SINCLAIR KNIGHT MERZ
SKM aurecon
CRR JOINT VENTURE

Cross River Rail
Environmental Impact Statement
Technical Report No. 7 – Air quality and greenhouse gas assessment

July 2011

Cross River Rail

TECHNICAL REPORT NO.7

AIR QUALITY AND GREENHOUSE GAS ASSESSMENT

JULY 2011

Contents

1 Introduction

This chapter describes the existing air quality within the study corridor and assesses the potential air quality impacts from both construction and operation of the Project. The chapter also presents estimates of greenhouse gas emissions from the construction and operation of the Project.

The Project has the potential to generate air quality impacts during construction through:

- dust from construction activities, including excavation and materials handling
- exhaust emissions from diesel powered construction equipment.

The Project has a small potential for air quality impacts from operation through

- coal dust from freight rail movements and exhaust emissions from diesel powered locomotives
- air contaminants from ventilation outlets.

The main community air quality concerns in relation to the tunnel construction works relate to dust generation from excavation and materials handling.

1.1 Methodology

The methodology used to prepare the air quality and greenhouse gas assessment report includes:

- reviewing the Australian air quality legislation including the *Environment Protection (Air) Policy 2008* and National Environment Protection Measure (NEPM) for Ambient Air Quality
- describing the dispersion meteorology of the study area by reviewing meteorological data from the Bureau of Meteorology (BoM)
- describing the existing air quality environment by identifying the major sources of air emissions, reviewing air quality data from the Department of Environment and Resource Management (DERM) and the nearby Airport Link project to establish background air quality levels in study corridor
- describing potential nuisance dust impacts resulting from construction activities
- estimating dust emissions from each of the construction worksites using National Pollutant Inventory emission factors
- modelling dust emissions with CALPUFF pollutant dispersion modelling software and comparing results with the ambient air quality guidelines
- describing potential air quality impacts resulting from operation of the Project
- estimating greenhouse gas emissions from the construction and operation of the Project in alignment with the requirements of the National Greenhouse and Energy Reporting System
- describing measures to reduce greenhouse gas emissions from the construction and operation of the Project.

1.2 Terms of Reference

This report addresses Sections 3.6 and 3.7 of the Terms of Reference:

1.2.1 Air quality

Description of existing environment

This section should describe the existing air quality that may be affected by the Project in the context of environmental values as defined by the *Environmental Protection Act 1994* (EP Act) and *Environmental Protection (Air) Policy 2008* (EPP(Air)).

A discussion of the existing regional and local air shed should be provided, including:

- background levels and sources of particulates, gaseous and odorous compounds and any major constituent pollutants including greenhouse gases influencing air quality in the study corridor and areas affected by the Project
- data on local meteorology and ambient levels of pollutants to provide a baseline data for later studies or for the modelling of air quality. Parameters should include air temperature, wind speed and direction, atmospheric stability, mixing depth and other parameters necessary for modelling.

Potential impacts and mitigation measures - construction

Environmental air quality impacts, such as gases, particulates and odours, from construction activities, including those produced by any industrial processes, and mitigation measures should be described, including:

- an inventory of air emissions (including 'worst case' emission events) and Project construction activities likely to emit pollutants, such as excavation, worksite compounds, stockpiles and spoil transport and placement
- where 'worst case' emissions are predicted to be significantly higher than those for normal operations, an evaluation of the worst-case impact as a separate exercise to determine whether the distance between Project worksites and neighbouring sensitive receptors would be adequate
- identification of any sites that could be sensitive to the effects of likely emissions, especially around proposed worksites and stations
- vehicle emissions and dust generation by heavy construction vehicles and along major haulage routes both internal and external to the Project worksites
- an assessment of human health risks, if any, associated with emissions from any of the Project worksites during construction
- identification of appropriate locations to monitor air quality (with consideration of meteorological conditions and sensitive receptors, including dust emissions, from all worksites or associated worksites with the potential to create a dust nuisance
- identification how the results of the air quality monitoring would be made publicly available (eg through publication on the proponent's internet site)
- a discussion on how the legislative and regulatory requirements relating to emission of pollutants during construction, including, but not limited to, relevant construction air quality goals outlined in EPP (Air)
- the identification of trigger levels for dust management response.

Potential air quality impacts from emissions must be discussed with reference to the National Environmental Protection Measures (NEPM) for ambient air quality and the EPP (Air).

Potential impacts and mitigation measures—operation

This section should identify and assess the potential changes to regional transport emissions to the regional air shed due to the operation of the Project. This should include consideration of predicted changes to distance travelled by road as well as changes to road transport emission profiles.

Likely impacts to regional air quality should be identified.

Mechanisms to maintain air quality within stations and tunnels should be identified, and any resulting impacts within the Project infrastructure and on the surface in the surrounding environment should be assessed.

1.2.2 Greenhouse gas emissions

This section should provide an inventory of the Projected annual emissions for each relevant greenhouse gas for the construction and operational phases of the Project, with total emissions expressed in 'CO_2 equivalent' terms for the following categories:

- Scope 1 emissions - means direct emissions of greenhouse gases from sources within the boundary of the facility and as a result of the facility's activities
- Scope 2 emissions - means emissions of greenhouse gases from the production of electricity, heat or steam that the facility would consume, but that are physically produced by another facility.

The methods by which estimates are made must be briefly described.

Estimates should include and clearly identify an assessment of the change in projected future greenhouse gas emissions from road transport in the region due to the operation of this Project.

The Department of Climate Change National Greenhouse Accounts (NGA) Factors may be used as a reference source for emission estimates and supplemented by other sources where practicable and appropriate.

This section should discuss the potential for greenhouse gas abatement measures, including:

- a description of the proposed measures (alternatives and preferred) to avoid and/or minimise direct greenhouse gas emissions
- an assessment of how the preferred measures minimise emissions and achieve energy efficiency
- a description of any proposals to further offset greenhouse gas emissions through indirect means (eg sequestration or carbon trading).

2 Air quality guidelines

2.1 Legislation

The *Environmental Protection Act 1994* provides for the management of the air environment in Queensland. Air quality guidelines are specified by the DERM in the Queensland *Environment Protection (Air) Policy 2008*. The air quality objectives in the EPP(Air) considered relevant to the Project are presented in **Table 1**.

Table 1 Air Quality Objectives in EPP (Air)

Pollutant	Air Quality Objectives		Averaging Period	Allowable Exceedances
Total Suspended Particulates	90 µg/m^3	-	1 year	none
Particulate matter (PM_{10})	50 µg/m^3	-	24 hours	5 days each year
Particulate matter ($PM_{2.5}$)	25 µg/m^3	-	24 hours	none
	8 µg/m^3	-	1 year	none
Carbon monoxide (CO)	11,000 µg/m^3	9 ppm	8 hours	1 day each year
Nitrogen dioxide (NO_2)	250 µg/m^3	0.12 ppm	1 hour	1 day each year
	62 µg/m^3	0.03 ppm	1 year	none
Sulphur dioxide (SO_2)	570 µg/m^3	0.2 ppm	1 hour	1 day each year
	230 µg/m^3	0.08 ppm	24 hours	1 day each year
	57 µg/m^3	0.02 ppm	1 year	none

The National Environment Protection Measure (NEPM) for Ambient Air Quality was released in 2003 by the National Environment Protection Council (NEPC, 2003). Generally, the NEPM standards and the EPP(Air) air quality objectives are consistent with each other. The NEPM has not set standards for $PM_{2.5}$, only recommending an advisory reporting standard for $PM_{2.5}$ of 25 µg/m^3 (24-hour averaging period) and 8 µg/m^3 (annual averaging period). The $PM_{2.5}$ standards were developed to facilitate collection of sufficient data for subsequent review of the standards.

There are no formal dust nuisance guidelines in the EPP(Air). However, DERM has recommended the following dust nuisance goals on other major infrastructure projects, for example the Northern Link (Legacy Way), in South East Queensland:

- Total Suspended Particulate concentration of 90 µg/m^3 (24 hour average)
- dust deposition rates of 120 mg/m^2/day averaged over one month.

2.2 Air quality goals for construction

The ambient air quality goals for construction of the Project are presented in **Table 2**.

Table 2 Air Quality Goals for Construction

Objective	Air Quality Indicator	Objective	Averaging Period	Allowable exceedances
Human Health	Total Suspended Particulates	90 µg/m^3	1 year	
	Particulate matter (PM_{10})	50 µg/m^3	24 hours	5 days per year
Nuisance	Total Suspended Particulates	80 µg/m^3	24 hours	
	Deposited dust	120 mg/m^2/day	30 days	

2.3 Air quality goals for operation

The ambient air quality goals for operations of the Project are recommended by DERM to be those in the EPP (Air) as presented in **Table 1**.

3 Existing air quality

This section identifies nearest sensitive receptors to the Project and describes the local environment, including meteorology and ambient air quality.

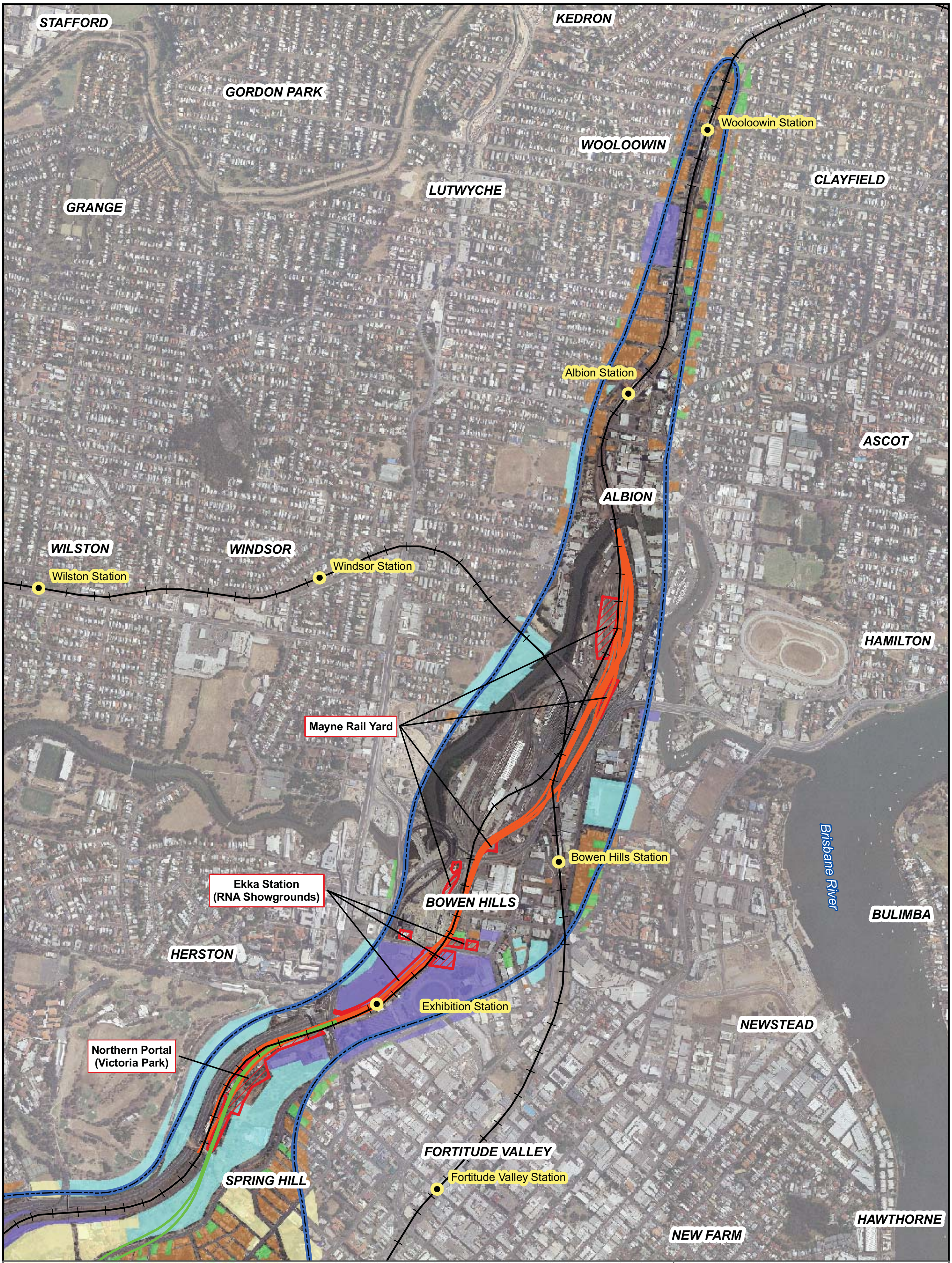
3.1 Sensitive receptors

Sensitive receptors are considered as a location where people are regularly present. These receptors include:

- residential dwellings
- educational, community and health buildings
- parks, outdoor education and recreational areas.

The locations of air quality sensitive receptors within the study corridor, the proposed new rail alignments and construction worksites are presented in:

- **Figure 1** for the northern section
- **Figure 2** for the central section
- **Figure 3** for the southern section.



LEGEND

- Study Corridor
- Station
- Track
- Worksites

Alignment

- Above Ground
- Underground

- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 1

Air Quality Sensitive Receptors (Northern Section)

0 250 500 750 m

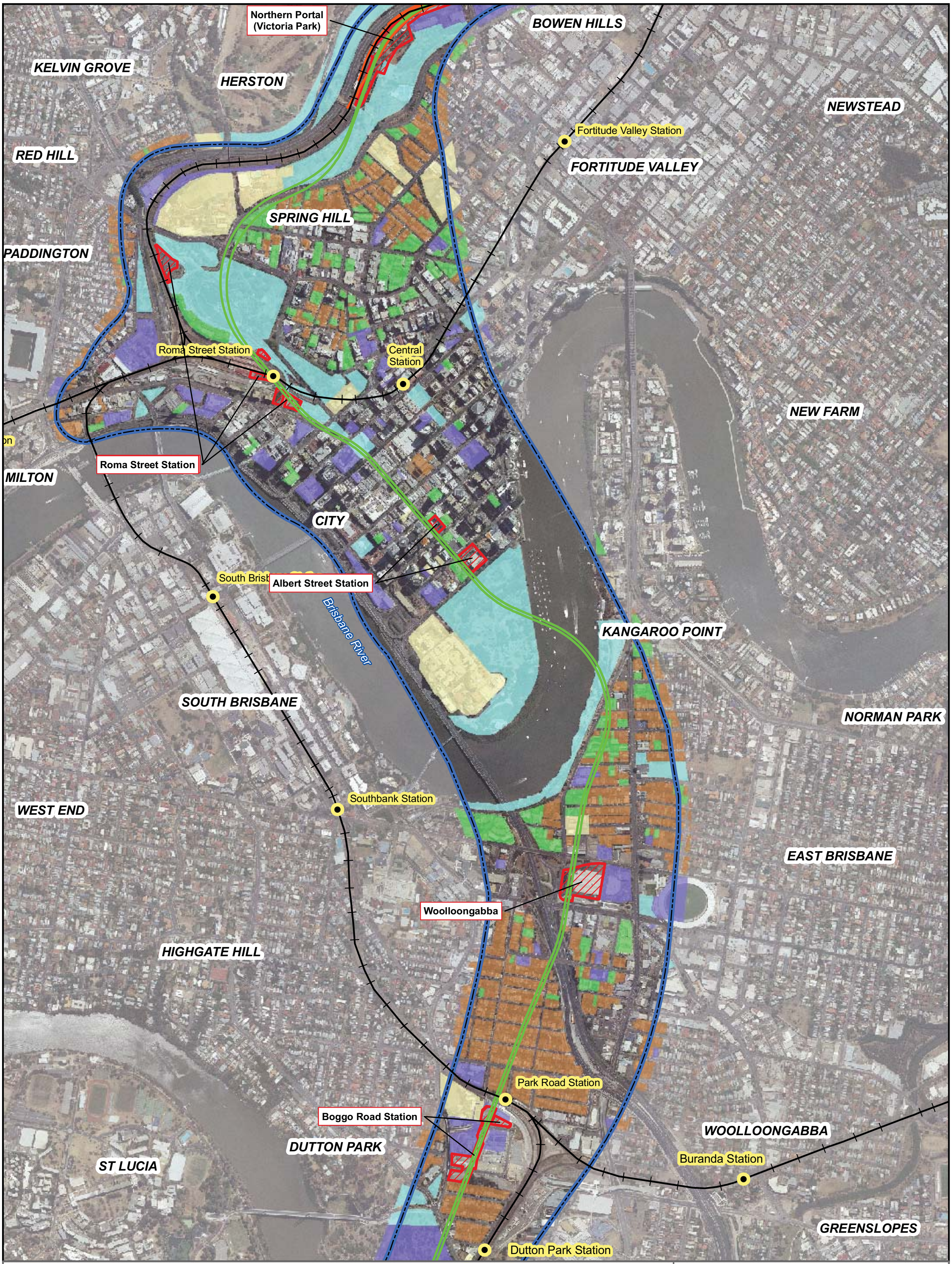
1:20,000 at A4

N

CrossRiverRail

SKM aurecon
CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_1_Sensitive_Receptors_North.mxd 07/07/2011 15:05



LEGEND

- Study Corridor
- Station
- Track
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

Alignment

- Above Ground
- Underground

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 2

Air Quality Sensitive Receptors (Central Section)

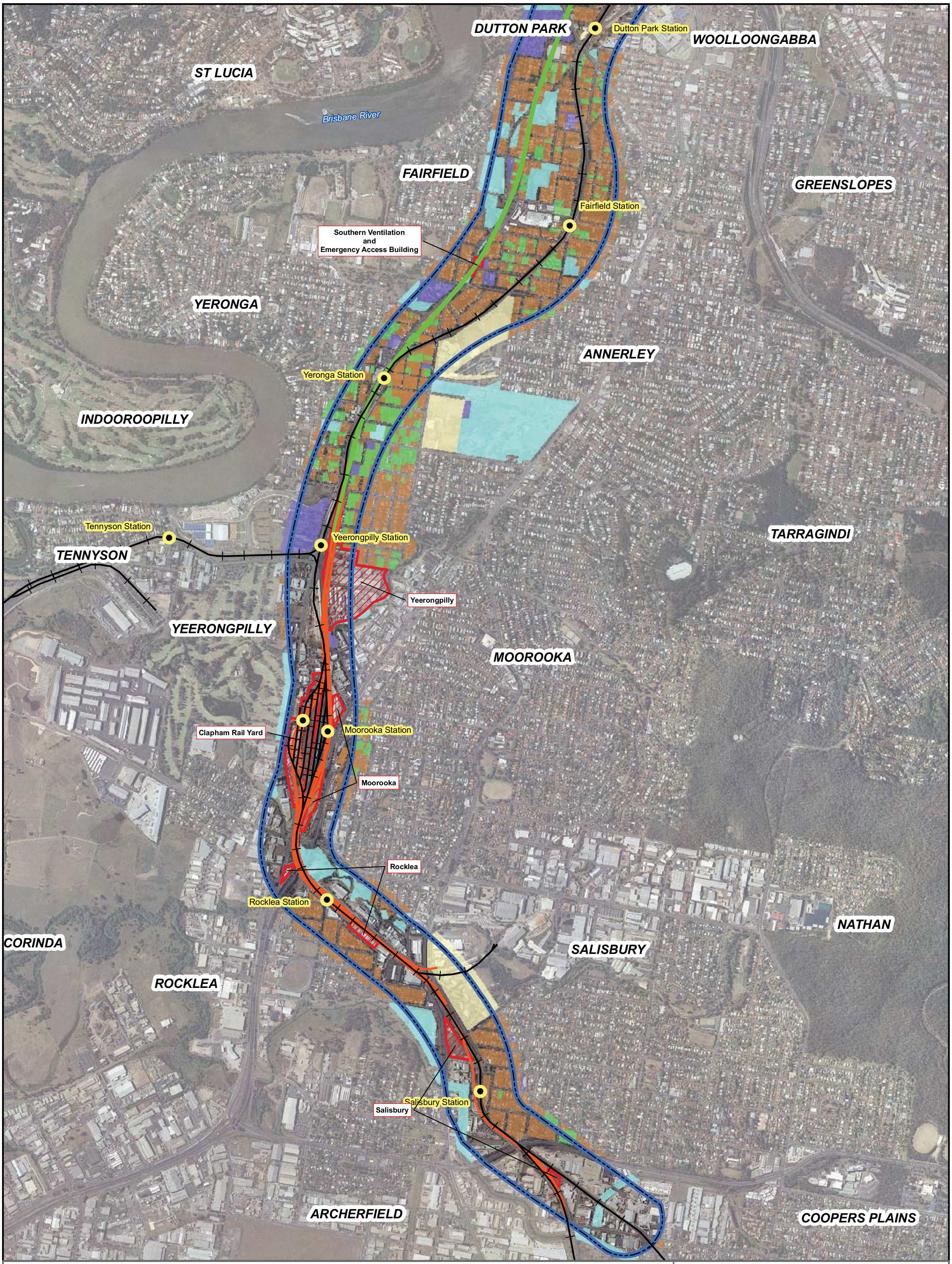
0 250 500 750 m

N

1:22,000 at A4

CrossRiverRail

SKM aurecon CRR JOINT VENTURE



LEGEND

- Study Corridor
- Station
- Track
- Worksites

Alignment

- Above Ground
- Underground

- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 3

Air Quality Sensitive Receptors (Southern Section)

0 250 500 750 1,000 m

1:30,000 at A4

CrossRiverRail

SKM aurecon CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_3_Sensitive_Receptors_South.mxd 07/07/2011 15:06

The Project would require a number of construction worksites located across the study corridor. Worksites for tunnelling activities would be located at Victoria Park, Woolloongabba and Yeerongpilly. Worksites would also be located at each of the proposed underground stations, at proposed surface stations, at Fairfield to support construction of the ventilation and emergency access building and at Mayne Rail Yard and Salisbury to support construction activities associated with surface works.

The nearest air quality sensitive receptors to worksites are presented in **Table 3** and **Table 4**.

Table 3 Nearest Sensitive Receptors to Worksites for Tunnelling

Worksite	Sensitive Receptors	(distance from construction works)
Northern Portal (Victoria Park)	Gregory Terrace Residential	(230 m)
	St Josephs College	(150 m)
	Centenary Aquatic Centre	(25 m)
	Gregory Terrace Residential	(130 m)
	Gregory Terrace Commercial	(150 m)
	Gregory Terrace Residential	(170 m)
	Bowen Bridge Road Commercial	(20 m)
Woolloongabba	Vulture Street Residential	(125 m)
	Vulture Street Commercial	(60m)
	Vulture Street Residential	(25 m)
	St Nicholas Cathedral	(25 m)
	Main Street Commercial	(150 m)
	Vulture Street Commercial	(15 m)
	Stanley Street Commercial	(60 m)
	St Josephs Primary School	(180 m)
Yeerongpilly	St Fabien's Church	(20 m)
	Tees Street Residential	(30 m)
	Wilkie Street Residential	(30 m)
	Livingstone Street Residential	(35 m)
	Fairfield Road Residential	(50 m)
	Cardross Street Residential	(80 m)

Table 4 Nearest Sensitive Receptors to Other Worksites

Worksite	Sensitive Receptors	(distance from construction works)
Mayne Rail Yard	Residential West	(300 m)
	Residential East	(180 m)
RNA Showgrounds	Residential North-east	(60 m)
	Residential North-west	(220 m)
	Royal Brisbane & Women's Hospital	(300 m)
Roma Street Station	Wickham Terrace Commercial	(150 m)
	St Alban Liberal Catholic Church	(125 m)
	Wickham Terrace Residential	(120 m)
	Wickham Terrace Commercial	(140 m)
	Brisbane Private Hospital	(130 m)
	Brisbane Dental Educational	(100 m)
	Turbot Street Commercial	(40 m)
	Roma Street Station Commercial	(10 m)
	Holiday Inn Residential	(50 m)

Worksite	Sensitive Receptors (distance from construction works)	
	Parkland Crescent Residential	(150 m)
Albert Street Station	Queensland University of Technology	(270 m)
	Parliament House	(260 m)
	Alice Street Commercial	(170 m)
	Alice Street Residential	(25 m)
	Albert Street Commercial	(20 m)
	Albert Street Residential	(5 m)
	Charlotte Street Commercial	(5 m)
	Mary Street Residential	(20 m)
	Margaret Street Commercial	(45 m)
Boggo Road Station	Ecosciences Building commercial	(5 m)
	Rawnsley Street Residential	(15 m)
	Maldon Street Commercial	(45 m)
	Maldon Street Residential	(40 m)
	Grantham Street Commercial	(35 m)
	Annerley Road Residential	(75 m)
	Boggo Road Police Station	(90 m)
	Dutton Park Primary School	(40 m)
	Leukemia Support Village	(100 m)
Ventilation and emergency access building	Railway Road Residential	(15 m)
	Sunbeam Street Residential	(50 m)
	Baptist Union of QLD Church	(60 m)
	Railway Road Commercial	(15 m)
	Venner Road Residential	(15 m)
	Fairfield Road Residential	(30 m)
	Byrnes Street Commercial	(25 m)
	Fairfield Road Residential	(40 m)
	Love Street Residential	(90 m)
Clapham Rail Yard	Residential East	(100 m)
	Residential West	(250 m)
Moorooka	Residential East	(130 m)
	Residential West	(500 m)
Rocklea	Residential West	(40 m)
	Residential East	(170 m)
Salisbury	Residential South	(50 m)
	Residential North-east	(350 m)

3.2 Dispersion meteorology and climate

The dispersion of air emissions following release from a source (eg a worksite) would vary depending on the terrain and the prevailing meteorological conditions.

