators

Potential solutions to achieve compliance for diesel generator exhausts may include a combination of the following:

- converters and scrubbers
- location of exhaust points away from sensitive uses
- location of air intakes and outdoor areas at distance from exhausts
- minimisation of vent diameter

- detailed modelling of plume temperatures using a buoyant/dense plume model.

9.3 Recommendations Regarding Demolition

Demolition of buildings in the precinct is likely to generate large quantities of dust in close proximity to sensitive uses. In addition to fine particulates, this dust may contain hazardous substances include crystalline silica (present in some cements) and asbestos.

The following measures are recommended:

- Prior to demolition, identify sensitive uses and other locations where air quality impacts may occur including accommodation in the Treasury Hotel and all air intakes in buildings adjacent to the demolition site.
- Identification and appropriate removal of asbestos-containing materials must be a key element of the Environmental Management Plans for demolition. For each building to be demolished, the asbestos management register is to be reviewed and a detailed Asbestos Management Plan prepared prior to any demolition.
- Environmental monitoring of crystalline silica is not practical due to the need for a large number of sampling locations and the risk of any silica missing the samplers is high. Therefore the appropriate management of potential silica from concrete demolition is to screening reports from monitoring of worker exposure to crystalline silica during demolition of concrete structures. The Environmental Management Plans should include prioritised assessment of results of such monitoring and an action plan dependent on the levels of crystalline silica measured.
- General dust control measures must have a high level of control including:
  - daily auditing by an independent observer
  - constant spraying with water during concrete breaking/grinding
  - installation of dust barriers on the sides of buildings being demolished
  - enclosed chutes with sprays or mists at landing points
  - where air intakes to neighbouring buildings are within six metres of demolition activities, temporary filtration should be applied.

9.4 Recommendations Regarding Construction

This assessment has not identified constraints to construction apart from those present in many other inner-city developments, such as proximity to existing commercial buildings and in the general vicinity of accommodation. Application of standard management practices should suffice including:

- dust barriers to prevent run-off of dust onto surrounding surfaces
- ceasing dust-generating activities during high wind conditions
- water spraying of dust generating activities
- watering of exposed surfaces
- switching off machinery when not in use
- limiting generator usage
- daily visual inspections
- incident and complaints reporting
- procedure for corrective actions to be implemented should incidents occur.

Dust control measures are to be included in the Construction Management Plans for all sites including the south-western end of the foot bridge at Southbank and the sewer line upgrade adjacent to North Quay.

9.5 Recommendations Regarding Operation

Control measures that may require ongoing maintenance include the following:

- Power generator exhausts are likely to require treatments such as catalytic converters and filters. These will require regular maintenance according to the manufacturer's specification. Annual stack testing is to be undertaken during maintenance testing to ensure compliance with emission limits to be specified during the detailed design phase.
- Mechanical ventilation is likely to be required for the tunnel over William Street, unless a more innovative treatment is designed. This system will require maintenance. Ambient monitoring of pollutants including $PM_{2.5}$ and NO_2 should also be undertaken to check compliance with the ambient air criteria. If surface coatings to reduce NO_2 are required, cleaning and maintenance must form part of the ongoing operations plan.
- Fabric filters may be required on building air intakes to reduce particulate levels, based on detailed specifications to be specified during the detailed design phase. These would require regular exchange according to the supplier's specification.

The environmental management plans developed for operation of the development must address these specific issues.

10. Conclusions

The constraints assessment conducted for the QWBIRD PoD has identified the following issues and made recommendations to achieve compliance:

- The criteria are goals for ambient air quality. Compliance can only be demonstrated by long-term monitoring during operation. However the likelihood of compliance can be managed by adherence to separation distances and control measures specified either in this report or determined by detailed, design-specific modelling.
- There are existing sensitive uses within the precinct and in the immediate vicinity of the precinct, and there are likely to be many sensitive receptors included in future development. These are to be clearly defined for each sub-precinct and design undertaken such that compliance with the criteria is predicted by the compliance assessment.
- Air quality impacts from the road network are a constraint for the location of sensitive uses near roads including William Street and Alice Street. Sensitive uses are to be located outside the constraint buffers or provided with fresh air ventilation with remote or filtered intakes.
- Building over William Street will increase the impacts of road emissions in the immediate vicinity of new sensitive uses. This will require control measures to reduce pollutant concentrations including remote fresh air intakes, and mechanical air extraction.
- Design of power generation for the development will be constrained by the impact of emissions, especially for diesel generators. Compliance is to be achieved through appropriate location of exhausts and control technologies.
- Short-term dust emissions from demolition and construction will be managed by good practice to minimise impacts, especially to manage asbestos, demolition dust and the proximity of neighbouring building air intakes.
- Compliance with the requirements of the State Planning Policy and Environmental Protection (Air) Policy is to be achieved through appropriate design and ongoing management.