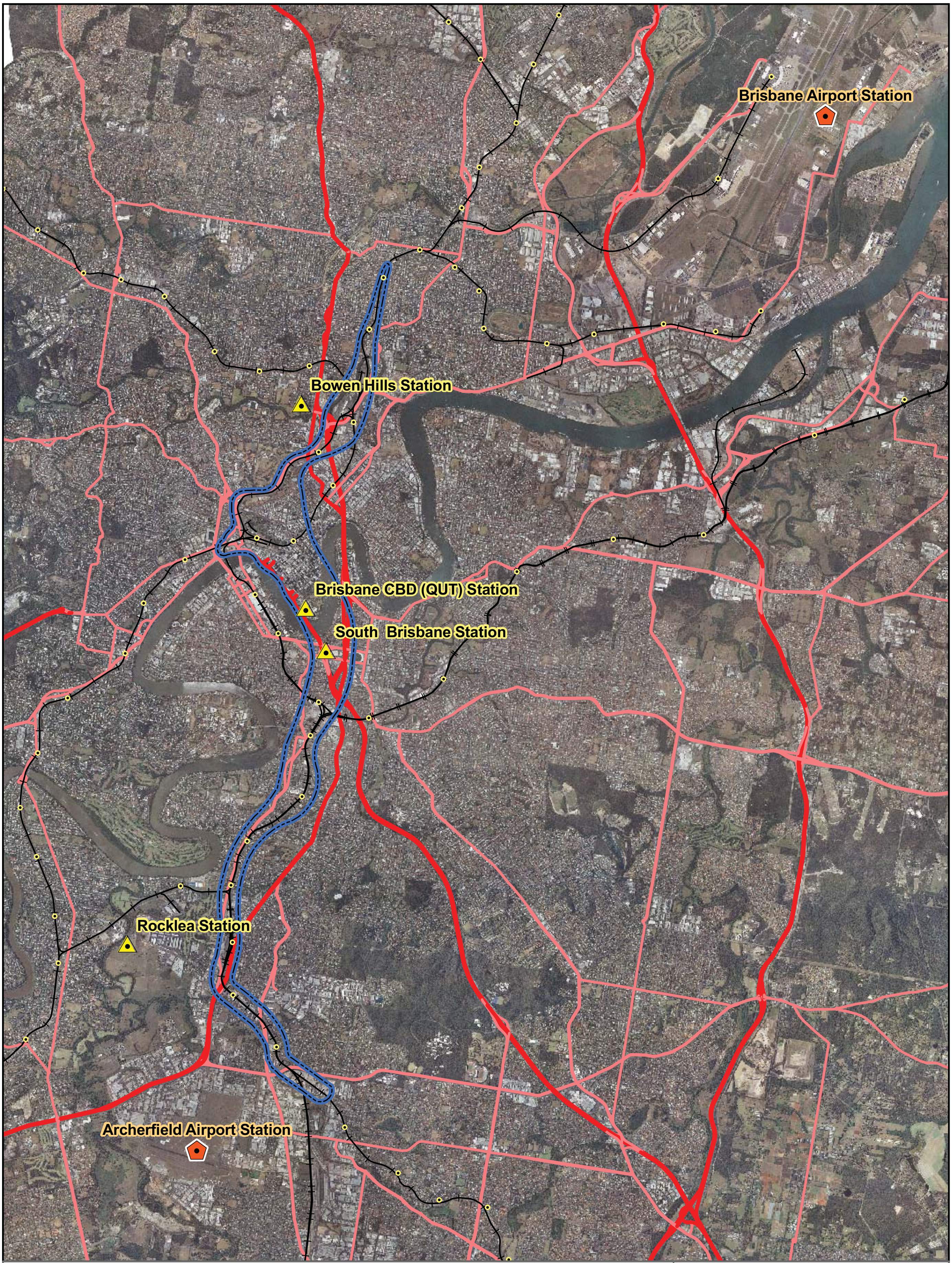
Dispersion modelling requires hourly breakdown of temperature, wind speed and direction, and other meteorological parameters. Advanced meteorological models such as CALMET can simulate complex meteorological patterns that exist in a particular region incorporating terrain data and land use characteristics. The CALMET model interpolates meteorological data and can generate a wind field at locations across the study corridor.

This section describes the dispersion meteorology and climatic data recorded by two BoM meteorological monitoring stations:

- Brisbane Airport (located 10 km to the northeast of the Northern section of the study corridor)
- Archerfield Airport (located 3 km to the southwest of the Southern section of the study corridor).

The locations of these meteorological stations are presented in **Figure 4**. The two BoM meteorological monitoring stations have been selected because:

- both have Automatic Weather Stations installed which record meteorological data every minute;
- the locations cover the extents of the modelling domain
- both are sited in accordance with AS 2923: *Guide for measurement of horizontal wind for air quality applications.*



LEGEND

- Study Corridor
- Station
- Track
- Meteorological Station
- Air Quality Monitoring Station

Road Network

- Major Roads
- Other Roads

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 4

Meteorological and Air Quality Monitoring Stations

0 1 2 3 Km

1:100,000 at A4

N

CrossRiverRail

SKM aurecon CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKMSpatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_4_Air_Quality_MetStation_Locations.mxd 07/07/2011 15:07

Brisbane Airport

The Brisbane Airport meteorology station is located 10 km to the northeast of the Northern section of the study corridor (refer to **Figure 4**).

Wind speed and direction data from Brisbane Airport recorded by the BoM from 2005 to 2009 have been analysed and are presented in the form of annual and seasonal windroses in **Figure 5**. The plot shows the frequency (length of petals) of winds from a particular direction and the strength (colour of petals) of these winds.

The key features of the dispersion meteorology at Brisbane Airport are:

- the dominant wind directions throughout the year are from the southwest/south-southwest and north/north-northeast
- winds during summer are predominantly from the east-southeast and the north-northeast with an average wind speed of 4.6 m/s
- winds during autumn and winter are predominantly from the southwest/south-southwest with an average wind speed of 3.9 m/s in autumn and 3.7 m/s in winter
- winds during spring are predominantly from the north/north-northeast with an average wind speed of 4.2 m/s
- strong winds are most frequent from the north and north-northeast during spring and summer
- calm conditions (wind speed less than 0.5 m/s) occur 2.3 % of the year and are most common during winter (3.8 %).

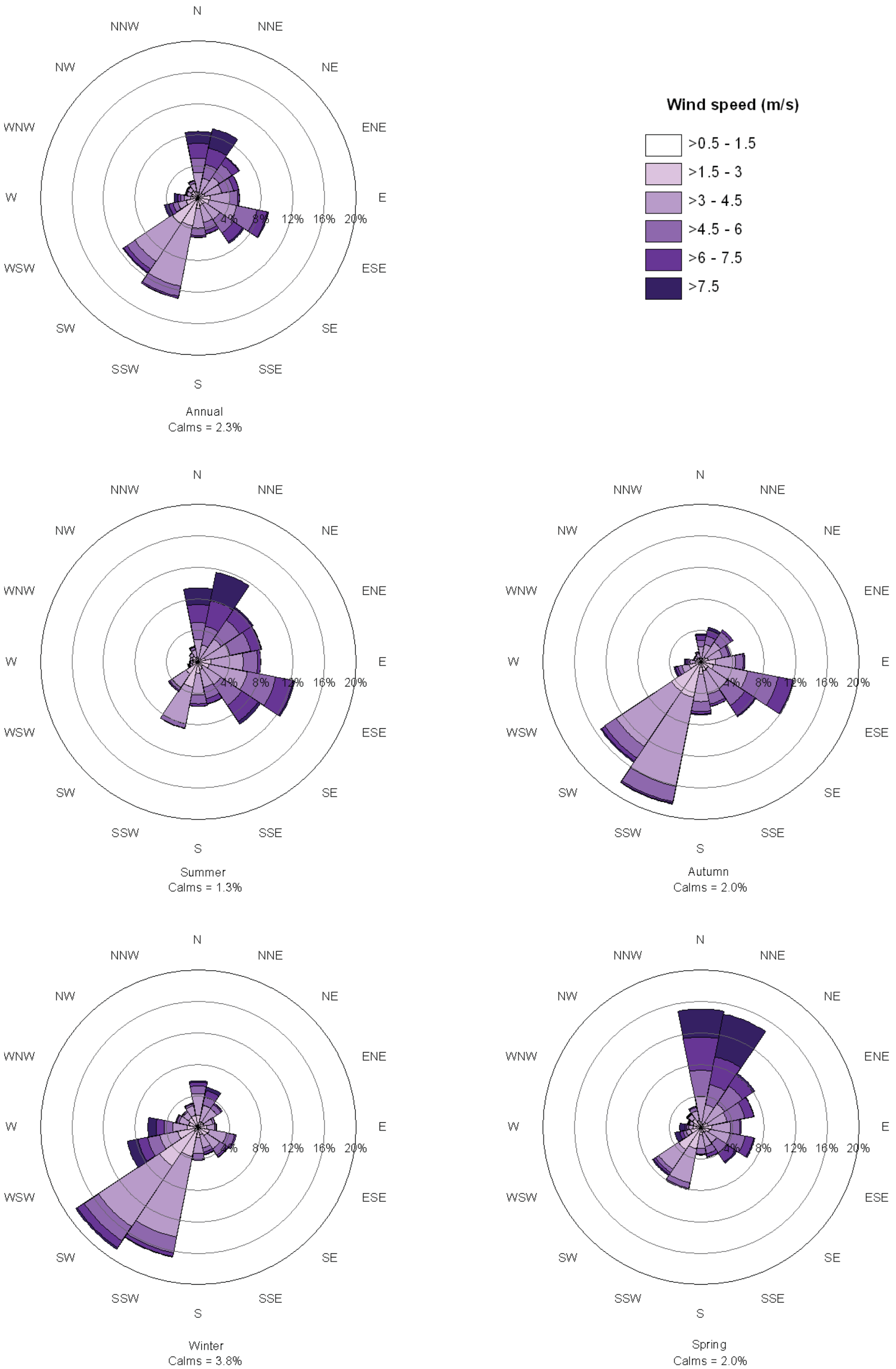


Figure 5 Annual and seasonal windroses for Brisbane Airport

Table 5 provides a summary of the temperature, humidity and rainfall data for the Brisbane Airport meteorological station from 1994 to 2010.

Brisbane Airport typically has warm days during summer with average maximum daytime temperatures around 29 °C in January and February, falling to 21 °C in June and July. Temperatures overnight are mild during summer and cool during the winter months, with average minimum daily temperatures of 9 °C in July, rising to almost 21 °C in January and February.

Highest rainfall is generally recorded during summer months with monthly rain averaging above 100 mm/month from November to February and also in May. Mean monthly rainfall is low from July to September with average monthly rainfall less than 40 mm.

Table 5 Climatic Summary for Brisbane Airport (BoM 040842)

	January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Annual**
Mean daily maximum temperature (°C)	29	29.1	27.9	26	23.6	21.3	20.9	21.8	24.2	25.5	26.8	28.3	25.4
Mean daily minimum temperature (°C)	21.2	21.1	19.4	16.3	12.8	10.5	8.8	9.6	12.7	15.7	18	20.1	15.5
Mean 9am air temp (°C)	26.4	26.2	25.1	22.4	18.9	16.1	15.3	17.1	20.5	22.6	24.1	25.6	21.7
Mean 9am relative humidity (%)	66	68	67	67	68	70	65	60	58	59	62	64	64
Mean 3pm air temp (°C)	27.4	27.5	26.4	24.5	22.3	20	19.6	20.4	22.5	23.6	24.9	26.5	23.8
Mean 3pm relative humidity (%)	63	63	61	58	56	55	50	51	54	58	61	62	58
Mean monthly rainfall (mm)	109	121	85	66	123	71	27	35	33	65	102	121	947
Highest monthly rainfall (mm)	285	284	201	192	577	213	112	138	122	175	228	253	1,729
Mean daily maximum temperature (°C)	29	29.1	27.9	26	23.6	21.3	20.9	21.8	24.2	25.5	26.8	28.3	25.4

Archerfield Airport

The Archerfield Airport meteorology station is located 3 km to the southwest of the Southern section of the study corridor (refer to **Figure 4**).

Wind speed and direction data from Archerfield Airport recorded by the BoM from 2005 to 2009 have been analysed and are presented in the form of annual and seasonal windroses in **Figure 6**.

The key features of the dispersion meteorology at Archerfield Airport are:

- the dominant wind directions throughout the year are from the south, east-southeast and north-northeast

- winds during summer are predominantly from the east-southeast and the north-northeast with an average wind speed of 3.9 m/s
- winds during autumn and winter are predominantly from the south-southwest/southwest with an average wind speed of 3.2 m/s in autumn and 3 m/s in winter
- winds during spring are predominantly from the north/north-northeast with an average wind speed of 3.9 m/s
- strong winds are most frequent from the north and north-northeast during spring and summer although strong westerlies occur during winter
- calm conditions (wind speed less than 0.5 m/s) occur 8.5 % of the year and are most common during winter (12.5 %).

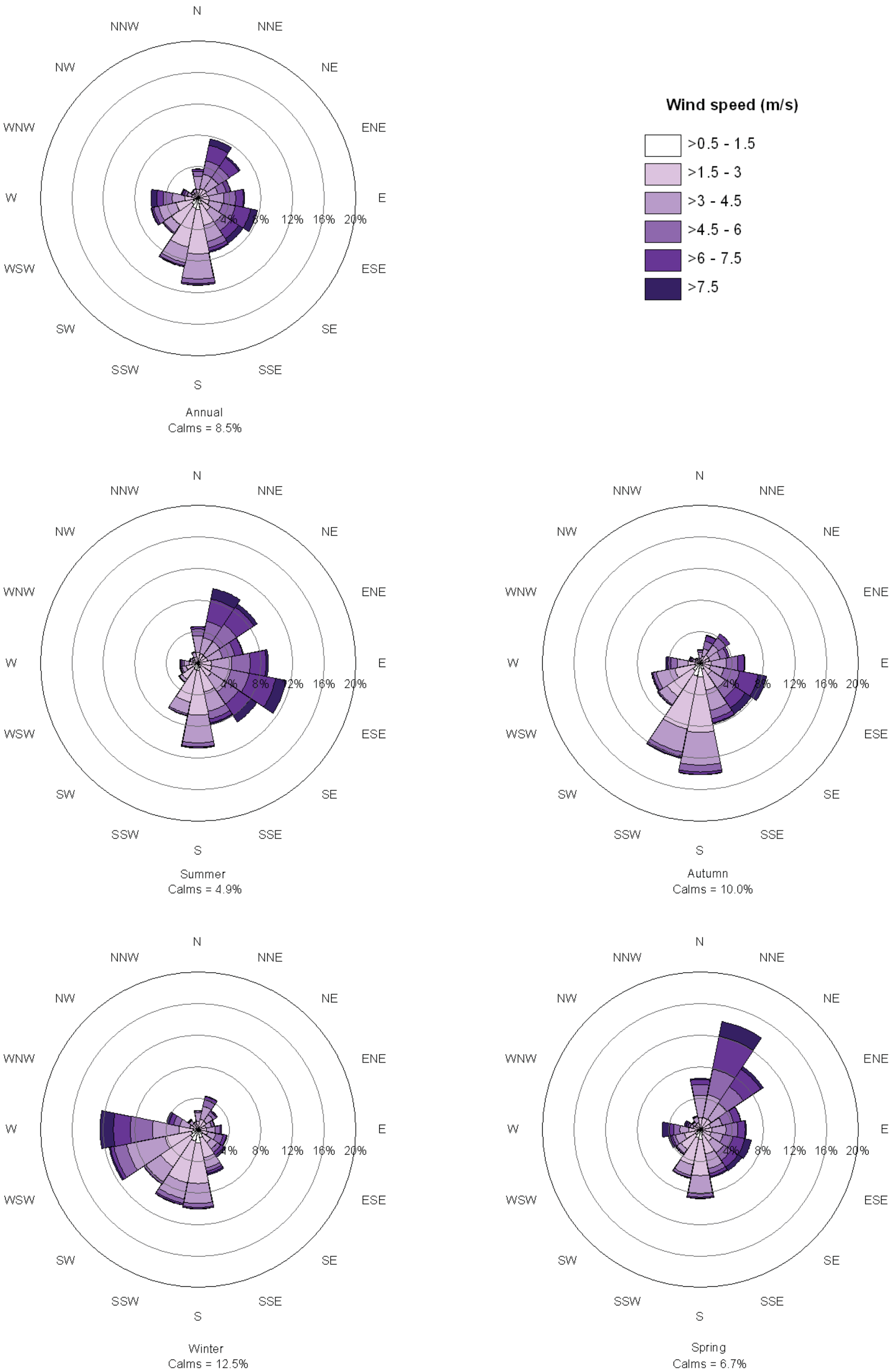


Figure 6 Annual and seasonal windroses for Archerfield Airport

Table 6 provides a summary of the temperature, humidity and rainfall data for the Archerfield Airport meteorological station from 1939 to 2010.

Archerfield Airport typically has warm days during summer with average maximum daytime temperatures around 30 °C in January and February falling to 21 °C in June and July. Overnight temperatures are mild during summer and cool during the winter months, with average minimum daily temperatures of 7 °C in July, rising to almost 20 °C in January and February.

Highest rainfall is generally recorded during summer months with monthly rain averaging above 100 mm/month from November to March. Mean monthly rainfall is low from August to September with average monthly rainfall less than 40 mm.

Table 6 Climatic Summary for Archerfield Airport (BoM 040211)

	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Mean daily maximum temperature (°C)	30.4	29.7	28.7	26.4	23.8	21.4	21.1	22.5	25.1	27	28.3	29.6	26.2
Mean daily minimum temperature (°C)	20.2	20	18.2	15	11.9	9.2	7.4	8	10.9	14.3	17	19	14.3
Mean 9am air temp (°C)	25.8	25.1	23.7	20.9	17.4	14.3	13.3	15	18.7	21.8	23.7	25.1	20.4
Mean 9am relative humidity (%)	66	70	70	71	74	75	71	67	62	60	61	64	67
Mean 3pm air temp (°C)	28.8	28.2	27.1	25	22.8	20.5	20.2	21.4	23.6	25.1	26.4	27.8	24.7
Mean 3pm relative humidity (%)	55	58	56	54	53	51	45	43	44	50	53	54	51
Mean monthly rainfall (mm)	133	153	125	80	75	66	50	37	36	77	101	126	1061
Highest monthly rainfall (mm)	623	600	458	462	551	494	375	138	115	395	392	444	1,964
Mean daily maximum temperature (°C)	30.4	29.7	28.7	26.4	23.8	21.4	21.1	22.5	25.1	27	28.3	29.6	26.2

3.3 Ambient air quality

The air quality of the study corridor is influenced by both regional air pollution and localised sources. The ambient air quality within the study corridor has been described by:

- identifying the regional influences on air quality in South East Queensland
- reviewing ambient air quality data recorded by the DERM in the study area
- identifying localised sources of air emissions in the study corridor
- establishing background air quality levels for the study corridor.

3.3.1 Regional influences on air quality

The Environmental Protection Agency and Brisbane City Council (2004) prepared an air emissions inventory for South East Queensland and identified the following key regional influences on air quality:

- particulate matter from dust storms (infrequent)
- particulate matter from bushfires and controlled burns (occurs once or twice per year in cooler months)
- motor vehicle emissions including NO_X, PM_{10}, $PM_{2.5}$, CO and SO_2
- biogenic emissions of volatile organic compounds (VOCs), which can be a precursor to the formation of photochemical smog.

3.3.2 Regional air quality data

The ambient air quality of the study area has been described by reviewing air quality data recorded by the DERM at Rocklea, South Brisbane and Brisbane CBD (QUT) from 2005 to 2009, and data recorded by Airport Link at Bowen Hills. The locations of these air quality monitoring stations are presented in **Figure 4**.

The air quality monitoring data from these monitoring stations are discussed below.

Bowen Hills

Bowen Hills monitoring station is located in an elevated position near the Inner City Bypass. The site measures meteorological data and concentrations of PM_{10} and $PM_{2.5}$. Air quality monitoring data from the Bowen Hills monitoring station from 2004 and 2005 are presented in **Table 7**. Daily PM_{10} and $PM_{2.5}$ concentrations at Bowen Hills from 2004 and 2005 are presented in **Figure 7** and **Figure 8**.

The data from Bowen Hills show that PM_{10} and $PM_{2.5}$ concentrations have been below the air quality goals, with the exception of four exceedances for $PM_{2.5}$ in 2004.

Table 7 Air Quality Monitoring Data at Bowen Hills from 2004 to 2005

Pollutant	Air Quality Objective	Averaging Period	Pollutant concentrations (µg/m^3)				
			Average	70th percentile	95^{h} percentile	99th percentile	Maximum
PM_{10}	50 µg/m^3	24 hours	17.4	18.6	32.7	45.5	63.2
	5 exceedances per year		2 exceedances in 2005				
$PM_{2.5}$	25 µg/m^3	24 hours	8.5	9.1	16.2	24.3	35.5
	0 exceedances per year		4 exceedances in 2004				

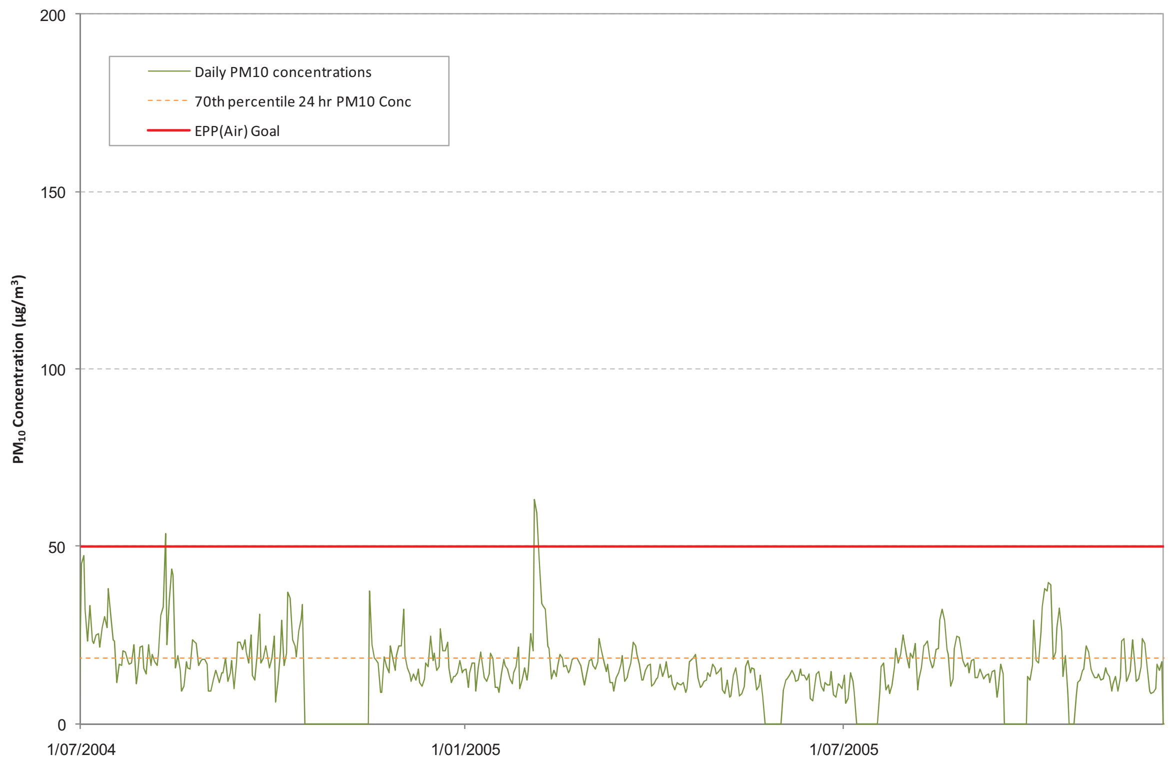


Figure 7 Daily PM10 Concentrations at Bowen Hills in 2004 and 2005

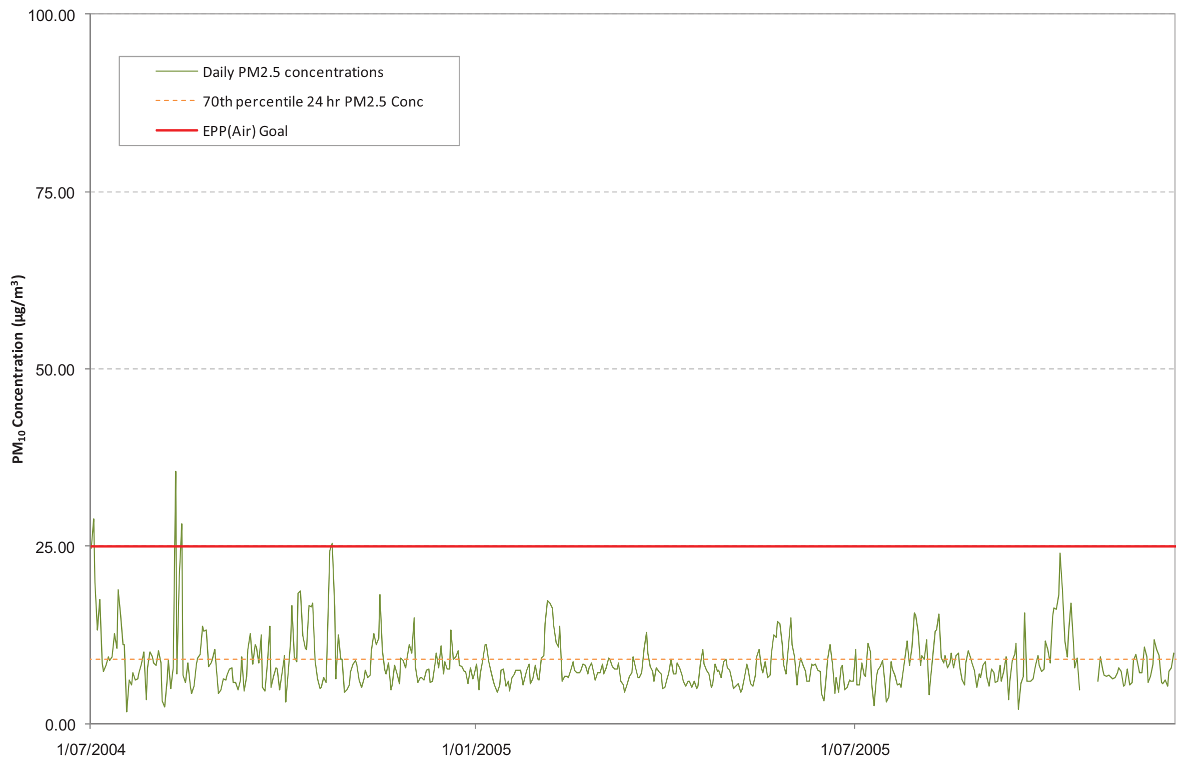


Figure 8 Daily PM2.5 Concentrations at Bowen Hills in 2004 and 2005

Brisbane CBD (QUT)

Brisbane CBD (QUT) monitoring station is located in an elevated position at the Queensland University of Technology campus. The site measures PM_{10} concentrations and meteorological data. Air quality monitoring data from Brisbane CBD monitoring station from 2005 to 2009 are presented in **Table 8**. Daily PM_{10} concentrations at Brisbane CBD from 2005 to 2009 are presented in **Figure 9**.

The data from Brisbane CBD show that PM_{10} concentrations have been below the air quality goal of 50 µg/m^3, except in 2009 when major dust storms resulted in seven exceedances.

Table 8 Air Quality Monitoring Data at Brisbane CBD (QUT) from 2005 to 2009

Pollutant	Air Quality Objective	Averaging Period	Pollutant concentrations (µg/m^3)				
			Average	70th percentile	95^{h} percentile	99th percentile	Maximum
PM_{10}	50 µg/m^3	24 hours	17.4	18.2	29.9	44.7	1,013
	5 exceedances per year		7 exceedances in 2009 due to major dust storm				

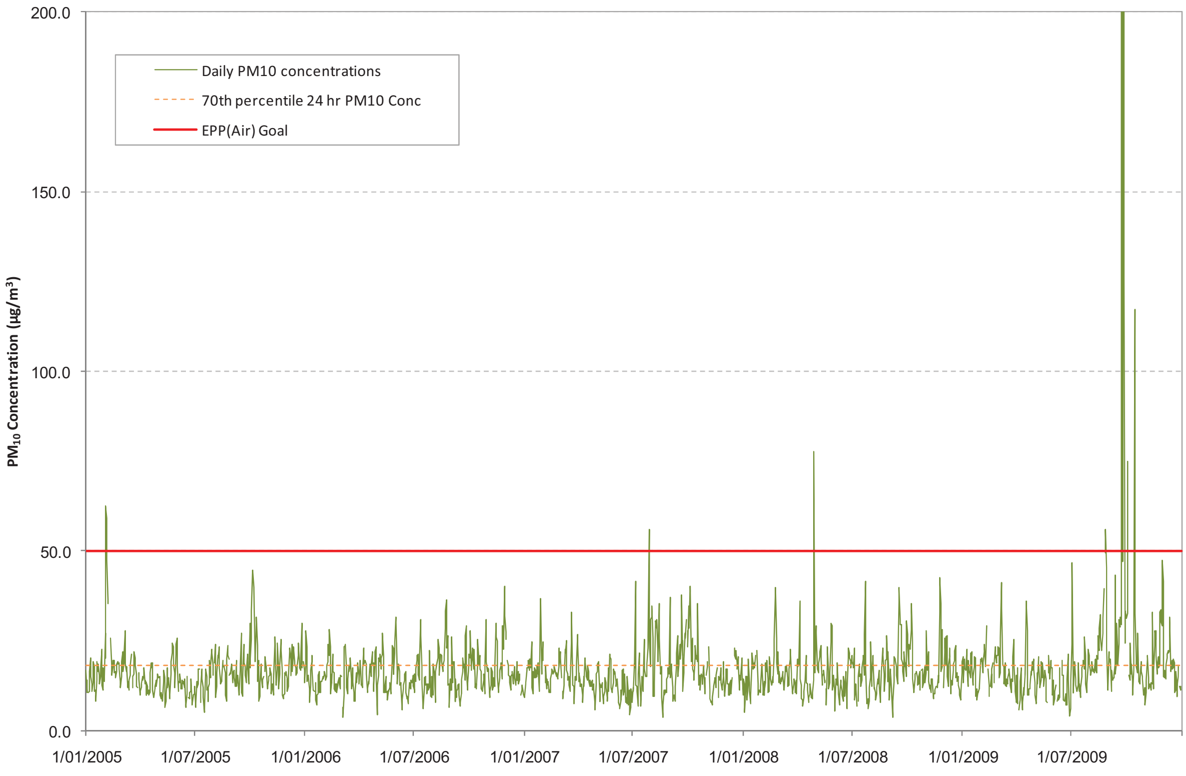


Figure 9 Daily PM10 Concentrations at Brisbane CBD (QUT) from 2005 to 2009

South Brisbane

The South Brisbane monitoring station is located nearby the Riverside Expressway. The site measures PM_{10} concentrations and meteorological data. Air quality monitoring data from the South Brisbane monitoring station from 2005 to 2009 are presented in **Table 9**. Daily PM_{10} concentrations at South Brisbane from 2005 to 2009 are presented in **Figure 10**.

The data from South Brisbane show that PM_{10} concentrations have been below the air quality goal of 50 µg/m^3, except in 2009 when major dust storms resulted in 14 exceedances.

Table 9 Air Quality Monitoring Data at South Brisbane from 2005 to 2009

Pollutant	Air Quality Objective	Averaging Period	Pollutant concentrations (µg/m^3)				
			Average	70th percentile	95^{h} percentile	99th percentile	Maximum
PM_{10}	50 µg/m^3	24 hours	21.3	22.4	35.3	49.6	1060.3
	5 exceedances per year		14 exceedances in 2009 due to major dust storm				
NO_2	250 µg/m^3	1 hour	34.0	41	63.6	80.0	141.6
	62 µg/m^3	1 year	-	-	-	-	36.9 (2005)

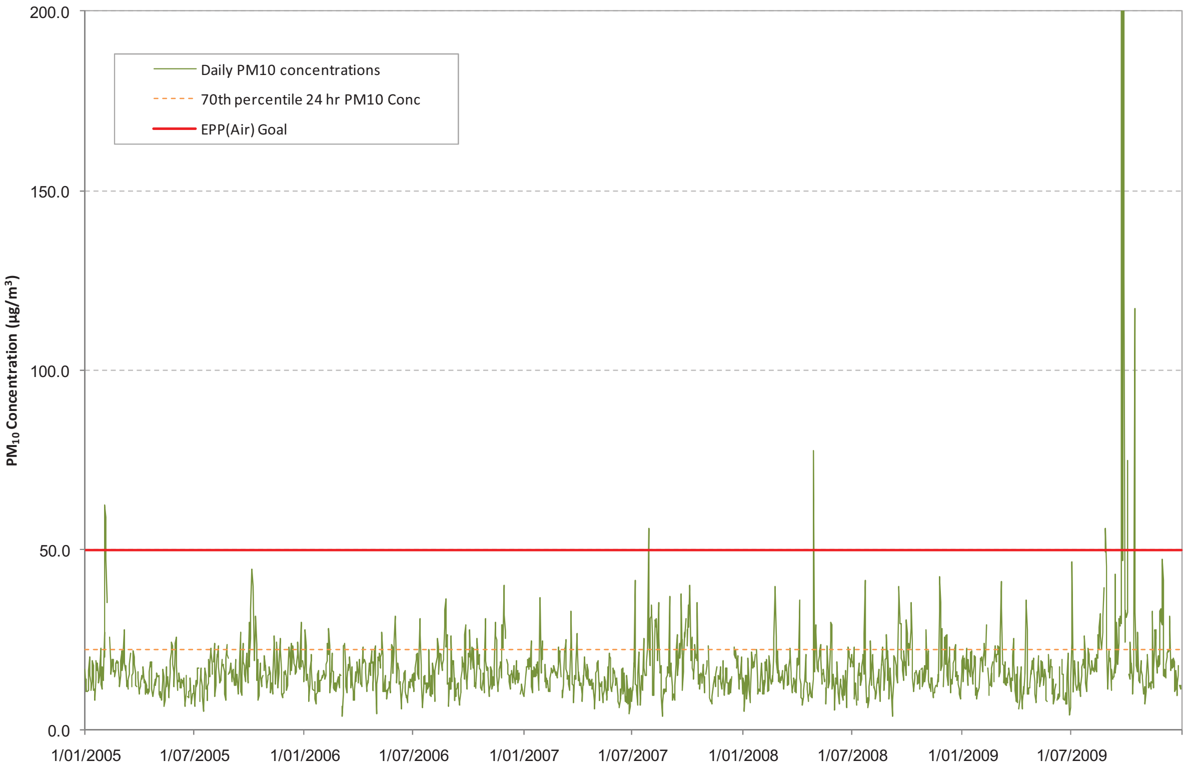


Figure 10 Daily PM10 Concentrations at South Brisbane from 2005 to 2009

Rocklea

The Rocklea monitoring station was established in 1978 and is located in an open area surrounded by industry and residential uses. The Rocklea monitoring station measures PM_{10}, $PM_{2.5}$, NO_2, ozone and meteorological data. Air quality monitoring data from Rocklea monitoring station from 2005 to 2009 are presented in **Table 10**. Daily PM_{10} and $PM_{2.5}$ concentrations at Rocklea from 2005 to 2009 are presented in **Figure 11** and **Figure 12**.

The data from Rocklea (**Table 10**) show that PM_{10} and NO_2 concentrations are below the air quality goals, except in 2009 when major dust storms resulted in ten exceedances of the PM_{10} goal of 50 µg/m^3.

Exceedances of the 24 hour ambient air quality goal for $PM_{2.5}$ were recorded in 2005, 2007, 2008, and 2009. The annual goal for $PM_{2.5}$ was exceeded in 2009 due to major dust storms.

Table 10 Air Quality Monitoring Data at Rocklea from 2005 to 2009

Pollutant	Air Quality Objective	Averaging Period	Pollutant concentrations (µg/m³)				
			Average	70th percentile	95th percentile	99th percentile	Maximum
PM_{10}	50 µg/m³	24 hours	18.5	19.2	32.7	45.9	1,033
	5 exceedances per year		10 exceedances in 2009 due to major dust storm				
$PM_{2.5}$	25 µg/m³	24 hours	7.2	7.8	14.3	21.7	100.7
	0 exceedances per year		8 exceedances in 2009 due to major dust storm				
	8 µg/m³	1 year	-	-	-	-	10.7 (2009)
NO_2	250 µg/m³	1 hour	16.5	20.5	43.1	61.6	96.5
	62 µg/m³	1 year	-	-	-	-	18.5 (2005)

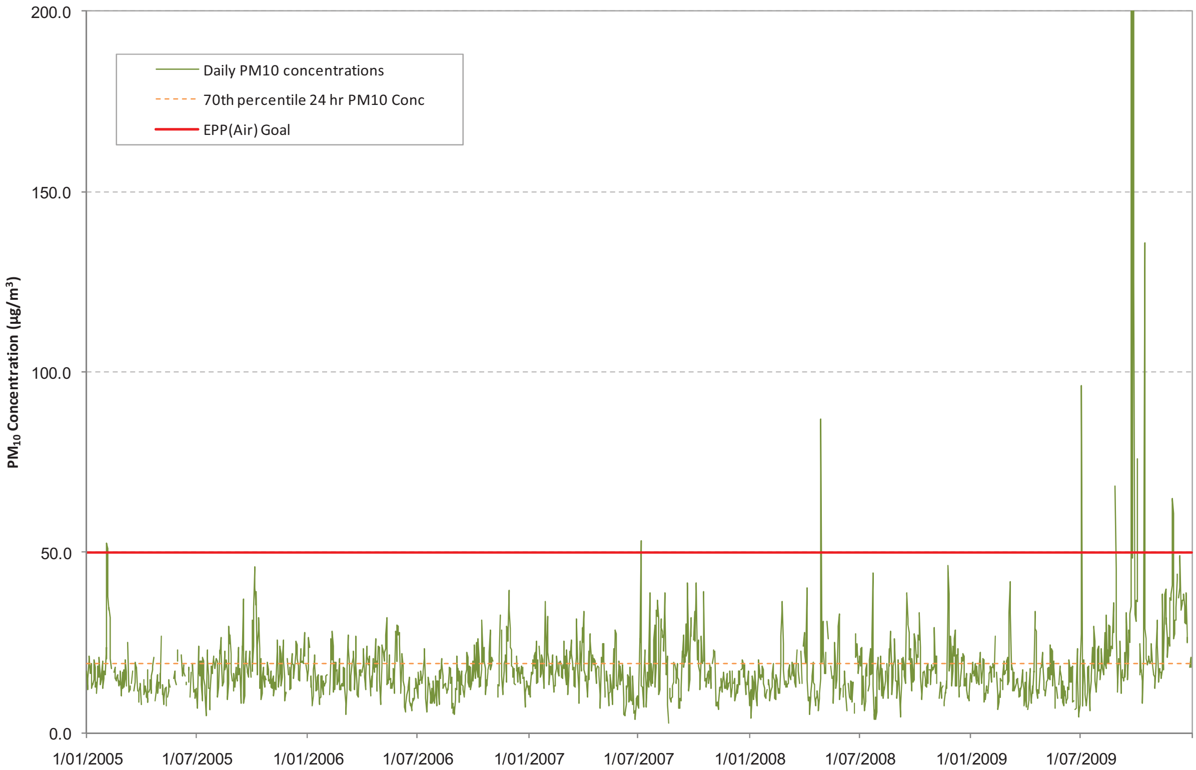


Figure 11 Daily PM10 Concentrations at Rocklea from 2005 to 2009

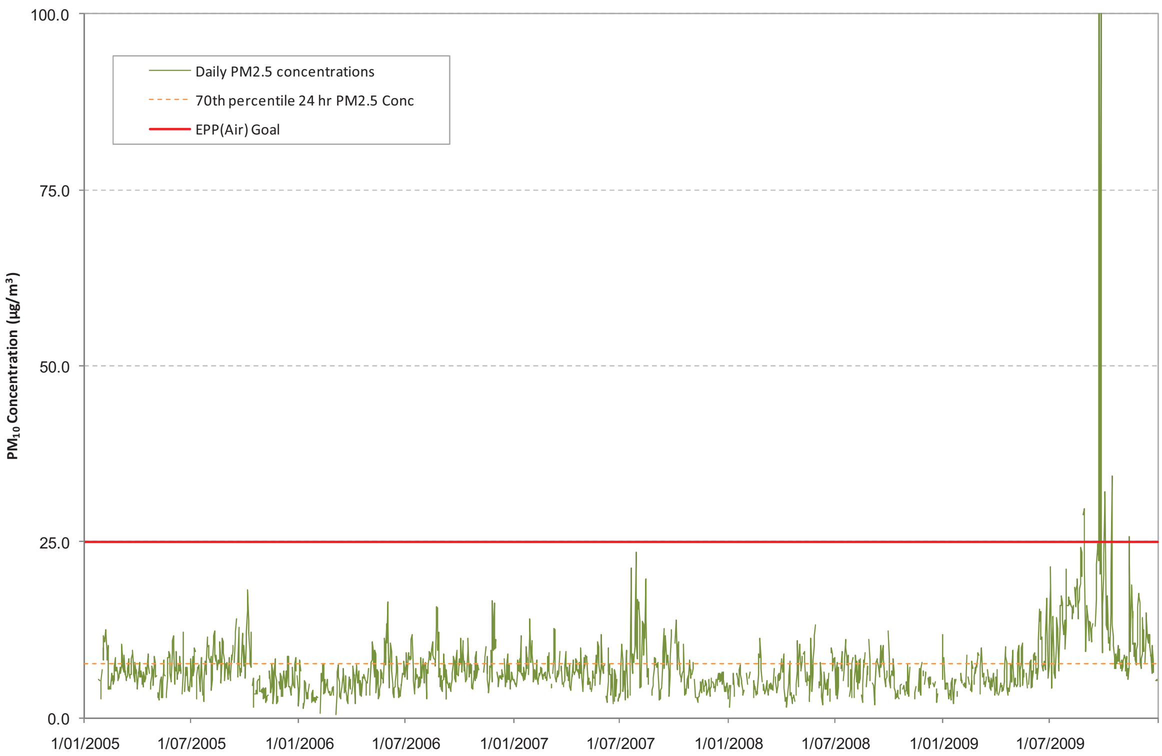


Figure 12 Daily PM2.5 Concentrations at Rocklea from 2005 to 2009

3.3.3 Local air quality

This section identifies air emissions within the study corridor and establishes background air quality levels for the air quality impact assessment.

Potential localised air emissions sources were identified from aerial imagery and the National Pollutant Inventory database.

Localised air emissions sources at the Northern section of the study corridor include:

- motor vehicle emissions from major roads including the Inner City Bypass, Sandgate Road, Bowen Bridge Road and Lutwyche Road
- transport infrastructure including a rail yard and a bus depot.

Localised air emissions sources at the Southern section of the study corridor include:

- motor vehicle emissions from major roads including the South East Freeway, Ipswich Road and Fairfield Road
- industrial sources near Rocklea and Acacia Ridge
- incineration of medical wastes from hospitals.

Construction works near to the Project worksites have the potential to cause cumulative impacts on air quality due to the excavation and movement of spoil and operation of construction equipment. Construction works likely to occur within the Project construction period include:

- Bowen Hills Urban Development Area
- RNA Showgrounds Redevelopment

- Woolloongabba Urban Development Area
- Woolloongabba Neighbourhood Plan
- Boggo Road Urban Village
- works related to the implementation of Kangaroo Point South Neighbourhood Plan
- works related to the Yeerongpilly Transit Oriented Development.

No major sources of odour were identified near the Northern or Southern sections of the study corridor.

Given the absence of major industrial air emissions sources within the study corridor, the regional air quality monitoring data has been used to establish the background air quality data. The adopted background air quality concentrations for the study corridor are presented in **Table 11**. For assessment of 24-hour average model predictions, the background particulate levels for PM_{10} and have been based on 70^{th} percentile monitoring data recorded at Rocklea. This approach is consistent with the approach suggested by the Victorian EPA (VEPA) where the 70^{th} percentile of background data is used to determine the potential for the relevant assessment criteria to be exceeded (VEPA 2006). For assessment of annual average model predictions, the background levels were based on annual average measurement data.

The adopted background air quality concentrations in **Table 11** are still considered conservative levels, that is, on most days in most parts of the study corridor, concentrations would be expected to be lower than these values.

Table 11 Adopted background air quality concentrations

Air Quality Indicator	Value	Averaging Period	Comment
Total Suspended Particulates	28 µg/m^3	1 year	Assumed to be 1.5 times average PM_{10} concentration at Rocklea, due to absence of TSP monitoring.
	29 µg/m^3	24 hours	Assumed to be 1.5 times 70^{th} percentile PM_{10} concentration at Rocklea, due to absence of TSP monitoring.
Particulate matter (PM_{10})	19 µg/m^3	24 hours	70^{th} percentile concentration at Rocklea
Dust deposition	60 mg/m^2/day	30 days	Assumed value

3.4 Summary

The key features of the existing air quality environment in the study corridor are:

- good air quality with concentrations of most pollutants well below the air quality goals except:
  - regional sources (such as controlled burns or dust storms) of PM_{10} typically result in one or two exceedances of the goal each year
  - $PM_{2.5}$ levels in Brisbane occasionally exceed the ambient air quality goals in the EPP(Air)
- air quality within the study corridor is considered to be mainly influenced by regional air emissions
- dispersion meteorology is characterised by winds from the northeast during summer and spring and winds from the southwest during autumn and winter.

4 Construction air quality impacts

4.1 Introduction

This section describes the likely air quality impacts expected from the construction of the Project and includes:

- sources of air emissions during construction
- estimating air emissions from worksites
- air dispersion modelling of dust from high risk worksites
- assessing the potential air quality impacts from construction works
- discussing the implications.

4.2 Sources of air emissions

4.2.1 Overview of construction methodology

Major components of construction include the following:

- site establishment and demolition activities
- tunnnelling activities and other excavation
- shaft excavation
- spoil removal
- spoil placement
- surface road and bridge works
- construction of railway stations and other buildings
- use of associated construction equipment, generators and other plant.

4.2.2 Site establishment and demolition activities

An initial step in site establishment would be the demolition of buildings and removal of kerbs, roadways and fencing located on acquired properties. Strict dust control and mitigation measures would be implemented during demolition works to minimise the potential for impacts from these activities.

Particular consideration would be given to demolition of buildings that may contain harmful substances including asbestos fibres, such as those at Albert Street and Yeeroongpilly worksites. In such cases, controls would be implemented to satisfy Part 13 of the *Workplace Health and Safety Regulation 2008*. It is expected that these measures would also be sufficient to adequately manage potential off-site impacts.

Significant earthworks are associated with establishing the following worksites:

- Northern portal – cuttings to conform general site elevation levels to the level of the Queensland Rail corridor
- Gabba Station – excavations to reduce levels in the south of the worksite to conform to the elevation of the busway corridor
- Boggo Road Station – minimal cutting required in the extreme north of the worksite to form a piling platform for construction of the station headwall

- Yeerongpilly Station and portal – excavation and cuttings to form the portal trough and create grades for new at-grade station below the level of Wilkie Street.

4.2.3 Tunnelling activities and other excavation

Tunnelling would be carried out using Tunnel Boring Machine (TBMs) between the northern and southern portals.

Surface excavations would be conducted by excavators and front end loaders down to rock level, with drilling and blasting used on rock. Drilling and blasting would be used in all shafts and station boxes where blast mats would be used to mitigate vibrations and prevent flyrock.

The construction of Boggo Road Station, Gabba Station, and the Yeerongpilly Station / southern portal would use a cut and cover method with pile walls or like retaining structures. Albert Street and Roma Street Stations would be mined caverns with ventilation and access shafts. Existing underground services such as water and sewage pipelines, gas pipelines and electricity and communications cabling may require relocation prior to, or during tunnelling and excavation activities.

Potentially harmful silica dust may be encountered during the excavation through certain types of geological formations. Where this is encountered, controls would be implemented to satisfy relevant occupational health and safety requirements. It is expected that these measures would also be sufficient to adequately manage potential off-site impacts from silica dust.

Potential odours could also arise from the excavation of contaminated material.

4.2.4 Spoil removal

An estimated total of 3.4 Mt of spoil is likely to be produced, with a total volume of 2.1 million m^3 (1.4 million m^3 insitu). The majority of spoil would be generated from the TBM worksites at Woolloongabba and Yeerongpilly, with significant volumes also generated at the northern portal and the station locations. The intended disposal routes from the main TBM worksites are via Ipswich Road to the west. Spoil disposal over a full 24 hour period is proposed, or sufficient storage on site provided, to allow for continuous tunnel excavation.

Priority worksites with respect to routes for spoil removal are:

- Northern portal
- Woolloongabba
- Boggo Road
- Yeerongpilly.

Where possible, spoil would be removed directly on and off freeways and major trunks while spoil quantities extracted from other worksites to be minimized. Spoil removal has been considered in **Chapter 4 Project Description**.

4.2.5 Spoil placement

It is proposed that spoil from construction would be disposed offsite at an industrial site off Swanbank Road, Swanbank, subject to commercial negotiations with property owners.

The nearest sensitive receptors to the proposed spoil placement location are residences 1.8 km to the east and south of the site.

Spoil material extracted from the TBMs is likely to be damp and haul truck bodies would be covered during transport. Minimal dust generation is expected from the transport of spoil to the disposal site.

Cunningham Highway and Centenary Highway are being considered as potential haul routes for transporting spoil to the disposal site.

The main source of air emissions from the disposal site would be dust generated from spoil handling. It is expected that trucks would dump spoil at the designated site, where it would be stockpiled and managed by a bulldozer.

4.2.6 Surface road and bridge works

Traditional construction methods using excavators, graders, compaction equipment and pavement placing equipment would be utilised for surface road works and bridge construction. The potential air quality impacts of these activities are expected to be similar to those outlined earlier for site establishment and demolition activities and could be managed in accordance with the measures outlined in **Section 4.8**.

In order to manage potential dust issues traditionally associated with concrete batching, the concrete required for the construction of the stations and road surfaces would be premixed off site and delivered in trucks, in preference to sourcing from an on site concrete batching plant. In some cases, pre-cast concrete panels may be delivered to the worksites.

4.2.7 Surface rail works

Traditional construction methods, including the use of excavators, graders and compaction equipment would be utilised for surface rail works. The potential air quality impacts of these activities are expected to be similar to those outlined earlier for site establishment and demolition activities and could be managed in accordance with the measures outlined in **Section 4.8**.

4.2.8 Construction of above ground railway stations and other buildings

Construction of the above ground stations is expected to generate dust through demolition and excavation activities and through the construction of worksite buildings. The potential air quality impacts of these activities are expected to be similar to those outlined earlier for site establishment and demolition activities, and could be managed in accordance with the measures outlined in **Section 4.8**.

4.2.9 Use of associated construction equipment, generators and other plants

Each worksite would be served by a number of supporting equipment and plant including excavators, cranes, piling rigs, compaction plants, bulldozers and trucks.

In case of power outages, generators would provide power to temporary ventilation equipment to be used at worksites.

4.3 Potential for air quality impacts

Construction activities with the greatest potential for dust impacts include:

- graders working unpaved areas and dozers moving material
- wind erosion from exposed surfaces
- wheel generated dust from vehicles travelling along unpaved or dirty paved surfaces
- the handling and transport of spoil.

The potential for air quality impacts from each of the worksites is presented in **Table 12** and **Table 13**.