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Appendix A Glossary

Parameter or Term	Description
ASK	ASK Consulting Engineers Pty Ltd
BCC	Brisbane City Council
BPIP	Building Profile Input Program
CO	Carbon monoxide
DBC	Destination Brisbane Consortium
DSITI	Department of Science, Information Technology and Innovation
Dust fallout deposition	Dust that has fallen out of the air onto a horizontal surface
EHP	Queensland Department of Environment and Heritage Protection
EMP	Framework Environmental Management Plan
EPA	Queensland Environmental Protection Act 1994
EPP (Air)	Queensland Environmental Protection (Air) Policy 2008
IRD	Integrated Resort Development
$g/m^2/month$	Grams per square metre per month
Microvol	A very low-volume gravimetric (filter-based) sampler using battery power.
m/s	Metres per second
$mg/m^2/day$	Milligrams per square metre per day
mg/m^3	Milligrams per cubic metre
NPI	National Pollutant Inventory
NEPM	National Environmental Protection (Ambient Air Quality) Measure
NO_x	Oxides of nitrogen including nitric oxide and nitrogen dioxide
NO_2	Nitrogen dioxide
PAHs	Polycyclic aromatic hydrocarbons
Partisols	A low-volume gravimetric (filter-based) sampler using mains power.
PDA	Queens Wharf Brisbane Priority Development Area
PoD	Plan of Development
$PM_{2.5}$	Particulates suspended in air with aerodynamic diameter less than 2.5 microns
PM_{10}	Particulates suspended in air with aerodynamic diameter less than 10 microns
ppm	Parts per million by volume
QWBIRD	Queens Wharf Brisbane Integrated Resort Development
REX	Riverside Expressway
SO_2	Sulphur dioxide
TAPM	The Air Pollution Model developed by CSIRO and used by ASK for meteorological modelling
TSP	Total particulates suspended in air
$\mu g/m^3$	Micrograms per cubic metre

Parameter or Term	Description
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UTM	Universal Transverse Mercator coordinate system
VOCs	Volatile organic compounds
WHO	World Health Organisation

Appendix B Building Details

Table B.1 Estimated Dimensions (metres) of Buildings Included into Both Baseline and QWBIRD Model

					Axis 1				Axis 2			
Building	**x**	**y**	**zgrid**	**height of top[1]**	**width of top from centre**	**height of "podium"**	**width of podium from centre**	**Axmax**	**width of top from centre**	**height of "podium"**	**width of podium from centre**	**Axmax**
1 William St	502553.2 E	6960926 S	7.30	60	20	30	38	40	9	60	23	25
The Mansions	502627.0 E	6961203 S	14.47	30	21	-	-	23	10	-	-	12
Former State Library	502348.0 E	6961203 S	6.94	33	14.5	23	28	30	7.5	23	10	12.5
Old DPI Building	502419.0 E	6961116 S	7.14	23	18	-	-	20.5	14	-	-	16.5
Services Club	502446.0 E	6961152 S	15.33	32	13	-	-	15	13	-	-	15
Treasury Hotel	502434.0 E	6961208 S	15.34	40	23	-	-	25	35	-	-	37
Treasury Casino	502334.0 E	6961317 S	15.00	35	39	-	-	41.5	33	-	-	35.5
Queensland Club	502702.0 E	6961027 S	14.50	18	15	-	-	17	22	-	-	24.5
29 George St	502665.0 E	6961065 S	14.50	35	22	-	-	24	19	-	-	21
41 & 63 George St	502614.0 E	6961130 S	15.00	56	45.5	-	-	47.5	29	-	-	31
85, 103 & 111 George St	502534.0 E	6961207 S	15.30	60	44	-	-	46.5	20	-	-	21.5
127/131, 151 & 171 George St	502460.2 E	6961291 S	15.30	60	22.5	13	45	47.5	18.5	18	22	23.5

Note: 1 Building Heights Capped at 60m

TableB.2 Estimated Dimensions (metres) of Buildings Included only into QWBIRD Model