Table 12 Potential for Air Quality Impacts at Worksites for Tunnelling

Worksite	Description of Activities	Potential for Air Quality Impacts
Northern Portal	This worksite would be used for: • construction of the north portal, dive structure and cut and cover tunnel sections. • retrieval of the TBMs for the tunnels between Woolloongabba and Victoria Park.	Excavation activities and spoil handling at the northern portal worksite may generate air quality impacts. The potential dust emissions have been estimated in **Section 4.4** and dust concentrations have been predicted in **Section 4.6**.
Woolloongabba	The worksite would be used for: • construction of the cut and cover box and station cavern for the Gabba Station • TBM launch site and removal of spoil from construction of the tunnels between Woolloongabba and Victoria Park • retrieval of the TBMs for the tunnels between Yeerongpilly and Woolloongabba.	Excavation activities and spoil handling at the Woolloongabba worksite may generate air quality impacts. The potential dust emissions have been estimated in **Section 4.4** and dust concentrations have been predicted in **Section 4.6**.
Yeerongpilly	The worksite would be used for construction of: • the southern portal and new Yeerongpilly Station • TBM launch site and removal of spoil from the tunnels between Yeerongpilly and Woolloongabba • the extended footbridge to the existing station • construction of the new re-aligned local streets.	Excavation activities and spoil handling at the Yeerongpilly worksite may generate air quality impacts. The potential dust emissions have been estimated in **Section 4.4** and dust concentrations have been predicted in **Section 4.6**.

Table 13 Potential for Air Quality Impacts at Other Worksites

Worksite	Description of Activities	Potential for Air Quality Impacts
Mayne Rail Yard	Worksite and material laydown area to support construction of the northern viaduct in Mayne Rail Yard. Construction of the Mayne feeder station.	This worksite is considered to have a low potential for air quality impacts. Dust would be minimised by the Contractor through the dust management measures in **Section 4.8.**
RNA Showgrounds	Worksites at the RNA Showgrounds would be used for construction of a new station and surface tracks and regrading of O'Connell Terrace. Construction support sites for the regrading of O'Connell Terrace, including road over rail bridge.	This worksite is considered to have a low potential for air quality impacts. Dust would be minimised by the Contractor through the dust management measures in **Section 4.8.**
Roma Street Station	The northern worksite would be used for the construction of the: • northern plant shaft and building for Roma Street Station • Re-located toilet facilities. The central worksite would be used for the construction of the: • central shaft for escalators and lift shaft access to the existing station concourse • re-location of the toilets facilities. The southern worksite would be used for the construction of the: • shaft to accommodate the southern entrance to the station and associated plant • main on-site support for construction of the station cavern.	Excavation activities do have the potential to generate dust at this location. Construction activities will occur in the shaft and dust emissions are not expected to exceed the air quality goals. Dust would be minimised by the Contractor through the dust management measures in **Section 4.8.**

Worksite	Description of Activities	Potential for Air Quality Impacts
Albert Street Station	The northern worksite would be used for the construction of the northern station entrance and associated plant. The southern worksite would be used for construction of the: • Albert Street Station cavern • shaft accommodating the southern entrance and associated plant • subway and entrance under Alice Street.	Excavation activities do have the potential to generate dust at this location. Construction activities will occur in the shaft or purpose built acoustic shed. Dust emissions from construction are not expected to exceed the air quality goals. Dust would be minimised by the Contractor through the dust management measures in **Section 4.8.**
Boggo Road Station	This worksite would be used for the construction of the cut and cover station box, entrance shafts and associated plant.	Cut and cover tunnelling and proximity to sensitive receivers may generate air quality impacts at this location. The potential dust emissions have been estimated in **Section 4.4** and dust concentrations have been predicted in **Section 4.6**.
Ventilation and emergency access building	Construction of ventilation shaft and emergency access building.	Construction activities will occur in the shaft and dust emissions are not expected to exceed the air quality goals. Dust would be minimised by the Contractor through the dust management measures in **Section 4.8.**
Clapham Rail Yard	Placing fill to raise the ground level for new surface tracks. Material laydown and worksite for surface track work within Clapham Rail Yard.	Given the large quantities of spoil received at Clapham Rail Yard there is potential for air quality impacts at this location. The potential dust emissions have been estimated in **Section 4.4** and dust concentrations have been predicted in **Section 4.6**.
Moorooka	Worksite and stockpiling of materials for the construction of the viaduct.	This worksite is considered to have a low potential for air quality impacts. Dust would be minimised by the Contractor through the dust management measures in **Section 4.8.**
Rocklea	Construction of the Muriel Avenue bridge and road works associated with the Ipswich Road on-ramp. Material laydown area for construction of the new surface tracks.	This worksite is considered to have a low potential for air quality impacts. Dust would be minimised by the Contractor through the dust management measures in **Section 4.8.**

Worksite	Description of Activities	Potential for Air Quality Impacts
Salisbury	These worksites would be used for: • storage and material laydown • construction of the new footbridge north of Salisbury Station and extension of the existing footbridge at Salisbury Station • southern surface tracks • road realignments.	This worksite is considered to have a low potential for air quality impacts. Dust would be minimised by the Contractor through the dust management measures in **Section 4.8.**

4.4 Emissions estimation

Dust emissions from construction would vary in line with the intensity of construction activities. In general, dust emissions from construction are greatest during periods of significant earth moving activities.

This section outlines the estimated dust emissions from five key worksites:

- northern portal
- Gabba Station
- Boggo Road Station
- Yeerongpilly Station
- Clapham Rail Yard.

These five worksites were chosen as they involved more significant construction periods, intensity of activities, scale of operations and durations than other worksites. Therefore, the five worksites listed above represent the highest potential of all worksites to cause adverse air quality impacts, and have been the focus of the modelling and assessment. Lower air quality impacts would be expected at the other worksites.

The proposed construction works at the five worksites with greatest potential for air quality impacts, the duration of construction activities, construction equipment and identified air emissions sources is presented in **Table 14**, **Table 15**, **Table 16** and **Table 17**.

Table 14 Construction Works, Duration of Activities and Air Emission Sources at Northern Portal

Worksite (area)	Construction Works (duration)	Equipment	Air Emission Sources
Northern Portal ($30,321\ m^2$)	- Worksite establishment including surface demolitions - Establish piling rigs on site (4 wks) - Installation of piles for cavern walls (4 wks) - Excavation of shaft (5 wks) - Installation of piles for cut and cover box structure (9 wks) - Cut and cover excavation (5 wks)	3 x drilling jumbo 2 x piling rigs 2 x bulldozer 1 x 150 t crane 2 x 60-100t crane 5 x 5 m^3 FEL 2 x 5 t excavator 3 x 20 t excavator 3 x 35 t excavator 1 x scissor lift 1 x ventilation plant 1 x shaft hoist 1 x shaft lift 2 x compressor 2 x generator 2 x pump	Fugitive dusts from: - excavation of rock and overburden; - stockpiling, handling and transport of spoil material (peak 15,750 t/wk); - demolitions of low rise buildings and sheds; - clearing of trees and topsoil; - vehicle movements on exposed areas; and - windblown dust from exposed areas; Diesel emissions from: - Construction vehicles and equipment - Haul trucks (peak 75 per day)

Table 15 Construction Works, Duration of Activities and Air Emission Sources at Woolloongabba

Worksite (area)	Construction Works (duration)	Equipment	Air Emission Sources
Gabba Station ($23,180\ m^2$)	- Worksite establishment including surface demolitions (12 wks) - Open excavation (8 wks) - Establishment of piling rigs (4 wks) - Piling installation (7 wks) - Construction of acoustic shed (4 wks) - Excavation and blasting (12 wks)	3 x drilling jumbo 1 x bulldozer 4 x piling rigs 2 x 150 t crane 4 x 60-100 t crane 2 x 3.5 m^3 FEL 4 x 5 m^3 FEL 2 x 5 t excavator 2 x 20 t excavator 4 x 35 t excavator 1 x scissor lift 2 x ventilation plant 1 x shaft hoist 1 x shaft lift 2 x compressor 2 x generator 2 x pump	Fugitive dusts from: - excavation of rock and overburden; - stockpiling, handling and transport of spoil material (Peak 45,000 t/wk); - demolitions of Go-print building - earthworks to create working platform - vehicle movements on exposed areas; and - windblown dust from exposed areas; Diesel emissions from: - Construction vehicles and equipment - Haul trucks (Peak 214 per day)

Table 16 Construction Works, Duration of Activities and Air Emission Sources at Boggo Road Station

Worksite (area)	Construction Works (duration)	Equipment	Air Emission Sources
Boggo Road Station (18,896 m^2 combined)	- Worksite establishment (6 wks) - Establishment of piling rigs (15 wks) - Piling installation and capping beam construction (40 wks) - Construction of top-slab (12 wks) - Excavation and blasting beneath top slab (25 wks)	2 x bulldozer 3 x drilling jumbo 1 x 150 t crane 4 x 60-100 t crane 2 x 3.5 m^3 FEL 4 x 5 m^3 FEL 2 x 5 t excavator 2 x 20 t excavator 4 x 35 t excavator 4 x scissor lift 4 x ventilation plant 2 x shaft hoist 2 x shaft lift 2 x compressor 2 x generator 2 x pump	Fugitive dusts from: - excavation of rock and overburden; - stockpiling, handling and transport of spoil material (Peak 18,750 t/wk); - demolition/relocation of Park Road Station entrance - clearing of trees and topsoil; - vehicle movements on exposed areas; and - windblown dust from exposed areas; Diesel emissions from: - Construction vehicles and equipment - Haul trucks (Peak 89 per day)

Table 17 Construction Works, Duration of Activities and Air Emission Sources at Boggo Road Station

Worksite (area)	Construction Works (duration)	Equipment	Air Emission Sources
Yeerongpilly Station and Portal (130,849 m^2)	- Worksite establishment and demolitions (12 wks) - Establishment of piling rigs (4 wks) - Piling installation (6 wks) - Excavation and installation of anchors and shotcrete (38 wks)	3 x drilling jumbo 1 x piling rigs 1 x 150 t crane 1 x 60-100 t crane 2 x 3.5 m^3 FEL 4 x 5 m^3 FEL 2 x 5 t excavator 3 x 20 t excavator 3 x 35 t excavator 3 x scissor lift 1 x ventilation plant 1 x shaft hoist 1 x shaft lift 2 x compressor 2 x generator 1 x pump	Fugitive dusts from: - excavation of rock and overburden; - stockpiling, handling and transport of spoil material (Peak 45,000 t/wk); - demolitions of low rise housing and industrial buildings; - vehicle movements on exposed areas; and - windblown dust from exposed areas; Diesel emissions from: - Construction vehicles and equipment - Haul trucks (Peak 214 per day)
Clapham Rail Yard (106,823 m^2)	- Spoil receival and handling - Regrading of area - Realignment and development of rail lines	2 x bulldozer	Fugitive dusts from: - stockpiling, handling and movement of spoil material - vehicle movements on exposed areas; and - windblown dust from exposed areas; Diesel emissions from: - Construction vehicles and equipment - Haul trucks

The construction works programme has been reviewed to determine the phase of construction works that is likely to generate the most emissions from each worksite. The dust emissions from these worst case scenarios were calculated for each worksite. Emissions were estimated using emission factors in the *Emission Estimation Technique Manual for Mining version 2.3* (NPI, 2001). The emission factors used in this estimation are presented in **Table 18**.

Table 18 Emission Factors for construction activities

Construction Activity	Unit	TSP	PM_{10}	Controls to be adopted (% Reduction)
Drilling	kg/hole	0.59	0.31	Water sprays (70%)
Blasting	kg/blast	11.7	6.09	Hoardings around site (30%)
Excavators / FELs on spoil	kg/tonne*	0.025	0.012	Hoardings and water sprays (65%)
Bulldozers on spoil	kg/hour	1.63	0.33	Hoardings around site (30%)
Loading trucks	kg/tonne*	0.0003	0.0001	Hoardings around site (30%)
Wheel generated dust	kg/vkt	3.88	0.96	water sprays (75%)
Trucks dumping spoil	kg/tonne*	0.0120	0.0043	-
Wind erosion	kg/ha/hour	0.4	0.2	-

Note:
**of spoil handled*

A number of assumptions were made in estimating the emissions:

- haul distances on unsealed roads for spoil movements and materials delivery has assumed to be 400 m per journey
- bulldozers operate at the northern portal, Woolloongabba, Boggo Road and Clapham Rail Yard
- blasting occurs twice per day with blast size of 100 m^2
- drill pattern for blasting is assumed to require 1 drill hole for each 1.5 m^2 blast area
- surface excavation activities would occur 12 hours per day, 6 days a week.

The estimated TSP and PM_{10} emissions in g/s for the various construction activities with controls are presented in **Table 19** and **Table 20**. The estimated dust emission rates are inputs to the dispersion model to predict TSP and PM_{10} concentrations and dust deposition rates. The predicted predict TSP and PM_{10} concentrations and dust deposition rates are compared to the ambient air quality goals

Table 19 Estimated TSP Emissions (g/s) from Worksites

	Victoria Park	Woolloongabba	Boggo Road Station	Yeerongpilly	Clapham Rail Yard
Drilling	0.03	0.03	0.03	0.03	-
Blasting	1.31	1.31	1.85	1.31	-
Excavators / FELs on spoil	1.31	1.31	1.85	1.31	-
Bulldozers on spoil	0.63	0.32	0.40	-	0.45
Loading trucks	0.01	0.03	0.02	0.03	-
Wheel generated dust	-	-	-	0.75	-

	Victoria Park	Woolloongabba	Boggo Road Station	Yeerongpilly	Clapham Rail Yard
Trucks dumping spoil	-	-	-	-	0.56
Wind erosion	0.39	0.23	0.23	0.44	0.93
Total (Blasting)	**3.68**	**3.23**	**4.38**	**3.88**	**1.94**
Total (No Blasting)	**2.38**	**1.92**	**2.53**	**2.57**	**1.94**

Table 20 Estimated PM10 Emissions (g/s) from Worksites

	Victoria Park	Woolloongabba	Boggo Road Station	Yeerongpilly	Clapham Rail Yard
Drilling	0.02	0.02	0.02	0.02	-
Blasting	0.68	0.68	0.96	0.68	-
Excavators / FELs on spoil	0.22	0.63	0.26	0.36	-
Bulldozers on spoil	0.13	0.06	0.08	-	0.09
Loading trucks	0.00	0.01	0.01	0.01	-
Wheel generated dust	-	-	-	0.19	-
Trucks dumping spoil	-	-	-	-	0.20
Wind erosion	0.19	0.12	0.11	0.22	0.47
Total (Blasting)	**1.25**	**1.52**	**1.44**	**1.48**	**0.76**
Total (No Blasting)	**0.56**	**0.84**	**0.48**	**0.80**	**0.76**

4.5 Modelling methodology

There are two components to the modelling for the Project; meteorological modelling, and air dispersion modelling. The methodology for these two components is discussed as follows.

4.5.1 Meteorological modelling

Meteorology varies across the region, particularly wind patterns. The meteorology has been incorporated into the assessment by considering data from relevant monitoring stations and extrapolating these data to other areas using a wind-field model. The result is a three-dimensional, time-varying wind-field.

On a relatively small scale, local winds are affected by the topography. At larger scales, winds are affected by synoptic scale winds, which are modified by convective processes in the daytime and also overnight by a complex pattern of regional drainage flows, governed by sloping terrain. In the modelling undertaken for this study it is not necessary to document the complex mechanisms that affect air movements in the area, it is simply necessary to ensure that these air movements are incorporated into the dispersion modelling studies that are conducted.

A limitation of common Gaussian plume dispersion models (such as AUSPLUME) is that they assume that the meteorological conditions are the same, spatially, over the entire modelling domain for any given hour. This may be adequate for sources in relatively uncomplicated terrain, although when the terrain or land use is more complex, such as the Brisbane metropolitan region, the meteorological and dispersion conditions can be more precisely represented using wind field and puff models.

This assessment has made use of the CALPUFF dispersion model. The CALPUFF model, through the CALMET meteorological processor, simulates complex meteorological patterns that exist in a particular region. The effects of local topography and changes in land surface characteristics are accounted for by this model.

Surface meteorological data, including 10 minute records of wind speed, wind direction, relative humidity and temperature, were sourced from the Bureau of Meteorology automatic weather stations at Brisbane Airport and Archerfield Airport. These sites provide coverage of the north-eastern and south-western regions of the study domain, and are not adversely affected by complex local terrain or building environments.

Wind patterns for the Brisbane Airport and Archerfield Airport sites were reviewed by preparing wind-roses shown in **Figure 13**. The wind-roses show that at Archerfield Airport the most common winds are from the south. A slightly different pattern of winds is observed at Brisbane Airport where the most common winds are from the southwest. It was found that 2008 was the year with the most complete meteorological records (for both sites) and windroses for 2008 have also been included in **Figure 13**. The wind patterns for 2008 show consistency with the longer term (2005-2009) patterns and it was therefore concluded that 2008 is a representative meteorological year. Data for 2008 have been the focus of the meteorological modelling.

Figure 13 Wind-roses for Archerfield Airport and Brisbane Airport

Upper-air temperature, wind speed, wind direction, pressure and height data are also required by the CALMET model. In this instance, upper air data from the Bureau of Meteorology Brisbane Airport site were obtained and processed into a form suitable for CALMET. In addition, the CSIRO's prognostic model known as TAPM (The Air Pollution Model) was used to generate the necessary three-dimensional meteorological information that was used as CALMET's initial guess wind-field.

A summary of the data and parameters used as part of the meteorological component of this study is shown below in **Table 21**.

Table 21 **Summary of Meteorological Parameters used for this study**

TAPM (v 4.0.3)	
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grids point	35 x 35 x 25
Year of analysis	January 2008 to December 2008, with one "spin-up" day. The spin-up day allows the meteorological variables to adjust to the model terrain and landuse.
Centre of analysis	Brisbane (27°28' S, 153°1' E)
Meteorological data assimilation	None
CALMET (v 6.326)	
Meteorological grid domain	20 km x 20 km (80 x 80 x 10 grid dimensions)
Meteorological grid resolution	0.25 km
Surface meteorological stations	Two surface stations: Archerfield Airport, using hourly records of temperature, wind speed, wind direction and relative humidity. Brisbane Airport, using hourly records of temperature, wind speed, wind direction and relative humidity. Barometric pressure, cloud cover and ceiling height data generated for Archerfield Airport and Brisbane Airport by the TAPM simulation.
Upper air meteorological station	Brisbane Airport. Missing soundings were supplemented with TAPM prognostic output. The 3-dimensional meteorological output from TAPM was also used as the initial guess wind-field for CALMET.
Simulation length	8760 hours (January 2008 to December 2008)

Figure 14 shows the model extents, terrain and land use information used as input to the CALMET model. The locations of the surface meteorological stations are also shown. Terrain information was extracted from the NASA Shuttle Research Topography Mission (SRTM) database, which has global coverage at approximately 90 m resolution. Land use data were extracted from aerial imagery.

Figure 15 shows a snapshot of winds as simulated by the CALMET model. The plot shows the effect of the terrain on the flow of winds for a particular set of atmospheric conditions where the variations in wind speed and direction at various locations of the study area are evident.

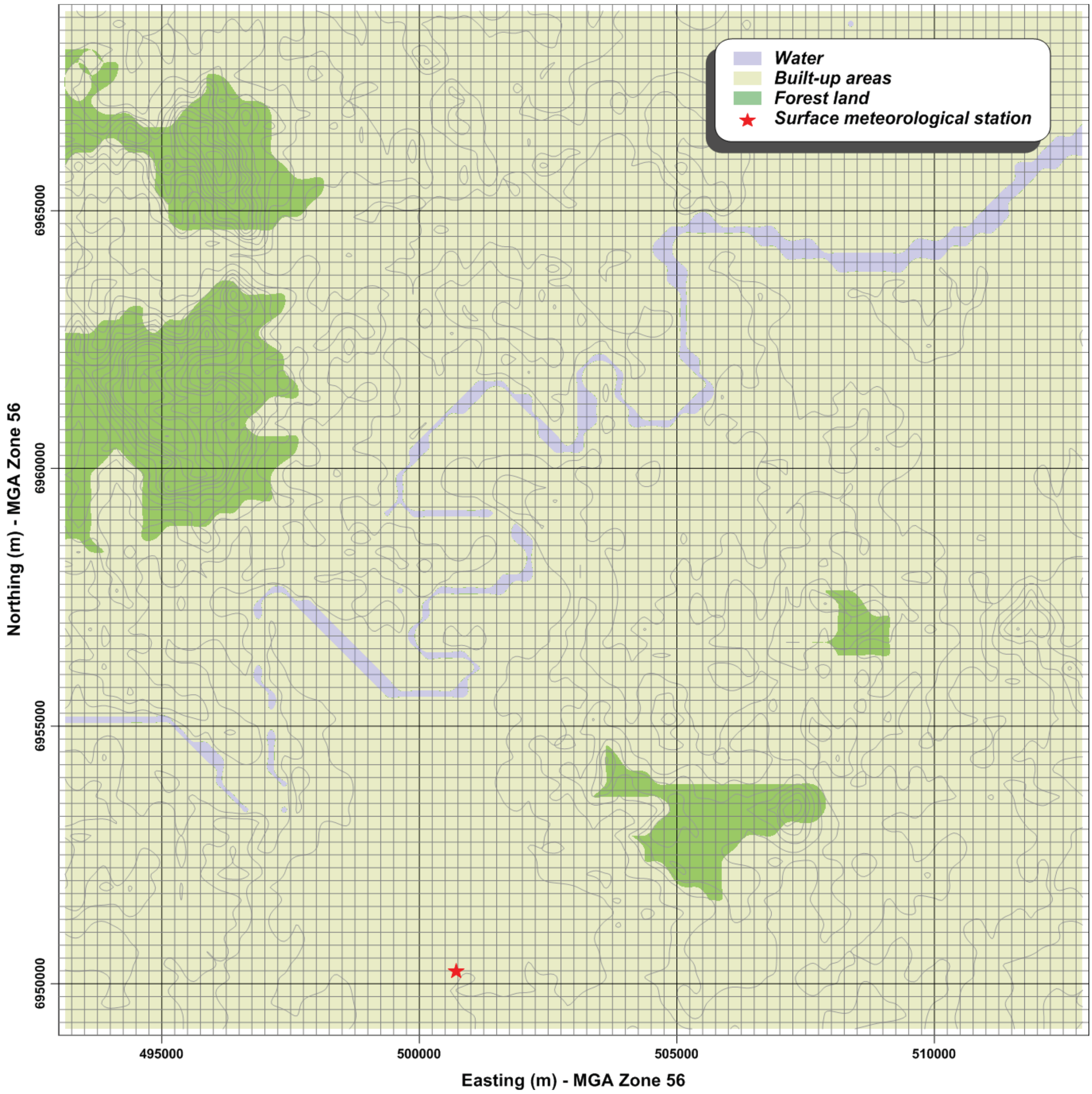


Figure 14 **CALMET model setup**

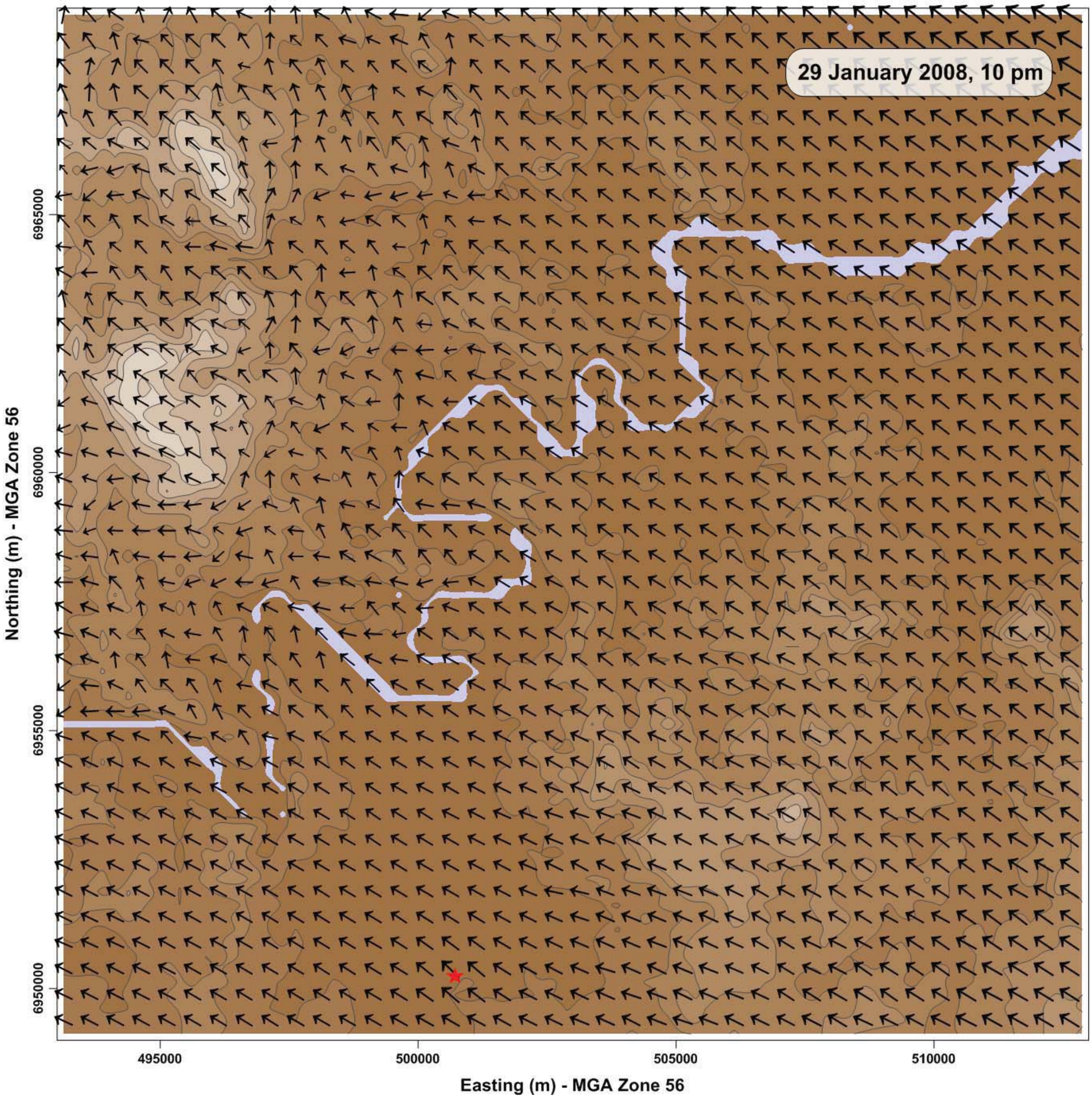


Figure 15 Example wind-field as generated by CALMET

4.5.2 Air dispersion modelling

Dust concentrations and deposition levels due to construction activities were predicted using the air dispersion model known as CALPUFF (Version 6.263). CALPUFF is a Lagrangian dispersion model that simulates the dispersion of pollutants within a turbulent atmosphere by representing emissions as a series of puffs emitted sequentially. Provided the rate at which the puffs are emitted is sufficiently rapid, the puffs overlap and the serial release is representative of a continuous release.

The CALPUFF model differs from traditional Gaussian plume models (such as AUSPLUME) in that it can model spatially varying wind and turbulence fields that are important in complex terrain, long-range transport and near calm conditions. It is the preferred model of the United States Environmental Protection Agency for the long-range transport of pollutants and for complex terrain (TRC, 2007). CALPUFF has the ability to model the effect of emissions entrained into the thermal internal boundary layer that forms over land, both through fumigation and plume trapping.

The modelling was performed using the meteorological information provided by the CALMET model and the estimated emissions from **Section 4.4**. The model was used in this study to predict the dust concentrations and deposition levels in the vicinity of the five major worksites. Dispersion coefficients used turbulence computed from micrometeorology and partial plume path was used for terrain adjustment.

The dispersion modelling options assumed as part of this air quality assessment include:

- emissions were modelled as volume sources across the Project worksite
- emissions were assumed to be emitted every hour of every day between 6 am and 6 pm, apart from blasting emissions, which occurred for one hour each day
- dust deposition rates were determined from the highest monthly average
- geometric mean diameter for coarse particulates (>10 µm) and fine particulate matter (PM_{10}) is 17 µm and 7 µm respectively
- geometric standard deviation for coarse particulates (>10 µm) and PM_{10} is 2 µm and 1 µm respectively.

4.6 Modelling results

This section outlines the predicted concentrations of TSP and PM_{10} and dust deposition rates for worst case emissions from the construction at five key worksites:

- northern portal
- Gabba Station
- Boggo Road Station
- Yeerongpilly Station
- Clapham Rail Yard.

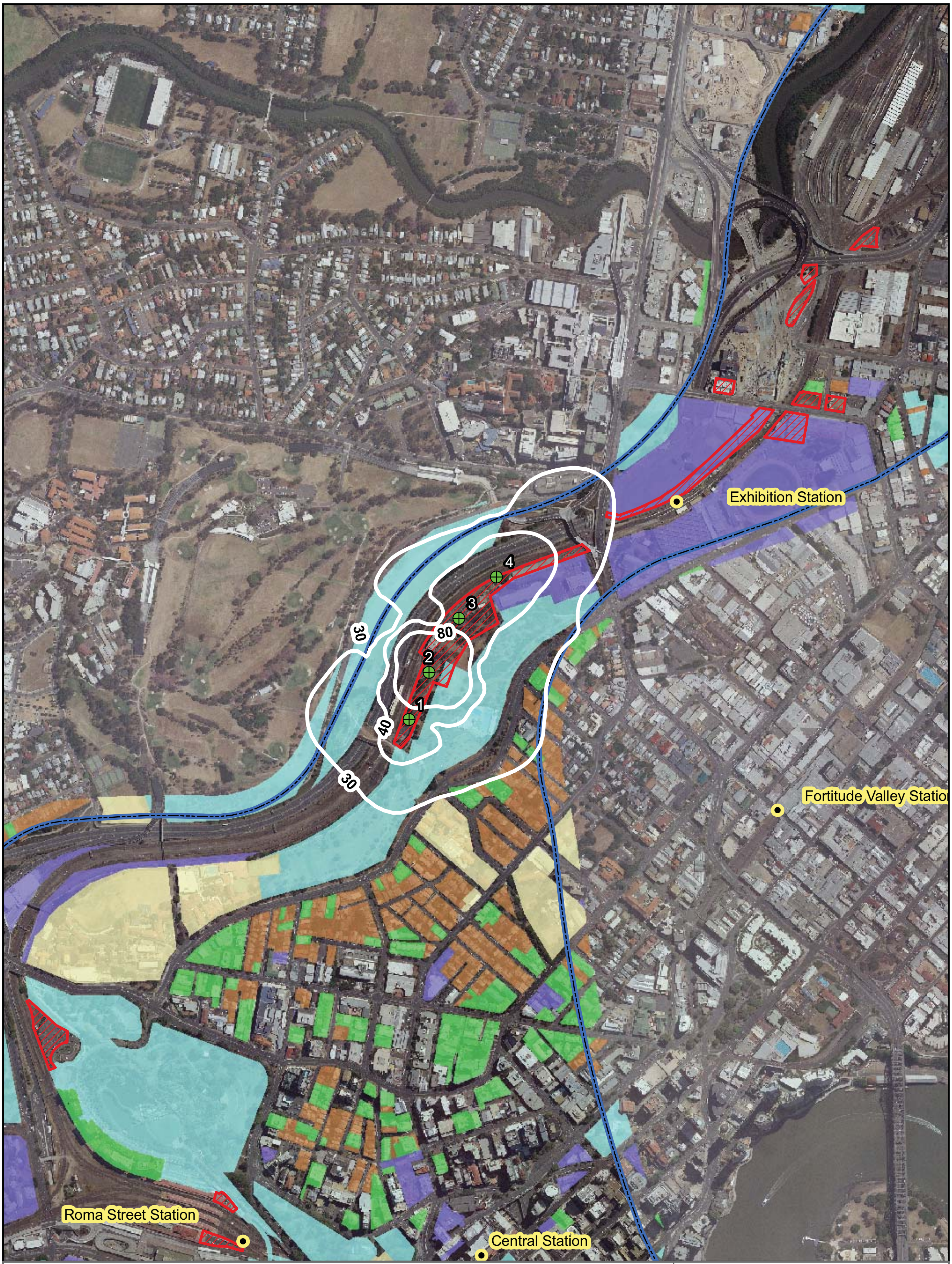
These five worksites were chosen as they involved more significant construction periods, intensity of activities, scale of operations, and durations than other worksites. Therefore, the five worksites listed above represent the highest potential of all worksites to cause adverse air quality impacts, and have been the focus of the modelling and assessment. Lower air quality impacts would be expected at the other worksites.

4.6.1 Northern portal

A contour plot of the predicted maximum increase in PM_{10} concentrations (24 hour average) from the northern portal worksite is presented in **Figure 16**. PM_{10} concentrations have the potential to exceed the air quality objective of 50 µg/m^3 in the EPP(Air) , in open parkland and community facilities immediately to the southeast of the worksite.

A contour plot of the predicted increase in dust deposition rates from the northern portal worksite is presented in **Figure 17**. The predicted dust deposition rates have the potential to exceed the air quality guideline of 120 mg/m^2/day in open parkland community facilities immediately to the southeast of the worksite.

Contour plots of TSP concentrations annual average and 24 hour average are presented in **Appendix B**. The annual average TSP concentrations meet the air quality objective in the EPP(Air). TSP concentrations (24 hour) have the potential to exceed the dust nuisance goal of 80 µg/m^3 to the southeast of the worksite.



LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

0 100 200 300 400 m

1:12,000 at A4

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

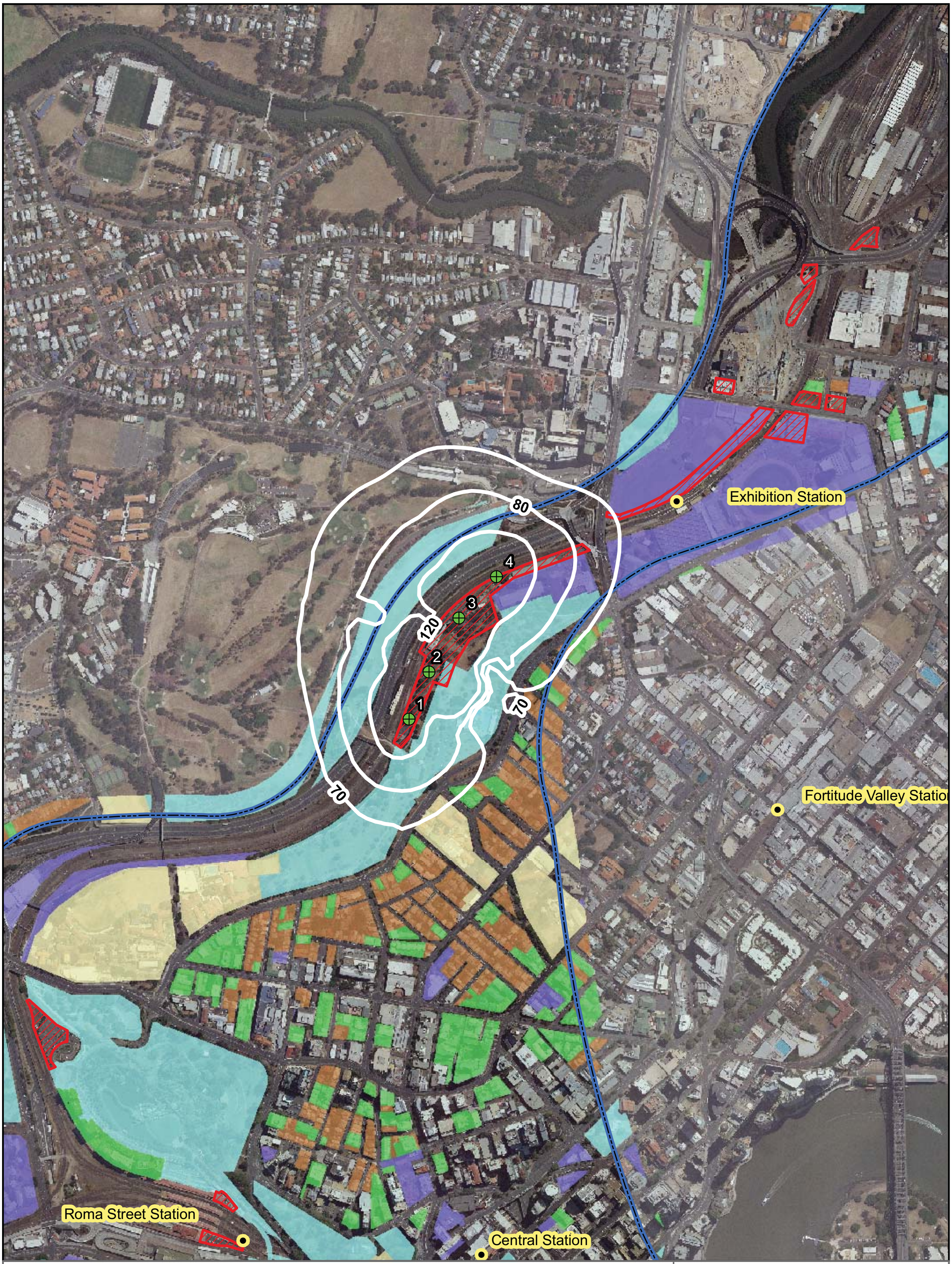
Figure 16

Maximum cumulative PM_{10} concentrations (24 hour average) for Northern Portal (including background of 19 µg/m^3)

CrossRiverRail

SKM aurecon CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_16_AQ_Pm10_NorthPortal.mxd 07/07/2011 15:07



LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 17

Monthly maximum cumulative Dust Deposition rates for Northern Portal (including background of 60 mg/m^2/day)

0 100 200 300 400 m

1:12,000 at A4

N

CrossRiverRail

SKM aurecon CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_17_AQ_TSP_Deposition_NorthPortal.mxd 07/07/2011 15:08

4.6.2 Gabba Station

A contour plot of increases in maximum PM_{10} concentrations (24 hour average) from the Gabba Station worksite is presented in **Figure 18**. The results show that PM_{10} concentrations have the potential to exceed the air quality objective of 50 µg/m^3 in the EPP(Air) at residential areas to the north and south of the worksite.

A contour plot of increases in dust deposition rates from the Gabba Station worksite is presented in **Figure 19**. The predicted dust deposition rate at residential areas to the north of the worksite have the potential to exceed the nuisance guideline of 120 mg/m^2/day.

Contour plots of TSP concentrations annual average and 24 hour average for all the worksites are presented in **Appendix B**. The annual average TSP concentrations meet the air quality objective in the EPP(Air). TSP concentrations (24 hour) may exceed the dust nuisance goal of 80 µg/m^3 to the north and south of the worksite.

4.6.3 Boggo Road Station

A contour plot of increases in maximum PM_{10} concentrations (24 hour average) from the Boggo Road Station worksite is presented in **Figure 20**. PM_{10} concentrations has the potential to exceed the air quality objective of 50 µg/m^3 in the EPP(Air) at sensitive receivers in the immediate surrounds of the worksite including parts of the Bioscience Precinct and Dutton Park Primary School. PM_{10} concentrations at the proposed location for the Leukemia Foundation are predicted to comply with the air quality objectives in the EPP(Air)

A contour plot of increases in dust deposition rates from the worksite are presented in **Figure 21**. The dust deposition rates at residential areas in the vicinity of the worksite has the potential to exceed the guideline of 120 mg/m^2/day at Dutton Park Primary School, the Ecosciences Precinct and at residential areas south of the worksite.

Contour plots of TSP concentrations annual average and 24 hour average for all the worksites are presented in **Appendix B**. The annual average TSP concentrations meet the air quality objective in the EPP(Air). TSP concentrations (24 hour average) have the potential to exceed the dust nuisance goal of 80 µg/m^3 at Dutton Park Primary School and the Ecosciences Precinct.

4.6.4 Yeerongpilly Station and southern portal

A contour plot of increases in maximum PM_{10} concentrations (24 hour average) from the Yeerongpilly Station worksite is presented in **Figure 22**. Based on these results, PM_{10} concentrations have the potential to exceed the air quality objective of 50 µg/m^3 in the EPP(Air) at residential areas to the east and northwest of the worksite.

A contour plot of increases to dust deposition rates from the Yeerongpilly Station worksite is presented in **Figure 23**. The predicted dust deposition rate exceeds the nuisance guideline of 120 mg/m^2/day at residential areas to the east and northwest of the worksite.

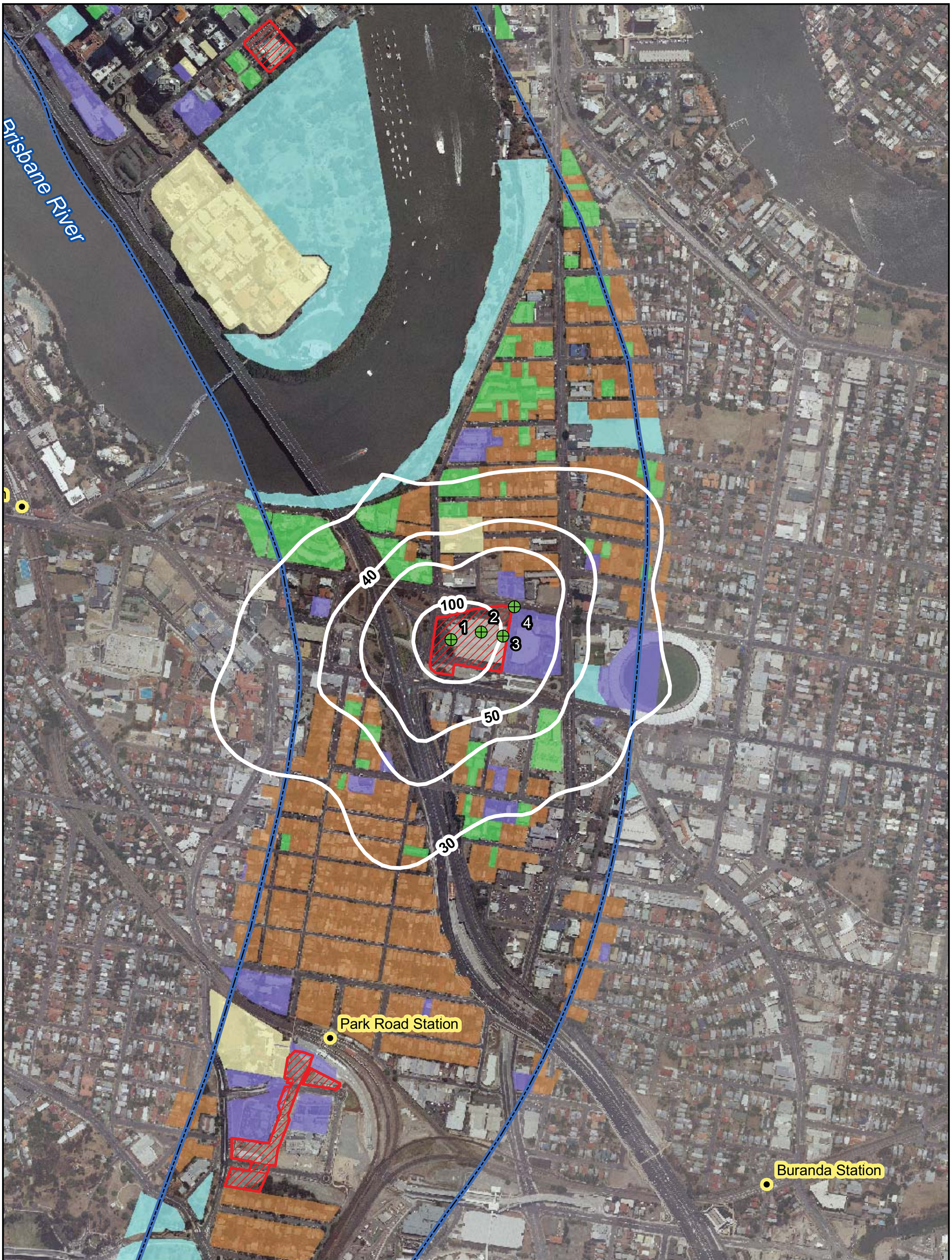
Contour plots of TSP concentrations annual average and 24 hour average for all the worksites are presented in **Appendix B**. The annual average TSP concentrations meet the air quality objective in the EPP(Air). TSP concentrations (24 hour) have the potential to exceed the dust nuisance goal of 80 µg/m^3 at residential areas to the east and northwest the worksite.

4.6.5 Clapham Rail Yard

A contour plot of increases in maximum PM_{10} concentrations (24 hour average) from the Clapham Rail Yard worksite is presented in **Figure 24**. The predicted PM_{10} concentrations during construction activities with the greatest potential for air quality impacts (ie earthworks over approximately 36 weeks, subject to rail operational requirements and safety constraints) comply with the air quality objective of 50 µg/m^3 in the EPP (Air).

A contour plot of the increase in dust deposition rates from the Clapham Rail Yard worksite is presented in **Figure 25**. The predicted dust deposition rates at sensitive receivers are likely to be within the guideline level of 120 mg/m^2/day at parkland to the northwest of the worksite.

Contour plots of TSP concentrations annual average and 24 hour average for all the worksites are presented in **Appendix B**. The annual average TSP concentrations meet the air quality objective in the EPP(Air). TSP concentrations (24 hour) are predicted to exceed the dust nuisance goal of 80 µg/m^3 at parkland to the northwest of the worksite.



LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 18

Maximum cumulative PM10 concentrations (24 hour average) for Woolloongabba (including background of 19 µg/m^3)

0 100 200 300 400 m

1:12,000 at A4

CrossRiverRail

SKM aurecon CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_18_AQ_Pm10_Woolloongabba.mxd 07/07/2011 15:09

LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 19

Monthly maximum cumulative Dust Deposition rates for Woolloogabba (including background of 60 mg/m^2/day)

0 100 200 300 400 m

1:12,000 at A4

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_19_AQ_TSP_Depsotion_Woolloongabba.mxd 07/07/2011 15:09

LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation
- Indicative Construction Monitoring Points

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 20

Maximum cumulative PM_{10} concentrations (24 hour average) for Boggo Road (including background of 19 μg/m^3)

0 50 100 150 200 m

1:6,000 at A4

CrossRiverRail

SKM aurecon
CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_20_AQ_Pm10_Boggo_Rd.mxd 07/07/2011 15:10

LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 21

Monthly maximum cumulative Dust Deposition rates for Boggo Road (including background of 60 mg/m^2/day)

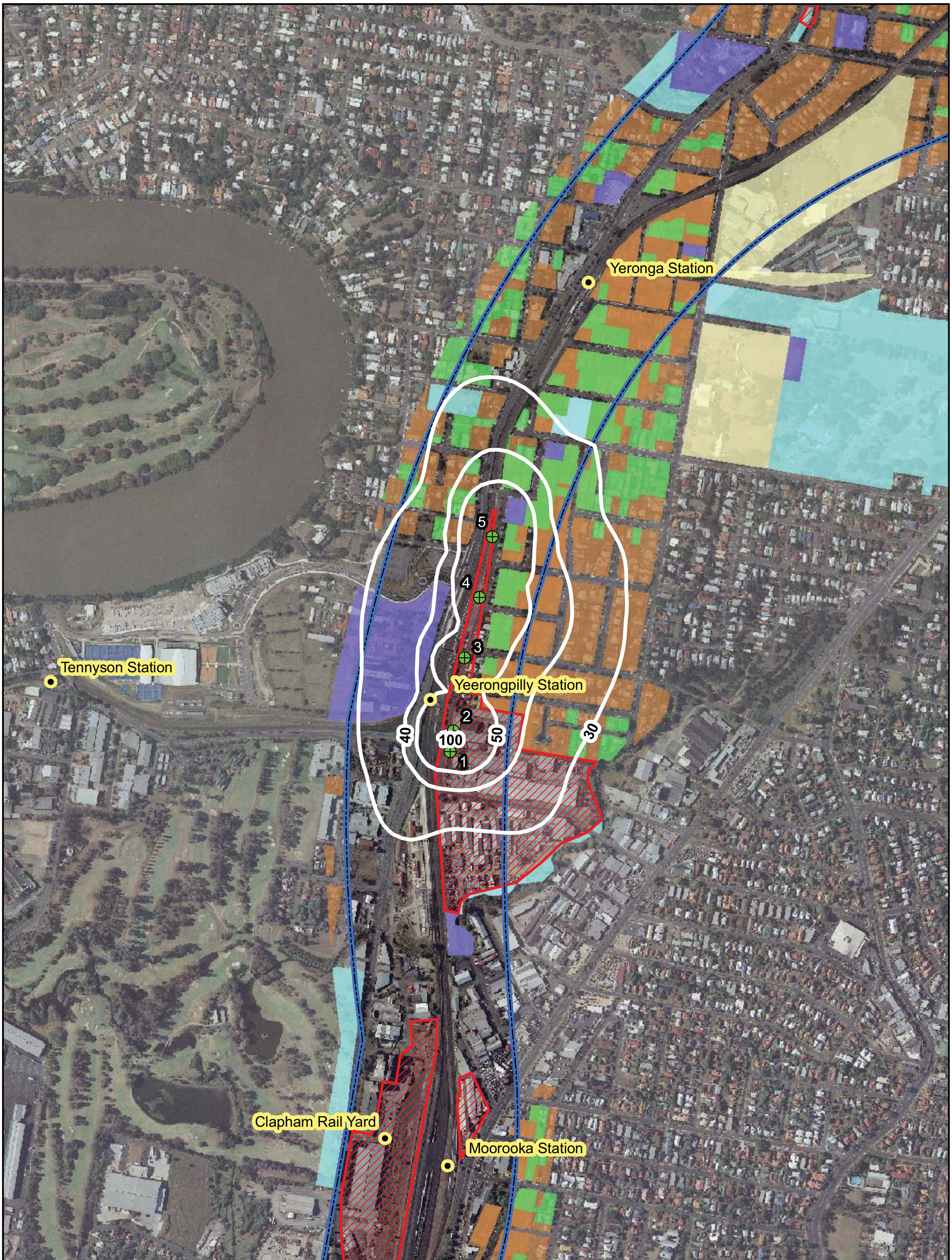
0 50 100 150 200 m

1:6,000 at A4

CrossRiverRail

SKM aurecon CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_21_AQ_TSP_Deposition_Boggo_Rd.mxd 07/07/2011 15:10



LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 22

Maximum cumulative PM_{10} concentrations (24 hour average) for Yeerongpilly (including background of 19 μg/m^3)