					Axis 1				Axis 2			
Building	**x**	**y**	**zgrid**	**height of top[1]**	**width of top from centre**	**height of "podium"**	**width of podium from centre**	**Axmax**	**width of top from centre**	**height of "podium"**	**width of podium from centre**	**Axmax**
Tower 1	502481.3 E	6961136 S	15.33	60	16	-	-	18	21	-	-	23
Tower 2	502441.0 E	6961057 S	7.03	60	23	-	-	25.5	18	-	-	20.5
Tower 3	502494.0 E	6961004 S	7.03	60	23	-	-	25	22	-	-	24.5
Tower 4	502559.0 E	6961050 S	14.373	60	14	-	-	16.5	20	-	-	22

Note: 1 Building Heights Capped at 60m

Appendix C Traffic Details

Table C.1 Traffic Data Included into Baseline Model

Road	Description	Sigma Y	Sigma Z	Peak Hour Traffic	Heavy Volume %	Speed (km/hr)	CO (g/m/s)	NOx (g/m/s)	PM2.5 (g/m/s)	PM10 (g/m/s)	Benzene (g/m/s)
Alice Street	Exit onto Riverside Express Southbound	3.02	0.93	2834	23	25	3.2E-03	8.7E-04	4.5E-05	5.6E-05	1.8E-05
Alice Street	Exit onto Riverside Express Northbound	2.21	0.93	435	23	25	4.8E-04	1.3E-04	6.9E-06	8.6E-06	2.7E-06
Alice Street	Between George and William	3.02	0.93	2575	23	15	2.7E-03	9.6E-04	4.0E-05	5.0E-05	1.4E-05
Charlotte Street	Between Albert and George	3.02	0.93	1395	3	15	1.4E-03	2.7E-04	1.1E-05	1.6E-05	7.9E-06
Elizabeth Street	Entry to Elizabeth from Northbound Riverside Express	2.21	0.93	395	11	25	5.2E-04	1.5E-04	6.0E-06	7.9E-06	2.5E-06
Elizabeth Street	Entry to Elizabeth from Southbound Riverside Express	2.21	0.93	563	11	25	7.4E-04	2.1E-04	8.6E-06	1.1E-05	3.5E-06
Elizabeth Street	Between William and George	4.65	0.93	1680	11	15	1.7E-03	4.5E-04	1.9E-05	2.4E-05	9.4E-06
George Street	Between Charlotte and Elizabeth	3.84	0.93	1117	6	15	1.1E-03	2.5-E04	1.0E-05	1.4E-05	6.3E-06

Road	Description	Sigma Y	Sigma Z	Peak Hour Traffic	Heavy Volume %	Speed (km/hr)	CO (g/m/s)	NOx (g/m/s)	PM2.5 (g/m/s)	PM10 (g/m/s)	Benzene (g/m/s)
George Street	Between Elizabeth and Queen	3.84	0.93	1454	6	15	1.5E-03	3.2E-04	1.3E-05	1.8E-05	8.2E-06
George Street	Between Margaret and Mary	3.02	0.93	1269	6	15	1.3E-03	2.8E-04	1.2E-05	1.6E-05	7.1E-06
George Street	Between Alice and Margaret	3.84	0.93	1305	6	15	1.3E-03	2.9E-04	1.2E-05	1.6E-05	7.3E-06
George Street	Between Mary and Charlotte	3.02	0.93	870	6	15	8.8E-04	1.9E-04	8.0E-06	1.1E-05	4.9E-06
Margaret Street	Entry to Margaret from Southbound Riverside Express	2.21	0.93	393	5	25	3.9E-04	8.3E-05	3.5E-06	4.8E-06	2.2E-06
Margaret Street	Between William and George	4.65	0.93	1142	5	15	1.1E-03	2.4E-04	1.0E-05	1.4E-05	6.4E-06
Margaret Street	Entry to Margaret from Northbound Riverside Express	3.02	0.93	464	5	25	4.9E-04	8.1E-05	4.2E-06	5.7E-06	2.9E-06
Mary Street	Between Albert and George	3.02	0.93	727	4	15	7.3E-04	1.5E-04	6.2E-06	8.5E-06	4.1E-06
North Quay	Between Queen and Adelaide	3.84	0.93	2031	28	15	2.2E-03	8.5E-04	3.6E-05	4.4E-05	1.1E-05