0 100 200 300 400 m

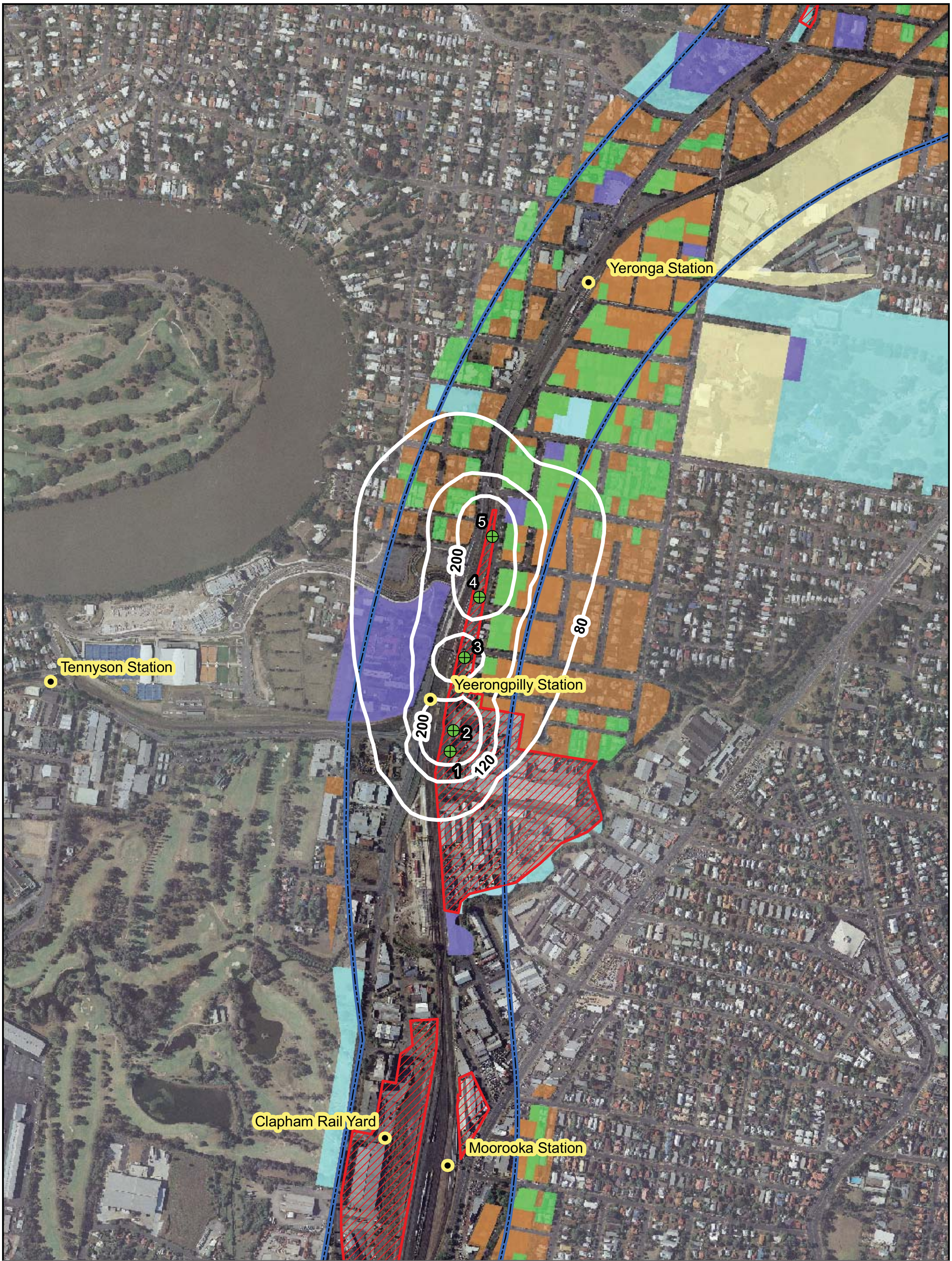
1:12,000 at A4

N

CrossRiverRail

SKM aurecon
CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_22_AQ_Pm10_Yeerongpilly.mxd 07/07/2011 15:11



LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 23

Monthly maximum cumulative Dust Deposition rates for Yeerongpilly (including background of 60 mg/m^2/day)

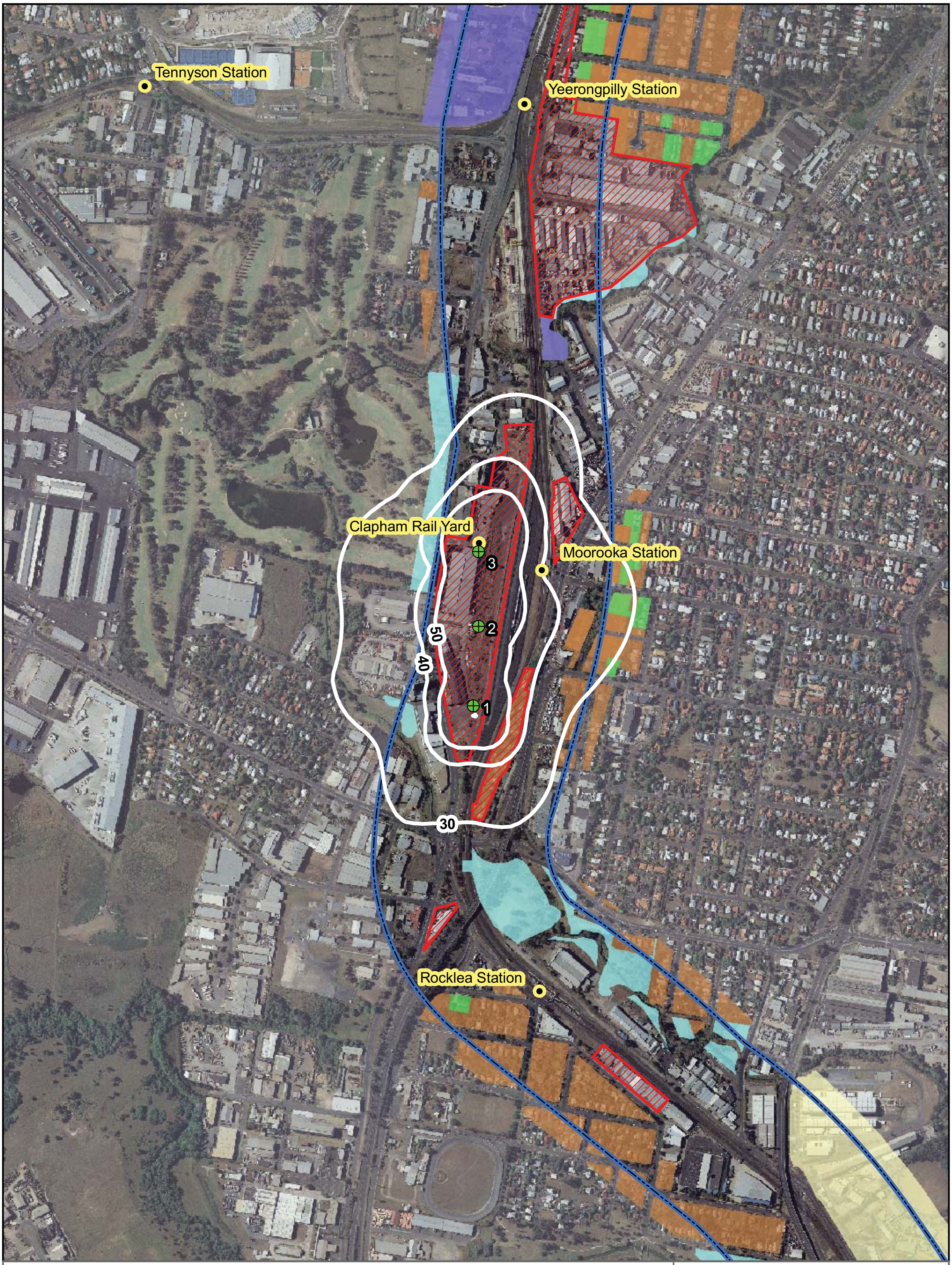
0 100 200 300 400 m

1:12,000 at A4

CrossRiverRail

SKM aurecon CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_23_AQ_TSP_Deposition_Yeerongpilly.mxd 07/07/2011 15:11



LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 24

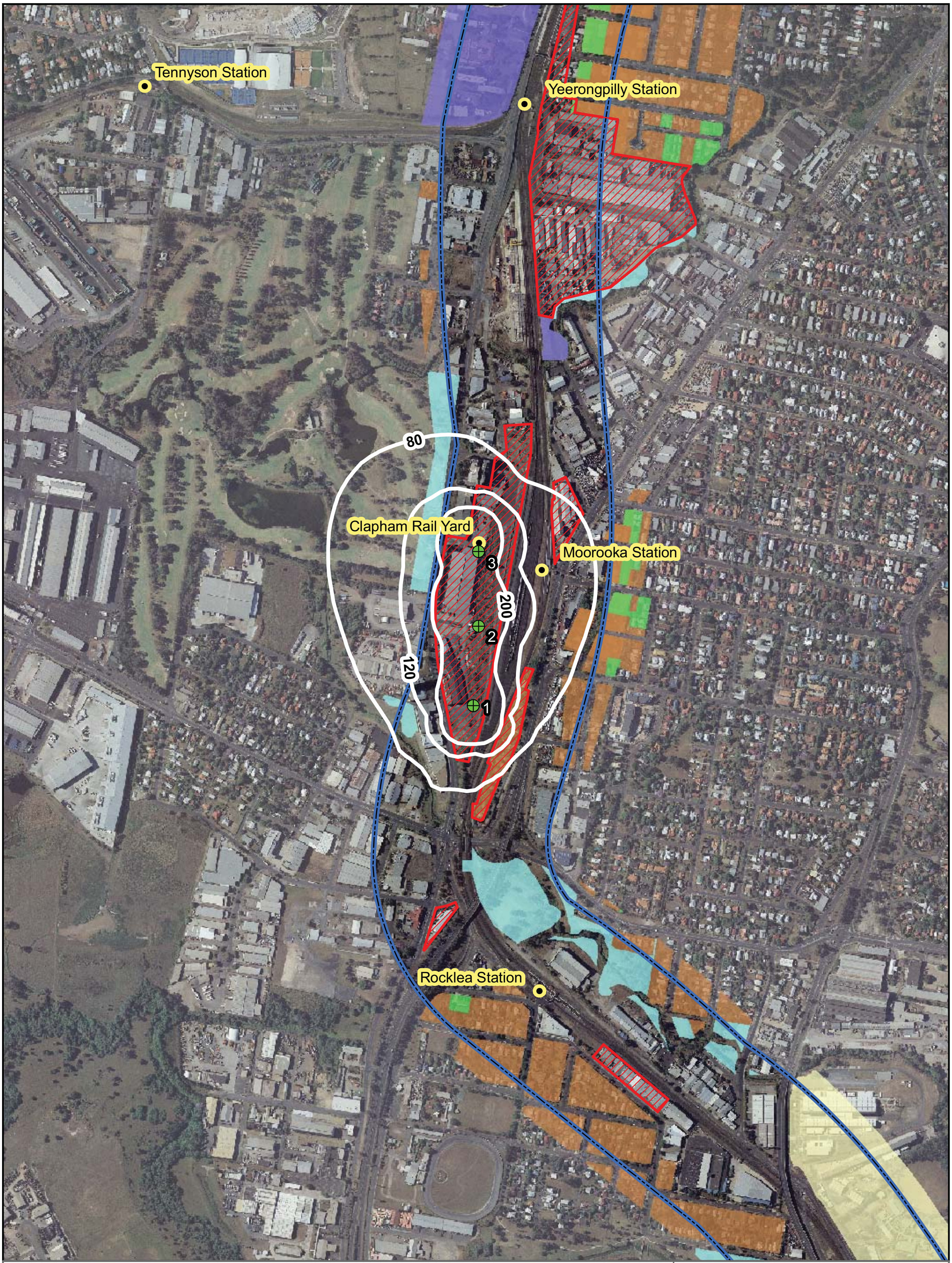
Maximum cumulative PM_{10} concentrations (24 hour average) for Clapham Rail Yard (including background of 19 µg/m^3)

0 100 200 300 400 m

N

1:12,000 at A4

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_24_AQ_Pm10_Clapham.mxd 07/07/2011 15:12



LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 25

Monthly maximum cumulative Dust Deposition rates for Clapham Rail Yard (including background of 60 mg/m^2/day)

0 100 200 300 400 m

1:12,000 at A4

N

CrossRiverRail

SKM aurecon CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKMSpatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_25_AQ_TSP_Deposition_Clapham.mxd 07/07/2011 15:13

4.7 Discussion

4.7.1 Limitations

The following factors should be considered when interpreting the air quality assessment:

- the construction scenario assessed is a snapshot of typical activities that could be expected to occur during maximum site activity and poor existing background air quality
- actual emission rates may differ from the estimates in **Section 4.4**
- emission factors are generally long-term averages, whereas actual emissions would vary on a short-term time scale
- estimated dust emission rates are based on an assumption that basic dust emission mitigation measures have been utilised on many of the dust emitting processes.

4.7.2 Human health risk

Exposure to ambient air pollution has been linked to a number of health impacts mainly related to the respiratory tract and pulmonary functions. The ambient air quality goals established in the EPP (Air) have been set to protect human health and wellbeing.

Particles generated through construction works (eg excavation and materials handling) are predominantly due to the crushing or abrasion of rock and most of the emissions will be larger than $PM_{2.5}$, (ultra-fine particles) which are of most concern in terms of health impacts. This has been studied extensively in the mining industry and an SPCC (1986) study concluded that in the mining areas of the Hunter Valley, NSW where particulate emissions are dominated by excavation of materials (similar to construction) $PM_{2.5}$ was less than 5% of total dust (TSP) emissions.

The predicted TSP and PM_{10} concentrations during construction are generally below the ambient air quality goals in the EPP (Air). During peak construction periods the predicted PM_{10} concentrations exceed the ambient air quality goal of 50 µg/m^3 (24 hour average) at sensitive receptors in close proximity to some of the worksites. Given the short duration of the peaks in construction activities (up to 10 weeks in duration) and background monitoring data in Brisbane recording regular exceedances of the 24 hour PM_{10} ambient air quality goal the potential for an increase in human health risk due to the construction of the Project at nearby sensitive receptors is considered to be low.

4.8 Mitigation measures for construction

The following sections outline construction mitigation measures which would be implemented to minimise the potential for nuisance dust impacts during construction works.

Measures for avoiding nuisance dust impacts

The most effective way of avoiding nuisance from construction activities is to have in place a system that addresses the following:

- effective management of dust generation
- effective monitoring of impacts
- effective communication with the local community on issues associated with construction activities
- a clearly identified point of contact should the community have comments or complaints
- a well defined process to ensure that any issues are dealt with promptly and to a satisfactory level
- a well defined system of recording any incidents or complaints.

The Contractor responsible for construction would need to implement a system which incorporates those elements for the duration of the tunnels and surface construction works. Further detail on the requirements for a comprehensive dust and odour management and communications system would be included as part of a Construction Dust Environmental Management Plan for the Project. The requirements for monitoring of particulate levels within areas adjacent to the main worksites would also be included as part of this plan.

Management measures for nuisance dust mitigation

Components of the dust and odour management and mitigation strategy to be considered during construction would include:

- Surface excavation works would incorporate consideration of prevailing meteorological conditions wind speed and direction, with works potentially ceasing if high winds are blowing in the direction towards sensitive receivers.
- Demolition activities (buildings on acquired land, kerbs and road pavements etc) would be performed using appropriate dust controls such as consideration of meteorological conditions, use of water sprays, and covering loads of material transported from the worksites.
- Movement and handling of excavated spoil would be performed within enclosed work sheds. The sheds would be constructed prior to the commencement of underground tunnelling and works and would cover the excavated areas.
- Work sheds shall be large enough to allow stockpiling of the excavated tunnel material, access and egress of trucks and truck loading operations.
- Truck wheel wash stations shall be installed at locations in worksites where trucks would be moving from unsealed areas of pavement to sealed roads (due to space constraints this may not be possible at the ventilation and emergency access building, Roma Street and Albert Street worksites).
- Where space constraints do not allow for wheel wash stations, additional washing and sweeping of road spaces would be implemented.
- The tunnel would be ventilated during excavation works. Ventilation air would be treated, by passing through a particulate filter, prior to exit from the work sheds. The particle filter would be regularly maintained and the performance of the particulate removal technology would meet required standards. Dust collected from the filtration system would be disposed of appropriately.
- Trucks transporting excavated material would be covered to prevent wind blown dust during transport.
- Loaded trucks would be washed down prior to exit from the worksites to ensure that loose material is not tracked onto the adjacent paved road network.
- The sealed access roads to the worksite sheds would be kept relatively dust free by regular sweeping and washing if needed. At certain times of the year, natural rainfall should keep this surface washed.
- Hoardings would be constructed around the worksite area to minimise the spread of dust from site activities.
- Water sprays would be implemented during drilling and exposed excavation activities.

Management measures for odour impacts

Reasonable and practicable measures to address the potential impact of odour on adjacent properties would be implemented as part of the construction Environmental Management Plan. These include:

- identifying and determining the potential for odour impacts at off-site sensitive receptors
- conducting works with odorous soils when wind directions are unlikely to affect sensitive receptors

- covering odorous, excavated soil stockpiled either on a worksite or a spoil placement site to reduce odour impacts.

Management measures for diesel exhaust emissions

The effects of diesel exhaust emissions can be minimised by the following measures:

- avoiding queuing of the construction traffic vehicle fleet in the streets adjacent to the worksites which would in turn minimise the amount of exhaust emissions generated during the construction works;
- marshalling and queuing for trucks and site vehicles away from residential areas and other sensitive receivers, where possible;
- where possible, exhaust emissions from mobile and stationary plant would be directed away from the ground and sensitive receivers;
- vehicles and machinery would be fitted with appropriate emission control equipment and regularly maintained to manufacturers specifications.

4.9 Air quality monitoring for construction

Regular monitoring of TSP, PM_{10} and dust deposition levels at nearest sensitive receptors adjacent to the worksites, and locations representative of the work space, would provide a basis for compliance with appropriate criteria.

Indicative dust monitoring locations around the five key worksites are presented in **Appendix C**. The proposed dust monitoring locations have been sited based on the results of dispersion modelling undertaken for this assessment. Descriptions of proposed dust monitoring locations are provided in **Table 22**.

Table 22 Indicative dust monitoring locations

Worksite	Indicative Dust Monitoring Locations
Northern portal	Victoria Park, adjacent to Brisbane Girls Grammar School Gregory Terrace, adjacent to Centenary Aquatic Centre
Roma Street	Adjacent to apartment complex, Roma Street Parkland
Albert Street	Albert Street, western side opposite southern shaft, at 3rd floor level Albert Street, western side opposite northern shaft, at street level
Woolloongabba	TMR / DERM monitoring station (existing) Reid Street, adjacent to Chalk Hotel car parking
Boggo Road	Dutton Park State School, adjacent boundary to worksite Maldon Street, adjacent to Multiple Sclerosis headquarters Rawnsley Street, at selected residence
Ventilation and emergency access building	Fairfield Road, western side north of Venner Road, at selected residence Railway Parade, north of Bledisloe Street, at selected residence
Yeerongpilly Station and southern portal	Crichton Street, east of realignment of Wilkie Street, at selected residence Olive Street, at selected residence Bow Street – Park Lane residential area, at selected residence Allawah Street, near Palomar Road, at selected residence
Swanbank spoil site	If required, off Cummer Road

The construction Contractor would be responsible for implementing a Construction Dust Monitoring Plan. The Plan would be submitted to DERM prior to commencement of construction activities and would detail the types of monitoring equipment, procedures for operating and calibrating dust monitoring equipment and the proposed location and frequency of dust monitoring.

The construction Contractor would be responsible for publishing the results of weekly dust monitoring on a publicly available website.

When dust levels exceed the construction air quality goals in **Table 2**, the construction Contractor would be responsible for investigating the exceedance, determining if it was related to construction activities and implementing dust control actions, or amending the work activities to prevent exceedances.

5 Operational air quality impacts

5.1 Introduction

This section provides an assessment of potential air quality impacts during operation of the Project. The approach to this assessment was to:

- identify the sources of air emissions during operation
- examine the key factors that influence emissions from identified sources
- evaluate the likely changes to emission sources due to the Project
- relate the likely changes in emission sources to potential air quality impacts at local and regional scales, taking account of existing background levels and relevant air quality objectives
- outline appropriate mitigation measures to ensure air quality objectives are not exceeded due to the Project.

5.2 Sources of air emissions

The Project would influence two key air emission sources, as follows:

- motor vehicles
- trains and railways, including tunnel and station ventilation.

Motor vehicles

The Project would result in changes to motor vehicle use and emissions at both local (near train stations) and regional scales. These changes would arise from changes to the availability and access to rail services.

Air emissions from motor vehicles vary depending on a number of factors. The main influences on air emissions from traffic include the type of vehicles comprising the fleet, the age of the vehicles, speed of traffic flow and the road gradient. In general, congested roads with numerous intersections (requiring stop start conditions) would generate higher emissions than a free flowing road with no intersections. Roads with a higher percentage of heavy vehicles typically generate higher emissions.

For some air pollutants, such carbon monoxide, higher vehicle speeds generally result in lower emissions, due to more complete combustion. However, oxides of nitrogen emissions generally increase with speed.

Trains and railways

The Project would also influence train movements in the Brisbane area, including suburban and interurban passenger trains and diesel powered freight and coal trains.

Brisbane's suburban and interurban passenger trains comprise Electric Multiple Units (EMUs) powered by electricity supplied from the grid by overhead wires. No direct emissions are associated with the EMUs, however indirect emissions are caused by the offsite generation of electricity.

Freight and coal trains operating within the Brisbane area are diesel-electric 2300 Series locomotives. These locomotives use diesel fuelled electricity generators to power traction engines. Emissions from diesel-electric locomotives are similar to emissions from other diesel fuelled vehicles, consisting predominantly of CO, Volatile Organic Compounds (VOCs) and NO_x.

Tunnel and station ventilation

Minor quantities of particulate matter emissions would be generated in tunnels, mainly due to train brake pad wear, vaporisation of metals due to sparking, wear of steel due to friction between wheels and rail, and recirculation of particulates from tunnel walls. Most of these emissions would be exhausted out of ventilation shafts in very low concentrations, well below all air quality standards.

During events such as station or train fires, tunnel and station ventilation systems would be used to exhaust the air to the surface. Vented air is likely to consist of carbon dioxide, VOCs and NO_x as well as ash and soot particulates.

5.3 Regional effects of motor vehicles

Changes to motor vehicle use have the potential to effect air quality on a regional scale. Network traffic statistics for the South East Queensland region have been estimated and used to predict the change in emissions with and without the Project.

Table 23 shows the estimates of daily vehicle kilometres travelled, with and without the Project, and for urban (roads with a Level of Service D, E and F on roads with speed limits more than 60 km/h and all roads with posted speed limits of 60 km/h or lower) and highway (roads with a Level of Service A, B and C on roads with speed limits more than 60 km/h) modes of travel. Overall, these data show that the Project would result in a 0.4% decrease in VKT in 2021 and a 0.9% decrease in 2031. The VKT are generally predicted to decrease for both modes of travel, except in 2031 where a slight increase in VKT is predicted for highway traffic with the Project. Overall, the Project is predicted to provide a 2 million VKT reduction per day in urban traffic by 2031.

Table 23 Network Traffic Statistics with and without the Project

Mode of travel	Daily (24-hour) vehicle kilometres travelled			
	2021		2031	
	With Project	Without Project	With Project	Without Project
Urban	29,613,808	29,830,844	39,645,335	41,599,168
Highway	40,849,822	40,928,773	48,220,090	47,031,197
Total	**70,463,629**	**70,759,617**	**87,865,425**	**88,630,365**

The network traffic statistics and derived exhaust emission factors have been used to estimate total vehicle emissions for the South East Queensland region. Emission rates from vehicles were estimated from the Transport and Main Roads Emission Factor Calculator v1.1, and the calculations assumed no grade correction, no seasonal correction and 8% overall heavy vehicles.

Details of the network emission calculations for 2021 and 2031 are provided below in **Table 24**. These estimates show that emissions of all identified pollutants would be approximately 0.4% lower with the Project in 2021 compared to the scenario without the Project. In 2031, it is estimated that emissions of all pollutants would be approximately 0.8% lower compared to the without Project scenario.

Table 24 Estimated Air Emissions with and without the Project at 2021

Speed (km/h)	Daily VKT	Emission factors (g/km/v)				Emissions (t/y)			
		NOx	CO	VOCs	PM_{10}	NOx	CO	VOCs	PM10
2021 With Project									
40	166,460	1.035	3.102	0.275	0.042	63	188	17	3
50	1,480,441	0.979	2.871	0.241	0.037	529	1,551	130	20
60	27,342,410	0.965	2.888	0.218	0.035	9,631	28,822	2,176	349
70	6,758,493	1.001	3.034	0.211	0.036	2,469	7,484	521	89
80	11,250,552	1.036	3.174	0.203	0.038	4,254	13,034	834	156
90	1,460,702	1.072	3.29	0.198	0.04	572	1,754	106	21
100	22,032,619	1.112	3.439	0.19	0.041	8,943	27,656	1,528	330
Total:						**26,461**	**80,489**	**5,312**	**968**
2021 Without Project									
40	170,482	1.035	3.102	0.275	0.042	64	193	17	3
50	1,496,338	0.979	2.871	0.241	0.037	535	1,568	132	20
60	27,484,565	0.965	2.888	0.218	0.035	9,681	28,972	2,187	351
70	6,798,433	1.001	3.034	0.211	0.036	2,484	7,529	524	89
80	11,282,017	1.036	3.174	0.203	0.038	4,266	13,070	836	156
90	1,459,540	1.072	3.29	0.198	0.04	571	1,753	105	21
100	22,096,790	1.112	3.439	0.19	0.041	8,969	27,737	1,532	331
Total:						**26,570**	**80,822**	**5,333**	**971**
2031 With Project									
40	207,860	1.035	3.102	0.275	0.042	79	235	21	3
50	1,654,556	0.979	2.871	0.241	0.037	591	1,734	146	22
60	32,551,831	0.965	2.888	0.218	0.035	11,466	34,314	2,590	416
70	7,756,129	1.001	3.034	0.211	0.036	2,834	8,589	597	102
80	14,673,710	1.036	3.174	0.203	0.038	5,549	17,000	1,087	204
90	1,787,879	1.072	3.29	0.198	0.04	700	2,147	129	26
100	29,233,459	1.112	3.439	0.19	0.041	11,865	36,695	2,027	437
Total:						**33,084**	**100,714**	**6,597**	**1,210**
2031 Without Project									
40	214,876	1.035	3.102	0.275	0.042	81	243	22	3
50	1,702,984	0.979	2.871	0.241	0.037	609	1,785	150	23
60	32,933,220	0.965	2.888	0.218	0.035	11,600	34,716	2,620	421
70	7,877,904	1.001	3.034	0.211	0.036	2,878	8,724	607	104
80	14,954,745	1.036	3.174	0.203	0.038	5,655	17,325	1,108	207
90	1,778,637	1.072	3.29	0.198	0.04	696	2,136	129	26
100	29,167,999	1.112	3.439	0.19	0.041	11,839	36,613	2,023	436
Total:						**33,358**	**101,542**	**6,659**	**1,220**

The predicted change in air emissions with and without the Project (in the order of 0.8%) is negligible and would have little effect on ambient air quality in the region. That is, measured air pollutant concentrations are unlikely to change as a result of the Project.