Road	Description	Sigma Y	Sigma Z	Peak Hour Traffic	Heavy Volume %	Speed (km/hr)	CO (g/m/s)	NOx (g/m/s)	PM2.5 (g/m/s)	PM10 (g/m/s)	Benzene (g/m/s)
Queens Wharf Road	Northbound	2.21	0.93	17	50	15	2.5E-05	1.5E-05	6.0E-07	7.1E-07	1.0E-07
Queens Wharf Road	Southbound	2.21	0.93	16	50	15	2.3E-05	1.4E-05	5.6E-07	6.7E-07	9.6E-08
Riverside Express	Alice to Margaret Exit	3.84	0.93	4795	23	30	4.8E-03	1.0E-03	4.2E-05	5.8E-05	2.7E-05
Riverside Express	Southbound between Margaret exit and Alice entry	3.84	0.93	4896	5	30	4.9E-03	1.0E-03	4.3E-05	5.9E-05	2.8E-05
Riverside Express	Southbound between Elizabeth exit and Margaret exit	3.84	0.93	5400	5	30	5.4E-03	1.1E-03	4.8E-05	6.6E-05	3.0E-05
Riverside Express	Northbound between Elizabeth exit and Adelaide	3.84	0.93	4340	5	30	4.4E-03	9.2E-04	3.8E-05	5.3E-05	2.4E-05
Victoria Bridge	Victoria Bridge	2.21	0.93	2078	44	15	2.3E-03	1.2E-03	4.9E-05	5.8E-05	1.1E-05
William Street	Between Queen and Elizabeth	5.47	0.93	1400	23	15	1.5E-03	5.2E-04	2.2E-05	2.7E-05	7.7E-06
William Street	Between Margaret and Elizabeth	4.65	0.93	1165	23	15	1.2E-03	4.4E-04	1.8E-05	2.3E-05	6.4E-06

Road	Description	Sigma Y	Sigma Z	Peak Hour Traffic	Heavy Volume %	Speed (km/hr)	CO (g/m/s)	NOx (g/m/s)	PM2.5 (g/m/s)	PM10 (g/m/s)	Benzene (g/m/s)
William Street	Between Alice and Margaret	4.65	0.93	1578	23	15	1.7E-03	5.9E-04	2.5E-05	3.1E-05	8.7E-06

ACOUSTICS & AIR QUALITY

Table C.1 Traffic Data Included into QWBIRD Model

Road	Description	Sigma Y	Sigma Z	Peak Hour Traffic	Heavy Volume %	Speed (km/hr)	CO (g/m/s)	NOx (g/m/s)	PM2.5 (g/m/s)	PM10 (g/m/s)	Benzene (g/m/s)
Alice Street	Exit onto Riverside Express Southbound	3.02	0.93	2548	23	25	2.8E-03	7.8E-04	4.0E-05	5.0E-05	1.6E-05
Alice Street	Exit onto Riverside Express Northbound	2.21	0.93	529	23	25	5.9E-04	1.6E-04	8.4E-06	1.0E-05	3.3E-06
Alice Street	Between George and William	3.02	0.93	2567	23	15	2.7E-03	9.6E-04	4.0E-05	5.0E-05	1.4E-05
Charlotte Street	Between Albert and George	3.02	0.93	1136	3	15	1.1E-03	2.2E-04	9.2E-06	1.3E-05	6.4E-06
Elizabeth Street	Entry to Elizabeth from Northbound Riverside Express	2.21	0.93	353	11	25	4.7E-04	1.3E-04	5.4E-06	7.0E-06	2.2E-06
Elizabeth Street	Entry to Elizabeth from Southbound Riverside Express	2.21	0.93	532	11	25	7.0E-04	2.0E-04	8.1E-06	1.1E-05	3.3E-06
Elizabeth Street	Between William and George	4.65	0.93	1593	11	15	1.6E-03	4.2E-04	1.8E-05	2.3E-05	8.9E-06
George Street	Between Charlotte and Elizabeth	3.84	0.93	1145	6	15	1.2E-03	2.5E-04	1.1E-05	1.4E-05	6.4E-06
George Street	Between Elizabeth and Queen	3.84	0.93	1433	6	15	1.4E-03	3.2E-04	1.3E-05	1.8E-05	8.0E-06