Although only small percentage changes in road network volumes and performance on a typical weekday are forecast with the Project in operation in the Brisbane metropolitan area, overall cumulative benefits are significant. Two-way traffic volumes in the morning peak period would be less with the Project than without the Project. The reduction in vehicle trips (and corresponding reductions in road vehicle emissions) across the CBD cordon is predicted to be 2,300 vehicles by 2031 during the morning peak period. Changes in road traffic volumes in the morning peak period for specific State Controlled road links were also examined. A small reduction in road traffic volumes on State Controlled Roads in, and immediately surrounding the study corridor in the morning peak period is forecast. This reduction in traffic would produce localised air quality benefits on the affected roadways.

5.4 Regional effects of railways

The Project would facilitate an increase in train movements on Brisbane's rail network. Depending on the type of trains and the travel routes, there is the potential for an increase in emissions to the region. Projected train movements with and without the Project have been examined to assess the potential change in air emissions, due to increased train movements. **Table 25** shows projected weekly train movements with and without the Project, and split by rail line and train type. The train types include electric and diesel-electric units.

Table 25 Predicted train volumes per week

Line	Trains per week (both directions)		
	Demand	**Without Project**	**With Project**
2021			
North Coast (E)	264	264	264
Salisbury – Tennyson (E)	172	24	172
Tennyson – Port (IM)	78	3	78
Tennyson – Port (Coal)	197	197	197
2031			
North Coast (E)	322	16	322
Salisbury – Tennyson (E)	209	24	209
Tennyson – Port (IM)	94	3	94
Tennyson – Port (Coal)	232	198	232

E = Electric, IM = Intermodal (freight)

As noted in **Section 5.2**, there are no significant direct emissions to air that are associated with electric trains. Minor particulate matter emissions would be related to brake pad wear, vaporisation of metals, the friction between the wheels and rail.

Coal trains would have the highest potential to cause adverse air quality impacts, compared with the suburban passenger, interurban passenger and freight trains. The majority of particulate matter emissions from coal trains are due to erosion of the surface of loaded coal wagons. The emissions are generally in the PM_{10} size range. Surface erosion usually results from the movement of air across the load surface, which is influenced by the speed of the train and local wind conditions. Other contributing factors are the coal type and moisture content, train vibration and the profile of the coal load in the wagon.

There are various measures to minimise emissions from coal trains. Typically, these measures include profiling the coal load in the wagon to reduce exposure to wind, and spraying the surface of loaded coal wagons with a polymer sealant after loading to prevent dust lift off.

In 2021, the ‘Without Project’ scenario would cater for demand of trains travelling the North coast line and coal trains travelling from Tennyson to the Port of Brisbane. It would, however, not be able to meet the predicted demand of electric trains travelling from Salisbury to Tennyson, and freight trains travelling from Tennyson to the Port. Under the ‘With Project’ scenario, the demand would be satisified, significantly increasing electric train movements from Salisbury to Tennyson and freight movements from Tennyson to the Port by 148 and 75 trains per week, respectively. Coal train volumes would remain the same.

By 2031, the ‘Without Project’ scenario would see the volumes of trains per week decrease due to constraints on rail line capacity by the increase in passenger trains. At the same time, demand on all lines would be increased. The ‘With Project’ scenario would meet the demand, allowing an increase of trains on all lines. Coal trains are predicted to increase by 34 trains per week.

Table 26 quantifies the relative contribution of railway emissions to “other mobile sources’’, as well as all sources in the South East Queensland region (EPA, 2003). Railway emissions as a percentage of all sources emissions have then been derived for NO_x, PM_{10} and VOCs. From this analysis it is clear that railway emissions are a small contributor to total emissions in this South East Queensland region. Therefore, the predicted changes to train movements due to the Project, as described above, are unlikely to affect regional air quality. Greenhouse gas emissions from railway are presented in **Section 6**.

Table 26 Percentage contribution of railway emissions to South East Queensland emissions

	NO_x	PM_{10}	VOC
Railway emissions as a percentage of “other mobile sources”	6.3%	1.7%	0.5%
Emissions from “other mobile sources” as a percentage of all sources	9.3%	3.5%	1.5%
Railway emissions as a percentage of all sources	0.6%	0.1%	0.01%

5.5 Underground train stations

A review of literature relating to air quality in underground railway stations was conducted. Various studies of subway systems around the world show that concentrations of dust (both $PM_{2.5}$ and PM_{10}), CO and CO_2 in underground railway stations are generally much higher than the above ground ambient air quality (Johansson and Johansson, 2003., Aarnio et al, 2005., Invernizzi et al, 2008).

In a study of an underground station in Stockholm, Johansson and Johansson (2003) found that the concentrations of PM_{10} and $PM_{2.5}$ closely followed train traffic intensity with consistently high levels during week days and slight decreases on weekends. Similarly, a study in Seoul by Kwon et al (2008) found that levels of CO_2 can be linearly correlated with the number of passengers using the station.

Across the studies reviewed, subway dust was found to include iron oxide, copper, zinc, manganese, chromium and VOCs. $PM_{2.5}$ dust sampled in the London Underground consisted of approximately 67% iron oxide (from wheels and rails), approximately 1-2% quartz (from ceramic brake pads), traces of other materials and the remainder consisting of volatile matter (Seaton et al, 2005).

A study by Grass et al (2010) conducted in the subway system of New York City found that concentrations of steel composites (iron, manganese and chromium) in subway air were significantly higher than the above ground ambient air. The toxicology results of subway workers with high exposure to subway air were compared with bus drivers and suburban office workers but no significant increase in health impacts. A similar study in Stockholm (Gustavsson et al., 2008) examined the incidence of lung cancer as a result of exposure to subway air particles, but did not find any discernible variation.

The typical particulate matter concentrations in underground railway tunnels, from the studies reviewed above, were as follows:

- average PM_{10} and $PM_{2.5}$ concentrations on platforms in Seoul, Korea of 129±21 µg/m^3 and 105±14 µg/m^3 respectively (Kwon et al 2008).
- average, weekday, daytime PM_{10} concentrations of up to around 470 µg/m^3 and corresponding average $PM_{2.5}$ concentrations of up to around 260 µg/m^3 (Johansson and Johansson 2003).

The above data cannot be directly correlated with EPP (Air) objectives, due to differing averaging times and measurement circumstances, although the data provides an indication of the maximum levels that might be experienced in underground train stations. Clearly, the diverse range of particulate mater concentration is likely to be the result of differing local circumstances. This includes differences in above ground ambient air quality, materials used (track, wheel and brake), station ventilation performance, the frequency of train movements, the number of passengers using the platform and the presence of platform screen doors. However, these studies highlight the potential for elevated particulate matter concentrations in underground railway tunnels and at stations.

The air quality objectives in the EPP(Air) for particulate matter have been set for the protection of human health, however these objectives are related to ambient air quality. In the absence of relevant indoor air quality standards or objectives, time-weighted average exposure limits for work-places have been examined to assess the significance of potential in-tunnel concentrations. The time-weighted average is the average airborne concentration of a particular substance when calculated over a normal 8-hour working day for a 5-day working week.

Time weighted average exposure limits are presented in **Table 27**. The inspirable fraction (ie airborne particles of dust that can be taken in through the nose or mouth during breathing), is related to airborne particles with equivalent aerodynamic diameters less than approximately 100 microns (similar to TSP). The respirable fraction relates to particles less than approximately 10 microns (or PM_{10}).

Table 27 Relevant time weighted average exposure limits

Pollutant	Time-weighted average exposure (8-hour working day for a 5-day working week)
Particulate matter – inspirable fraction[1] Inspirable dust is airborne particles of dust that can be taken in through the nose or mouth during breathing.	10 mg/m^3 (or 10,000 µg/m^3)
Particulate matter – respirable fraction[2] Respirable dust is that fraction of inspirable dust composed of fine particles which can reach the lower bronchioles and alveolar regions of the lung.	3 mg/m^3 (or 3,000 µg/m^3)

Notes:
1. *NOHSC exposure limits (NOHSC, 1995)*
2. *Value noted by the ACGIH (American Conference of Industrial Hygienists) has been referenced in absence of specific goals in Australia*

The typical in-tunnel particulate matter concentrations discussed above are below both the inspirable and respirable work place limits shown in **Table 27**. This suggests that the health of individuals at underground stations would not be adversely affected, assuming exposure is not for extended periods of time, that is, more than eight hours per day. A suitable impact mitigation measure would be to operate the underground railway system such that the time that individuals who occupy stations is minimised to the maximum extent practicable.

Finally, the presence of platform screen doors at underground platforms would physically separate air in the rail corridor from air in the railway stations. Combined with effective station ventilation systems, this barrier is likely to reduce exposure to users from dusts and other contaminants.

5.6 Station ventilation

Air within the tunnel and stations would be exhausted to the surface by ventilation systems at the underground stations and at the ventilation and emergency access building between the Yeerongpilly and Boggo Road stations.

Ventilation at stations would be powered by four 60 m^3/s fans operating out of shafts at each end of the platform. These shafts would draw and exhaust air from louvered inlets on the roof of stations, above the station plaza. The southern ventilation shaft would use two bi-directional 60 m^3/s fans running in either exhaust or supply mode. Air would be drawn and exhausted from an 8 m high ventilation stack located at the southern ventilation shaft building. It is estimated that average velocity of exhaust air would be in the range of 10 to 15 m/s. Contaminants in exhaust air would be similar to station and tunnel air quality, however are likely to be at lower concentrations due to the increased volume of air.

The tunnel ventilation system would draw fresh air through the entrance of the tunnel, pass it through the tunnel, and discharge it through ventilation shafts into the surrounding outdoor air. In the event of an emergency, such as a fire in either the stations or tunnels, potentially dangerous fumes would be emitted through the ventilation shafts. Suitable emergency plans would be in place in these circumstances.

5.7 Thermal impacts

The tunnel ventilation system would be designed to prevent the build-up of hot air in the tunnel. The system would draw fresh air through the entrance of the tunnel, pass it through the tunnel, and discharge it through ventilation shafts into the surrounding outdoor air. The ventilation shafts would be used to adjust the rate of air flow through the tunnels, and ensure air from the tunnels is well dispersed and diluted into the outdoor air. With continual air flow, this system is unlikely to increase in-tunnel temperatures significantly above ambient temperatures. In-tunnel air temperature and thermal comfort would be considered further at the detailed design phase.

5.8 Summary

This section has provided an assessment of the potential air quality impacts during Project operation. The key findings of this assessment were as follows:

- predicted changes to motor vehicle use and emissions are unlikely to affect regional air quality
- predicted changes to train movements and emissions are unlikely to affect regional air quality.

While particulate matter concentrations are likely to comply with work place limits, minimising occupancy time in underground tunnels and stations would ensure that individuals are not adversely affected by elevated particulate matter concentrations.

6 Greenhouse gas emissions

6.1 Introduction

The potential greenhouse gas and climate change impacts of the Project have been assessed by:

- estimating the direct and indirect greenhouse gas emissions resulting from the construction and operation of the Project; and
- identifying mitigation measures to reduce greenhouse gas emissions.

6.2 Greenhouse gas estimation methodology

A preliminary greenhouse gas inventory has been prepared for the construction and operation of the Project in alignment with the requirements of the National Greenhouse and Energy Reporting System. Greenhouse gas emissions attributable to the Project have been considered in terms of two 'scopes' of emission categories:

- Scope 1: direct emissions from sources within the Project area; and
- Scope 2: indirect emissions from the generation and consumption of electricity produced outside of the Project area.

Scope 3 emissions or indirect emissions that are a consequence of the Project but not from sources owned or controlled by the Project have not been estimated for this assessment.

The National Greenhouse Accounts (NGA) Factors (DCCEE, 2010) were used in the preparation of the greenhouse gas inventory. The relevant emission factors are presented in **Table 28**.

Table 28 Greenhouse Gas Emission factors

Emission Source	Scope	Emission Factor
Diesel Fuel	1	2.70 t CO_2-e/kL
Unleaded Petrol	1	2.38 t CO_2-e/kL
Electricity from grid (QLD)	2	0.89 kg CO_2-e/kWh

Source: National Greenhouse Accounts (NGA) Factors (DCCEE, 2010)

For the purposes of this assessment, the efficiency of the road network was assumed to be reflected in a comparison of projected VKT with and without the Project.

The greenhouse gas emissions from vehicles were determined using the following assumptions:

- the breakdown of Queensland vehicle fleet (ABS, 2009):
  - 76% passenger cars
  - 20% light commercial vehicles
  - 1% light rigid trucks
  - 2% heavy rigid trucks
  - 1% articulated trucks
- fuel consumption rates per kilometre were derived from the Green Vehicle Guide (DIT, 2010) and the Survey of Motor Vehicle Use (ABS, 2008 c) (refer to **Table 29**)
- the assumed fuel mix by vehicle type is
  - passenger cars is 95% petrol and 5% diesel

- light commercial vehicles is 60% petrol and 40% diesel
- light rigid trucks, medium rigid trucks and articulated trucks are 100% diesel.

Table 29 Fuel Consumption Rates by Vehicle Type

Vehicle Type	Fuel	Fuel Consumption (L/100 km)			Source
		Urban	Highway	Combined	
Passenger Car – light	Petrol	8.81	5.38		DIT, 2010
	Diesel	5.93	4.14		DIT, 2010
Passenger Car – medium	Petrol	11.10	6.31		DIT, 2010
	Diesel	7.17	4.75		DIT, 2010
Passenger Car – large	Petrol	14.10	7.57		DIT, 2010
	Diesel	8.99	5.62		DIT, 2010
Light Commercial Vehicles	Petrol	16.16	9.28		DIT, 2010
	Diesel	11.33	7.93		DIT, 2010
Light Rigid Trucks	Diesel			13.10	ABS, 2008
Medium Rigid Trucks	Diesel			28.5	ABS, 2008
Articulated Vehicles	Diesel			54.6	ABS, 2008

Source: Green Vehicle Guide (DIT, 2010) and Survey of Motor Vehicle Use (ABS, 2008 c)

6.3 Greenhouse gas emissions

6.3.1 Construction

The main sources of greenhouse gas emissions for the construction of the Project are:

- direct CO_2 emissions from fuel combustion in construction equipment (scope 1); and
- indirect CO_2 emissions due to consumption of electricity (scope 2).

Estimates of diesel and electricity usage for the construction of the Project are presented in **Table 30,** along with the corresponding greenhouse gas emission estimates.

Table 30 Greenhouse Gas Emissions during Construction of the Project

Emission Source	Value	Units	GHG Emissions (t CO_2-e)
Excavation of tunnels, shafts and caverns			
Electricity Consumption	196,250,000	kWh	174,663
Diesel Fuel Consumption	8,125	kL	21,922
Site preparation, surface works and station construction			
Electricity Consumption	275,026,000	kWh	244,773
Diesel Fuel Consumption	78,235	kL	211,089
Total			**652,447**

The construction of the Project is estimated to result in approximately 0.65 Mt CO_2-e of greenhouse gases, or approximately 0.13 Mt CO_2-e per year, based on a five and a half year construction period. The annual greenhouse gas emissions during construction of the Project represent 0.02 % and 0.10 % of Australia's and Queensland's 2008 greenhouse gas emissions, respectively.

6.3.2 Operation

The most significant greenhouse gas emissions associated with the operation of the Project would be generated as a result of electricity consumption from trains and stations.

It has been estimated that each three-car train unit would consume approximately 152 kWh per journey, with each train typically being made up of two units. This is based on an approximate travel time through the Project network of 19 minutes. **Table 31** below shows the estimated electricity consumption for train journeys through the Project.

Table 31 Train Electricity Consumption

Year	Train Journeys / Day	Train Journeys / year	Electricity Consumption (kWh/year)
2021	634	231,410	70,348,640
2031	1,106	403,690	122,721,760

Electricity use within underground and above ground stations has been estimated for peak, off-peak and station close periods for weekdays and weekends in both summer and winter. The estimates took into account electricity use for station ventilation, tunnel ventilation, air condition, fire services, hydraulics, vertical transport and lighting. The estimated annual electricity consumption is:

- 1,511,379 MWh in above ground rail stations
- 8,373,893 MWh in underground rail stations.

The estimated electricity consumption and associated greenhouse gas emissions for the operation of the Project are presented in **Table 32**.

Table 32 Operational Energy Consumption and Associated Greenhouse Gas Emissions Estimate

Location/Device	Electricity Consumption (kWh/year)	Greenhouse Gas Emissions (t CO_2-e/year)
Bowen Hills	1,511,379	1,345
Exhibition	1,511,379	1,345
Roma St	8,373,893	7,453
Albert St	8,373,893	7,453
Woolloongabba	8,373,893	7,453
Boggo Rd	8,373,893	1,345
Yeerongpilly	1,511,379	1,345
Stations Sub-total	**38,029,709**	**33,846**
Trains (2021)	70,348,640	62,610
Trains (2031)	122,721,760	109,222
Total (2021)	**108,378,349**	**96,456**
Total (2031)	**160,751,469**	**143,068**

The operation of the Project is estimated to result in approximately 0.09 Mt CO_2-e of greenhouse gases per year in 2021, and 0.14 Mt CO_2-e per year in 2031. The annual greenhouse gas emissions during operation of the Project in 2021 represent 0.01 % and 0.06 % of Australia's and Queensland's 2008 greenhouse gas emissions, respectively. In 2031, the annual emissions would represent 0.02 % and 0.14 % of Australia's and Queensland's 2008 greenhouse gas emissions, respectively.

6.3.3 Changes to road network performance

The Project may affect the greenhouse gas emissions from Brisbane's vehicle fleet by providing additional capacity for freight and passenger rail services. Additional services may alleviate demand for both private and heavy vehicle travel, reducing vehicle kilometres travelled (VKT) and improving the efficiency of traffic flow for vehicles using the road network.

Traffic forecasts were prepared using the Project traffic model which is based on data supplied by the Department of Transport and Main Roads (DTMR), as described in **Chapter 5 Transport**. The projected VKT on the South East Queensland road network with and without the Project is presented in **Table 33**.

Table 33 Average Weekday Travelled (AWDT) VKT Data for Brisbane with and without the Project

Year	Speed Limit	Without Project (AWDT)			With Project (AWDT)		
		Total VKT	% Urban	% Hwy	Total VKT	% Urban	% Hwy
2009	40	106,388	100%	0%			
	50	1,285,841	100%	0%			
	60	22,255,079	100%	0%			
	70	5,281,425	2%	98%			
	80	7,145,413	4%	96%			
	90	951,506	4%	96%			
	100	16,152,709	3%	97%			
	TOTAL	**53,178,362**					
2021	40	170,482	100%	0%	166,460	100%	0%
	50	1,496,338	100%	0%	1,480,441	100%	0%
	60	27,484,565	100%	0%	27,342,410	100%	0%
	70	6,798,433	4%	96%	6,758,493	3%	97%
	80	11,282,017	4%	96%	11,250,552	3%	96%
	90	1,459,540	0%	100%	1,460,702	0%	100%
	100	22,096,790	0%	100%	22,032,619	0%	100%
	TOTAL	**70,788,165**			**70,491,676**		
2031	40	214,876	100%	0%	207,860	100%	0%
	50	1,702,984	100%	0%	1,654,556	100%	0%
	60	32,933,220	100%	0%	32,551,831	100%	0%
	70	7,877,904	6%	94%	7,756,129	5%	95%
	80	14,954,745	9%	91%	14,673,710	8%	92%
	90	1,778,637	10%	90%	1,787,879	9%	91%
	100	29,167,999	16%	84%	29,233,459	12%	88%
	TOTAL	**88,630,365**			**87,865,425**		

The estimated daily fuel consumption with and without the Project is presented in **Table 34**.

Table 34 Estimated Daily (AWDT) Fuel Consumption with and without the Project

Year	Without Project		With Project	
	Unleaded Petrol (kL)	Diesel (kL)	Unleaded Petrol (kL)	Diesel (kL)
2009	3,809.1	791.4		
2021	4,955.7	1,074.8	4,931.4	1,071.0
2031	6,370.5	1,314.9	6,254.0	1,315.3

AWDT = average weekday travelled

The difference in greenhouse gases emissions as a result of changed network performance on the South East Queensland road network due to the Project is presented in **Table 35**. The Project is predicted to reduce greenhouse gas emissions from changes in road network performance by:

- 22.5 kt CO_2-e in 2021
- 91.1 kt CO_2-e in 2031.

The predicted reduction in greenhouse gas emissions of 91.1 kt CO_2-e represents approximately 0.8% of Queensland's transport greenhouse gas emissions in 2008 (11 Mt CO_2-e).

Table 35 Greenhouse Gas Emissions (t CO_2-e) from Change in Road Network Performance

Year	GHG Emissions - Without Project		GHG Emissions - With Project		Difference in Annual GHG Emission
	AWDT	Annual	AWDT	Annual	
2009	11,202	3,696,798			-
2021	14,696	4,849,683	14,628	4,827,212	-22,471
2031	18,711	6,174,784	18,436	6,083,721	-91,063

AWDT = average weekday travelled
Annual = AWDT x 330

The Project aligns with the Queensland Government's policies to reduce greenhouse gas emissions from the transport sector by improving traffic flow for reduced emissions and provides more opportunities to streamline freight deliveries.

6.4 Greenhouse gas management

6.4.1 Minimising emissions

The gas emissions from the construction of the Project would be minimised through:

- maintaining construction equipment and haul trucks in good working order so fuel efficiency of equipment is maximised
- procurement of energy efficient construction equipment
- using of appropriately sized equipment for construction activities
- minimising waste from construction
- substituting high energy intensity building materials, where possible, for materials that have a lower energy intensity.

6.4.2 Minimising emissions from operation

Aspects of the reference design which reduce energy demand and reduce greenhouse gas emissions include:

- pressure differentials, platform screen doors and targeted cooling to improve air-conditioning efficiency
- tunnelling between Boggo Road station and Yeerongpilly instead of surface track widening allows reduced energy use from straighter track alignment between Boggo Road and Yeerongpilly.

The greenhouse gas emissions from the operation of the Project would be minimised through:

- energy efficient design of ventilation systems to minimise power requirements
- improved specification for new rolling stock to reduce energy demands
- review annual energy use to identify potential energy efficiency opportunities to reduce greenhouse gas emissions.

Queensland Rail would be responsible for operating the Project and would be required to estimate and report annual greenhouse gas emissions under the National Greenhouse and Energy Reporting System.

6.4.3 Renewable energy and greenhouse gas offsets

There are further opportunities to reduce greenhouse gas emissions from the Project through:

- purchasing energy from renewable electricity sources; and
- providing greenhouse gas offsets.

The proponent would produce an offset for a proportion of greenhouse gas emissions generated from the construction and operation of the Project. The plan would be prepared prior to commencement of permanent construction works.

7 References

American Conference of Industrial Hygienists 2005, *Guide to Occupational Exposure Values*

Aarnio, P., Yli-Tuomi, T., Kousa, A., Makela, T., Hirsikko, A., Hameri, K., Raisanen, M., Hillamo, R., Koskentalo, T., Jantunen, M., 2005 ‘The concentrations and composition of and exposure to fine particles ($PM_{2.5}$) in the Helsinki subway system’, *Atmospheric Environment*, vol. 39, no. 28, pp. 5059-5066.

AS 2923: 1987 Ambient Air – Guide for measurement of horizontal wind for air quality applications, Australian Standard

Australian Bureau of Statistics (ABS) 2008, *Survey of Motor Vehicle Use (12 months to 31 Oct 2007)*, report 9208.0

Australian Bureau of Statistics (ABS) 2009, *Motor Vehicle Census 31 March 2009,* report 9309.0

Clean Energy Act 2008 (Queensland) Reprint No. 1B

Department of Climate Change and Energy Efficiency (DCCEE) 2010, *National Inventory by Economic Sector 2008*

Department of Infrastructure and Transport (DIT) 2010, *Green Vehicle Guide*, viewed 13 October 2010, <http://www.greenvehicleguide.gov.au/GVGPublicUI/search.aspx>

Energy Efficiency Opportunities Act 2006 (Commonwealth) No. 31 of 2006

Environmental Protection (Air) Policy 2008 (Queensland) Reprint No. 1 revised edition

Environmental Protection Act 1994 (Queensland) Reprint No. 9H

Environmental Protection Agency (EPA) 2003, *Environmental management of mining activities: Preparing an environmental management overview strategy (EMOS) for non-standard mining projects, version 1.1*, Ecoaccess Guideline 8, 03/2003

Environmental Protection Agency (EPA) and Brisbane City Council 2004, *South East Queensland Air Emissions Inventory*

Grass, D.S, Ross, J.M, Family, F., James Simpson, H., Coulibaly, D., Hernandez, J., Chen, Y., Slavkovich, V., Li, Y., Graziano, J., Santella, R.M., Brandt-Rauf, P., Chillrud, S.N., 2010, ‘Airborne particulate metals in the New York City subway: A pilot study to assess the potential for health impacts’, *Environmental Research*, vol. 110 no. 1. Pp. 1-11

Gustavsson, P., Bigert, C., Pollan, M., 2008 ‘ Incidence of lung cancer among subway drivers in Stockholm’, *American Journal of Industrial Medicine*, vol. 51, no. 7, pp545-547

Intergovernmental Panel on Climate Change (IPCC) 2007, *The Fourth Assessment Report in Climate Change 2007: Synthesis Report*

Invernizzi, G., Ruprecht, A., Bettoncelli, G., & Sasco, A 2008, ‘Air Quality in Subway Platforms and Carriages of Six Major Cities’, *Epidemiology*, vol. 19, no. 6. P. S144

Johansson, C. & Johansson P., 2003 ‘Particulate matter in the underground of Stockholm’, Atmospheric Environment, vol. 37, no. 1, pp. 3-9

Kwon, S., Cho, Y., Park, D., Park., E 2008, ‘Study on the Indoor Air Quality of Seoul Metropolitan Subway during the Rush Hour’, Indoor and Built Environment, vol. 17, no. 4, pp. 361 – 369

National Environment Protection Council (NEPC) 2003, *National Environment Protection (Ambient Air Quality) Measure*, 7 July 2003.