ACOUSTICS & AIR QUALITY

Road	Description	Sigma Y	Sigma Z	Peak Hour Traffic	Heavy Volume %	Speed (km/hr)	CO (g/m/s)	NOx (g/m/s)	PM2.5 (g/m/s)	PM10 (g/m/s)	Benzene (g/m/s)
George Street	Between Margaret and Mary	3.02	0.93	941	6	15	9.5E-04	2.1E-04	8.7E-06	1.2E-05	5.3E-06
George Street	Between Alice and Margaret	3.84	0.93	955	6	15	9.6E-04	2.1E-04	8.8E-06	1.2E-05	5.4E-06
George Street	Between Mary and Charlotte	3.02	0.93	591	6	15	5.9E-04	1.3E-04	5.5E-06	7.4E-06	3.3E-06
Margaret Street	Entry to Margaret from Southbound Riverside Express	2.21	0.93	446	5	25	4.5E-04	9.5E-05	3.9E-06	5.4E-06	2.5E-06
Margaret Street	Between William and George	4.65	0.93	1633	5	15	1.6E-03	3.5E-04	1.4E-05	2.0E-05	9.2E-06
Margaret Street	Entry to Margaret from Northbound Riverside Express	3.02	0.93	641	5	25	6.8E-04	1.1E-04	5.8E-06	7.9E-06	4.1E-06
Mary Street	Between Albert and George	3.02	0.93	639	4	15	6.4E-04	1.3E-04	5.4E-06	7.5E-06	3.6E-06
North Quay	Between Queen and Adelaide	3.84	0.93	1334	28	15	1.4E-03	5.6E-04	2.3E-05	2.9E-05	7.3E-06
Queens Wharf Road	Southbound	2.21	0.93	115	50	15	1.7E-04	1.0E-04	4.1E-06	4.8E-06	6.9E-07

Road	Description	Sigma Y	Sigma Z	Peak Hour Traffic	Heavy Volume %	Speed (km/hr)	CO (g/m/s)	NOx (g/m/s)	PM2.5 (g/m/s)	PM10 (g/m/s)	Benzene (g/m/s)
Riverside Express	Northbound Alice to Margaret Exit	3.84	0.93	4984	23	30	5.0E-03	1.1E-03	4.4E-05	6.0E-05	2.8E-05
Riverside Express	Southbound between Margaret exit and Alice entry	3.84	0.93	4840	5	30	4.9E-03	1.0E-03	4.3E-05	5.9E-05	2.7E-05
Riverside Express	Southbound between Elizabeth exit and Margaret exit	3.84	0.93	5426	5	30	5.4E-03	1.2E-03	4.8E-05	6.6E-05	3.1E-05
Riverside Express	Northbound between Elizabeth exit and Adelaide	3.84	0.93	4442	5	30	2.1E-03	1.1E-03	4.6E-05	5.5E-05	1.0E-05
Victoria Bridge	Victoria Bridge	2.21	0.93	1923	46	15	1.9E-03	3.2E-04	1.3E-05	1.9E-05	1.1E-05
William Street	Between Queen and Elizabeth	5.47	0.93	1276	23	15	1.3E-03	4.8E-04	2.0E-05	2.5E-05	7.0E-06
William Street	Between Margaret and Elizabeth	4.65	0.93	1019	23	15	1.1E-03	3.8E-04	1.6E-05	2.0E-05	5.6E-06
William Street	Between Alice and Margaret	4.65	0.93	1597	23	15	1.7E-03	6.0E-04	2.5E-05	3.1E-05	8.8E-06

Appendix D Summary of SDAP Assessment

1.2 MANAGING AIR AND LIGHTING IMPACTS FROM TRANSPORT CORRIDORS STATE CODE

Table 1.2.1: Building work, material change of use and reconfiguring a lot

Performance outcomes	Acceptable outcomes	Response
Air quality		
PO1 Development involving sensitive development achieves acceptable levels of air quality for occupiers or users of the development by mitigating adverse impacts on the development from air emissions generated by state transport infrastructure.	**AO1.1** Every private open space and passive recreation area of an accommodation activity meets the air quality objectives in the *Environmental Protection (Air) Policy 2008* for the following indicators: carbon monoxide nitrogen dioxide sulphur dioxide photochemical oxidants respirable particulate matter (PM10) fine particulate matter (PM2.5) lead toluene formaldehyde xylenes. AND	Compliance with the objectives can be achieved by adherence to separation distances and the implementation of control measures specified either in this report or determined by detailed design-specific modelling. Accommodation activities (including private open space and private passive recreation areas) are to be located outside identified constraint buffers or provided with fresh air ventilation with remote or filtered intakes. Ongoing compliance is to be achieved through appropriate design and ongoing management.
	AO1.2 Every outdoor education area and passive recreation area of an educational establishment, childcare centre and hospital, meets the air quality objectives in the *Environmental Protection (Air) Policy 2008* for the following indicators: carbon monoxide nitrogen dioxide sulphur dioxide	Compliance with the objectives can be achieved by adherence to separation distances and the implementation of control measures specified either in this report or determined by detailed design-specific modelling. Childcare centres (including outdoor education and associated passive recreation areas) are to be located outside identified constraint buffers or provided with fresh air ventilation

Performance outcomes	Acceptable outcomes	Response
	photochemical oxidants respirable particulate matter (PM10) fine particulate matter (PM2.5) lead toluene formaldehyde xylenes.	with remote or filtered intakes. Ongoing compliance is to be achieved through appropriate design and ongoing management.

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