National Greenhouse and Energy Reporting Act 2007 (Commonwealth) No. 175 of 2007

National Occupational Health and Safety Commission 1995, “*Adopted National Exposure Standards for Atmospheric Contaminants in the Occupational Environment*”, NOHSC:3008 (1995) Guidance Note, NOHSC:1003 (1995) National Exposure Standards

National Pollutant Inventory (NPI) 2001, viewed 26 May 2010, <www.npi.gov.au>

Queensland Government 2009, *ClimateQ: toward a greener Queensland*, July 2009

Seaton, A. Cherrie, J., Dennekamp, M., Donaldson, K. Hurley, J.F., Tran, C.L, 2005, The London Underground: dust and hazards to health, *Occupational Environmental Medicine*, vol. 62 . pp. 355-362

SPCC, 1986, “*Particle size distributions in dust from open cut coal mines in the Hunter Valley*”, Report Number 10636-002-71, Prepared for the State Pollution Control Commission of NSW (now OEH) by Dames & Moore, 41 McLaren Street, North Sydney, NSW 2060.

TRC (2007) CALPUFF model web-site (http://www.src.com/calpuff/regstat.htm) – June 2010.

WHO, 2005, WHO air quality guidelines global update 2005, World Health Organization, ‘Report on a Working Group meeting’, Bonn, Germany, 18-20 October 2005

Appendix A Meteorological data statistics

This section provides statistics on the meteorological data, as simulated by the CALMET model. Statistics have been extracted for Archerfield and Brisbane Airports to cover the southern and northern regions of the Project area.

Joint wind speed, wind direction and stability class frequency tables for Archerfield Airport

STATISTICS FOR FILE: I:\QENV\Projects\QE40190\Technical\Air Quality\calmet\prtmet_ts\aap.aus
MONTHS: All
HOURS : All
OPTION: Frequency

PASQUILL STABILITY CLASS 'A'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000228	0.000799	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001027
NE	0.000228	0.000913	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001142
ENE	0.000114	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000228
E	0.000114	0.000228	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000342
ESE	0.000114	0.000685	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000799
SE	0.000114	0.000228	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000342
SSE	0.000228	0.000342	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000571
S	0.000114	0.000228	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000342
SSW	0.000114	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000228
SW	0.000571	0.000685	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001256
WSW	0.000114	0.000913	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001027
W	0.000685	0.000571	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001256
WNW	0.000114	0.000913	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001027
NW	0.000114	0.000457	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000571
NNW	0.000000	0.001941	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001941
N	0.000342	0.000571	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000913
CALM									0.000685
TOTAL	0.003311	0.009703	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.013699

MEAN WIND SPEED (m/s) = 1.87
NUMBER OF OBSERVATIONS = 120

PASQUILL STABILITY CLASS 'B'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000685	0.001256	0.003767	0.000342	0.000000	0.000000	0.000000	0.000000	0.006050
NE	0.000571	0.001484	0.001712	0.000571	0.000000	0.000000	0.000000	0.000000	0.004338
ENE	0.000571	0.001256	0.002055	0.000457	0.000000	0.000000	0.000000	0.000000	0.004338
E	0.000000	0.001484	0.003653	0.000457	0.000000	0.000000	0.000000	0.000000	0.005594
ESE	0.000342	0.001826	0.003767	0.001027	0.000000	0.000000	0.000000	0.000000	0.006963
SE	0.000342	0.002740	0.003311	0.001027	0.000000	0.000000	0.000000	0.000000	0.007420
SSE	0.001256	0.004566	0.004338	0.000342	0.000000	0.000000	0.000000	0.000000	0.010502
S	0.001941	0.003425	0.003082	0.000114	0.000000	0.000000	0.000000	0.000000	0.008562
SSW	0.003995	0.004338	0.000799	0.000000	0.000000	0.000000	0.000000	0.000000	0.009132
SW	0.003767	0.005137	0.000685	0.000000	0.000000	0.000000	0.000000	0.000000	0.009589
WSW	0.003539	0.006963	0.004224	0.000228	0.000000	0.000000	0.000000	0.000000	0.014954
W	0.003425	0.007763	0.005251	0.000571	0.000000	0.000000	0.000000	0.000000	0.017009
WNW	0.002055	0.004338	0.001370	0.000000	0.000000	0.000000	0.000000	0.000000	0.007763
NW	0.001598	0.002854	0.000571	0.000000	0.000000	0.000000	0.000000	0.000000	0.005023
NNW	0.001027	0.003311	0.001256	0.000000	0.000000	0.000000	0.000000	0.000000	0.005594
N	0.001256	0.002511	0.003311	0.000114	0.000000	0.000000	0.000000	0.000000	0.007192
CALM									0.003082
TOTAL	0.026370	0.055251	0.043151	0.005251	0.000000	0.000000	0.000000	0.000000	0.133105

MEAN WIND SPEED (m/s) = 2.56
NUMBER OF OBSERVATIONS = 1166

PASQUILL STABILITY CLASS 'C'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000571	0.001142	0.004224	0.006050	0.000913	0.000114	0.000000	0.000000	0.013014
NE	0.000342	0.001142	0.002854	0.004566	0.000228	0.000000	0.000000	0.000000	0.009132
ENE	0.000000	0.000571	0.003196	0.003311	0.000228	0.000000	0.000000	0.000000	0.007306
E	0.000228	0.001027	0.005365	0.003539	0.000228	0.000000	0.000000	0.000000	0.010388
ESE	0.000000	0.001142	0.004452	0.010502	0.001142	0.000228	0.000000	0.000000	0.017466
SE	0.000457	0.001712	0.003653	0.007648	0.002283	0.000685	0.000000	0.000000	0.016438
SSE	0.000913	0.002169	0.004452	0.003539	0.000342	0.000000	0.000000	0.000000	0.011416
S	0.002968	0.006393	0.007420	0.002740	0.000000	0.000000	0.000000	0.000000	0.019521
SSW	0.003653	0.004566	0.002626	0.001826	0.000000	0.000000	0.000000	0.000000	0.012671
SW	0.004795	0.007078	0.001370	0.000342	0.000000	0.000000	0.000000	0.000000	0.013584
WSW	0.001484	0.006507	0.007991	0.002626	0.000342	0.000000	0.000000	0.000000	0.018950
W	0.000799	0.003311	0.006507	0.003881	0.000114	0.000342	0.000799	0.000000	0.015753
WNW	0.000457	0.001370	0.001712	0.001027	0.000114	0.000114	0.000228	0.000000	0.005023
NW	0.000228	0.000571	0.000114	0.000685	0.000228	0.000000	0.000000	0.000000	0.001826
NNW	0.000342	0.001598	0.000685	0.000114	0.000000	0.000000	0.000000	0.000000	0.002740
N	0.000342	0.001370	0.001941	0.002055	0.000000	0.000000	0.000000	0.000000	0.005708
CALM									0.006279
TOTAL	0.017580	0.041667	0.058562	0.054452	0.006164	0.001484	0.001027	0.000000	0.187215

MEAN WIND SPEED (m/s) = 3.71
NUMBER OF OBSERVATIONS = 1640

PASQUILL STABILITY CLASS 'D'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000000	0.000799	0.001941	0.008676	0.012557	0.001370	0.000000	0.000000	0.025342
NE	0.000114	0.001712	0.002740	0.004566	0.001370	0.000000	0.000000	0.000000	0.010502
ENE	0.000000	0.000342	0.002397	0.002283	0.000228	0.000000	0.000000	0.000000	0.005251
E	0.000000	0.002511	0.006050	0.005365	0.001370	0.000000	0.000000	0.000000	0.015297
ESE	0.000000	0.001712	0.003881	0.011872	0.010731	0.001256	0.000228	0.000000	0.029680
SE	0.000114	0.001712	0.007534	0.011644	0.009475	0.002169	0.000000	0.000000	0.032648
SSE	0.000228	0.002511	0.007763	0.003995	0.001826	0.000228	0.000000	0.000000	0.016553
S	0.000000	0.006393	0.004452	0.001941	0.000342	0.000000	0.000000	0.000000	0.013128
SSW	0.000114	0.004795	0.001712	0.000342	0.000000	0.000000	0.000000	0.000000	0.006963
SW	0.000114	0.003881	0.000228	0.000114	0.000114	0.000000	0.000000	0.000000	0.004452
WSW	0.000228	0.003196	0.001142	0.001484	0.002169	0.000571	0.000114	0.000000	0.008904
W	0.000114	0.000799	0.001256	0.005137	0.005936	0.002511	0.001027	0.000000	0.016781
WNW	0.000000	0.000457	0.000342	0.002740	0.000685	0.000685	0.000000	0.000000	0.004909
NW	0.000000	0.000457	0.000114	0.000114	0.000000	0.000000	0.000000	0.000000	0.000685
NNW	0.000000	0.000114	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000228
N	0.000000	0.000799	0.000685	0.000913	0.000799	0.000000	0.000000	0.000000	0.003196
CALM									0.000114
TOTAL	0.001027	0.032192	0.042352	0.061187	0.047603	0.008790	0.001370	0.000000	0.194635

MEAN WIND SPEED (m/s) = 4.98
NUMBER OF OBSERVATIONS = 1705

PASQUILL STABILITY CLASS 'E'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000000	0.000228	0.009361	0.004795	0.000000	0.000000	0.000000	0.000000	0.014384
NE	0.000000	0.000685	0.003995	0.001142	0.000000	0.000000	0.000000	0.000000	0.005822
ENE	0.000000	0.000342	0.002169	0.000000	0.000000	0.000000	0.000000	0.000000	0.002511
E	0.000000	0.001370	0.002854	0.000114	0.000000	0.000000	0.000000	0.000000	0.004338
ESE	0.000000	0.003311	0.003881	0.001142	0.000000	0.000000	0.000000	0.000000	0.008333
SE	0.000000	0.002055	0.005594	0.002854	0.000000	0.000000	0.000000	0.000000	0.010502
SSE	0.000000	0.005251	0.006050	0.000913	0.000000	0.000000	0.000000	0.000000	0.012215
S	0.000000	0.007192	0.002169	0.000114	0.000000	0.000000	0.000000	0.000000	0.009475
SSW	0.000000	0.001826	0.001826	0.000571	0.000000	0.000000	0.000000	0.000000	0.004224
SW	0.000000	0.000913	0.000685	0.000114	0.000000	0.000000	0.000000	0.000000	0.001712
WSW	0.000000	0.000342	0.006735	0.001941	0.000000	0.000000	0.000000	0.000000	0.009018
W	0.000000	0.000228	0.006393	0.003082	0.000000	0.000000	0.000000	0.000000	0.009703
WNW	0.000000	0.000114	0.000571	0.000114	0.000000	0.000000	0.000000	0.000000	0.000799
NW	0.000000	0.000114	0.000114	0.000114	0.000000	0.000000	0.000000	0.000000	0.000342
NNW	0.000000	0.000114	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000228
N	0.000000	0.000114	0.006621	0.000913	0.000000	0.000000	0.000000	0.000000	0.007648
CALM									0.000000
TOTAL	0.000000	0.024201	0.059132	0.017922	0.000000	0.000000	0.000000	0.000000	0.101256

MEAN WIND SPEED (m/s) = 3.67
NUMBER OF OBSERVATIONS = 887

PASQUILL STABILITY CLASS 'F'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.003653	0.010731	0.002055	0.000000	0.000000	0.000000	0.000000	0.000000	0.016438
NE	0.002740	0.011644	0.001826	0.000000	0.000000	0.000000	0.000000	0.000000	0.016210
ENE	0.002968	0.005708	0.000228	0.000000	0.000000	0.000000	0.000000	0.000000	0.008904
E	0.002968	0.009018	0.001027	0.000000	0.000000	0.000000	0.000000	0.000000	0.013014
ESE	0.002968	0.006849	0.001598	0.000000	0.000000	0.000000	0.000000	0.000000	0.011416
SE	0.003311	0.007648	0.001484	0.000000	0.000000	0.000000	0.000000	0.000000	0.012443
SSE	0.010160	0.014498	0.001941	0.000000	0.000000	0.000000	0.000000	0.000000	0.026598
S	0.031507	0.036416	0.001941	0.000000	0.000000	0.000000	0.000000	0.000000	0.069863
SSW	0.026484	0.033105	0.000913	0.000000	0.000000	0.000000	0.000000	0.000000	0.060502
SW	0.011301	0.016438	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.027854
WSW	0.006164	0.011758	0.002854	0.000000	0.000000	0.000000	0.000000	0.000000	0.020776
W	0.003881	0.005251	0.001826	0.000000	0.000000	0.000000	0.000000	0.000000	0.010959
WNW	0.001598	0.002626	0.000457	0.000000	0.000000	0.000000	0.000000	0.000000	0.004680
NW	0.001370	0.002397	0.000457	0.000000	0.000000	0.000000	0.000000	0.000000	0.004224
NNW	0.000799	0.003082	0.000228	0.000000	0.000000	0.000000	0.000000	0.000000	0.004110
N	0.002626	0.007078	0.001142	0.000000	0.000000	0.000000	0.000000	0.000000	0.010845
CALM									0.051256
TOTAL	0.114498	0.184247	0.020091	0.000000	0.000000	0.000000	0.000000	0.000000	0.370091

MEAN WIND SPEED (m/s) = 1.66
NUMBER OF OBSERVATIONS = 3242

ALL PASQUILL STABILITY CLASSES

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.005137	0.014954	0.021347	0.019863	0.013470	0.001484	0.000000	0.000000	0.076256
NE	0.003995	0.017580	0.013128	0.010845	0.001598	0.000000	0.000000	0.000000	0.047146
ENE	0.003653	0.008333	0.010046	0.006050	0.000457	0.000000	0.000000	0.000000	0.028539
E	0.003311	0.015639	0.018950	0.009475	0.001598	0.000000	0.000000	0.000000	0.048973
ESE	0.003425	0.015525	0.017580	0.024543	0.011872	0.001484	0.000228	0.000000	0.074658
SE	0.004338	0.016096	0.021575	0.023174	0.011758	0.002854	0.000000	0.000000	0.079795
SSE	0.012785	0.029338	0.024543	0.008790	0.002169	0.000228	0.000000	0.000000	0.077854
S	0.036530	0.060046	0.019064	0.004909	0.000342	0.000000	0.000000	0.000000	0.120890
SSW	0.034361	0.048744	0.007877	0.002740	0.000000	0.000000	0.000000	0.000000	0.093721
SW	0.020548	0.034132	0.003082	0.000571	0.000114	0.000000	0.000000	0.000000	0.058447
WSW	0.011530	0.029680	0.022945	0.006279	0.002511	0.000571	0.000114	0.000000	0.073630
W	0.008904	0.017922	0.021233	0.012671	0.006050	0.002854	0.001826	0.000000	0.071461
WNW	0.004224	0.009817	0.004452	0.003881	0.000799	0.000799	0.000228	0.000000	0.024201
NW	0.003311	0.006849	0.001370	0.000913	0.000228	0.000000	0.000000	0.000000	0.012671
NNW	0.002169	0.010160	0.002397	0.000114	0.000000	0.000000	0.000000	0.000000	0.014840
N	0.004566	0.012443	0.013699	0.003995	0.000799	0.000000	0.000000	0.000000	0.035502
CALM									0.061416
TOTAL	0.162785	0.347260	0.223288	0.138813	0.053767	0.010274	0.002397	0.000000	1.000000

MEAN WIND SPEED (m/s) = 3.02
NUMBER OF OBSERVATIONS = 8760

FREQUENCY OF OCCURENCE OF STABILITY CLASSES

A : 1.4%
B : 13.3%
C : 18.7%
D : 19.5%
E : 10.1%
F : 37.0%

STABILITY CLASS BY HOUR OF DAY

Hour	A	B	C	D	E	F
01	0000	0000	0000	0016	0059	0290
02	0000	0000	0000	0020	0052	0293
03	0000	0000	0000	0018	0051	0296
04	0000	0000	0000	0016	0040	0309
05	0000	0000	0000	0017	0040	0308
06	0000	0000	0067	0068	0020	0210
07	0000	0041	0151	0103	0008	0062
08	0000	0079	0192	0094	0000	0000
09	0004	0132	0170	0059	0000	0000
10	0011	0152	0148	0054	0000	0000
11	0037	0189	0091	0048	0000	0000
12	0034	0176	0107	0048	0000	0000
13	0025	0170	0120	0050	0000	0000
14	0009	0130	0160	0066	0000	0000
15	0000	0061	0186	0118	0000	0000
16	0000	0034	0165	0166	0000	0000
17	0000	0002	0067	0296	0000	0000
18	0000	0000	0015	0223	0042	0085
19	0000	0000	0001	0112	0110	0142
20	0000	0000	0000	0037	0130	0198
21	0000	0000	0000	0021	0109	0235
22	0000	0000	0000	0021	0092	0252
23	0000	0000	0000	0017	0073	0275
24	0000	0000	0000	0017	0061	0287

STABILITY CLASS BY MIXING HEIGHT

Mixing height	A	B	C	D	E	F
<=500 m	0000	0094	0265	0214	0427	3238
<=1000 m	0012	0245	0312	0433	0403	0004
<=1500 m	0059	0589	0587	0500	0057	0000
<=2000 m	0045	0223	0441	0452	0000	0000
<=3000 m	0004	0015	0035	0106	0000	0000
>3000 m	0000	0000	0000	0000	0000	0000

MIXING HEIGHT BY HOUR OF DAY

Hour	0000 to 0100	0100 to 0200	0200 to 0400	0400 to 0800	0800 to 1600	1600 to 3200	Greater than 3200
01	0182	0059	0061	0050	0013	0000	0000
02	0188	0058	0065	0040	0014	0000	0000
03	0189	0058	0068	0036	0013	0001	0000
04	0190	0064	0071	0028	0011	0001	0000
05	0195	0068	0063	0027	0011	0001	0000
06	0184	0057	0072	0036	0015	0001	0000
07	0101	0031	0073	0109	0048	0003	0000
08	0000	0021	0072	0123	0144	0005	0000
09	0000	0000	0015	0092	0223	0035	0000
10	0000	0000	0001	0055	0271	0038	0000
11	0000	0000	0000	0018	0291	0056	0000
12	0000	0000	0000	0003	0271	0091	0000
13	0000	0000	0000	0001	0234	0130	0000
14	0000	0000	0000	0001	0209	0155	0000
15	0000	0000	0000	0001	0202	0162	0000
16	0000	0000	0002	0027	0182	0154	0000
17	0008	0008	0030	0071	0162	0086	0000
18	0026	0031	0063	0074	0137	0034	0000
19	0045	0050	0078	0096	0080	0016	0000
20	0083	0050	0087	0077	0056	0012	0000
21	0102	0057	0086	0083	0030	0007	0000
22	0129	0056	0084	0066	0027	0003	0000
23	0145	0064	0070	0064	0022	0000	0000
24	0169	0057	0076	0045	0018	0000	0000

Joint wind speed, wind direction and stability class frequency tables for Brisbane Airport

STATISTICS FOR FILE: I:\QENV\Projects\QE40190\Technical\Air Quality\calmet\prtmet_ts\bap.aus
MONTHS: All
HOURS : All
OPTION: Frequency

PASQUILL STABILITY CLASS 'A'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000114	0.001484	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001598
NE	0.000114	0.001142	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001256
ENE	0.000342	0.000457	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000799
E	0.000342	0.001712	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002055
ESE	0.000228	0.000799	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001027
SE	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000114
SSE	0.000228	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000342
S	0.000000	0.000342	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000342
SSW	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000114
SW	0.000342	0.000228	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000571
WSW	0.000342	0.000571	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000913
W	0.000114	0.000571	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000685
WNW	0.000000	0.000342	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000342
NW	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000114
NNW	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000114
N	0.000000	0.000913	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000913
CALM									0.001256
TOTAL	0.002283	0.009018	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.012557

MEAN WIND SPEED (m/s) = 1.85
NUMBER OF OBSERVATIONS = 110

PASQUILL STABILITY CLASS 'B'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.001484	0.003196	0.006963	0.001142	0.000000	0.000000	0.000000	0.000000	0.012785
NE	0.001142	0.004452	0.007648	0.000457	0.000000	0.000000	0.000000	0.000000	0.013699
ENE	0.001256	0.003311	0.005251	0.000000	0.000000	0.000000	0.000000	0.000000	0.009817
E	0.001256	0.004338	0.003995	0.000457	0.000000	0.000000	0.000000	0.000000	0.010046
ESE	0.000685	0.004795	0.005251	0.000114	0.000000	0.000000	0.000000	0.000000	0.010845
SE	0.001027	0.002511	0.009475	0.001826	0.000000	0.000000	0.000000	0.000000	0.014840
SSE	0.001142	0.001712	0.005137	0.000114	0.000000	0.000000	0.000000	0.000000	0.008105
S	0.000799	0.002169	0.001712	0.000342	0.000000	0.000000	0.000000	0.000000	0.005023
SSW	0.001027	0.003196	0.002283	0.000114	0.000000	0.000000	0.000000	0.000000	0.006621
SW	0.002511	0.004452	0.001826	0.000114	0.000000	0.000000	0.000000	0.000000	0.008904
WSW	0.001484	0.003767	0.001712	0.000000	0.000000	0.000000	0.000000	0.000000	0.006963
W	0.001826	0.002055	0.001370	0.000000	0.000000	0.000000	0.000000	0.000000	0.005251
WNW	0.001484	0.000913	0.000342	0.000114	0.000000	0.000000	0.000000	0.000000	0.002854
NW	0.001256	0.002397	0.001142	0.000000	0.000000	0.000000	0.000000	0.000000	0.004795
NNW	0.001712	0.003196	0.002283	0.000000	0.000000	0.000000	0.000000	0.000000	0.007192
N	0.001142	0.003767	0.004566	0.000228	0.000000	0.000000	0.000000	0.000000	0.009703
CALM									0.000685
TOTAL	0.021233	0.050228	0.060959	0.005023	0.000000	0.000000	0.000000	0.000000	0.138128

MEAN WIND SPEED (m/s) = 2.82
NUMBER OF OBSERVATIONS = 1210

PASQUILL STABILITY CLASS 'C'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000342	0.002169	0.005251	0.005479	0.000000	0.000000	0.000000	0.000000	0.013242
NE	0.000457	0.002740	0.006507	0.002055	0.000000	0.000000	0.000000	0.000000	0.011758
ENE	0.000571	0.001256	0.002626	0.000342	0.000000	0.000000	0.000000	0.000000	0.004795
E	0.000342	0.004338	0.004338	0.001941	0.000000	0.000000	0.000000	0.000000	0.010959
ESE	0.000342	0.003767	0.007991	0.003995	0.000000	0.000000	0.000000	0.000000	0.016096
SE	0.000457	0.001598	0.012443	0.019521	0.000685	0.000000	0.000000	0.000000	0.034703
SSE	0.001027	0.001370	0.009247	0.012215	0.000913	0.000114	0.000000	0.000000	0.024886
S	0.000228	0.001941	0.006735	0.003196	0.000114	0.000000	0.000000	0.000000	0.012215
SSW	0.000571	0.004224	0.006279	0.001941	0.000000	0.000000	0.000000	0.000000	0.013014
SW	0.000913	0.005365	0.004909	0.002283	0.000000	0.000000	0.000000	0.000000	0.013470
WSW	0.000571	0.001598	0.004224	0.002854	0.000000	0.000000	0.000000	0.000000	0.009247
W	0.001027	0.002626	0.001826	0.001142	0.000685	0.000342	0.000000	0.000000	0.007648
WNW	0.000799	0.001370	0.000913	0.000685	0.000228	0.000000	0.000000	0.000000	0.003995
NW	0.001598	0.001826	0.000457	0.000571	0.000000	0.000000	0.000000	0.000000	0.004452
NNW	0.000457	0.004909	0.003995	0.001712	0.000000	0.000000	0.000000	0.000000	0.011073
N	0.000799	0.002511	0.002854	0.001142	0.000000	0.000000	0.000000	0.000000	0.007306
CALM									0.001142
TOTAL	0.010502	0.043607	0.080594	0.061073	0.002626	0.000457	0.000000	0.000000	0.200000

MEAN WIND SPEED (m/s) = 3.82
NUMBER OF OBSERVATIONS = 1752

PASQUILL STABILITY CLASS 'D'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000114	0.002055	0.003653	0.004110	0.001142	0.000000	0.000000	0.000000	0.011073
NE	0.000000	0.002397	0.002740	0.000114	0.000000	0.000000	0.000000	0.000000	0.005251
ENE	0.000000	0.002283	0.002397	0.000228	0.000000	0.000000	0.000000	0.000000	0.004909
E	0.000000	0.003995	0.004224	0.001712	0.000000	0.000000	0.000000	0.000000	0.009932
ESE	0.000000	0.003881	0.008447	0.007306	0.001484	0.000000	0.000000	0.000000	0.021119
SE	0.000228	0.002854	0.015753	0.027854	0.010046	0.000000	0.000000	0.000000	0.056735
SSE	0.000000	0.001712	0.012329	0.011530	0.005479	0.000228	0.000000	0.000000	0.031279
S	0.000000	0.001826	0.003196	0.005594	0.000571	0.000000	0.000000	0.000000	0.011187
SSW	0.000000	0.005936	0.004224	0.000799	0.000000	0.000000	0.000000	0.000000	0.010959
SW	0.000000	0.003425	0.002626	0.002169	0.000228	0.000000	0.000000	0.000000	0.008447
WSW	0.000000	0.002283	0.002055	0.003311	0.002854	0.000685	0.000000	0.000000	0.011187
W	0.000000	0.001027	0.000571	0.000457	0.000685	0.000000	0.000000	0.000000	0.002740
WNW	0.000000	0.000799	0.000228	0.000114	0.000000	0.000000	0.000000	0.000000	0.001142
NW	0.000000	0.001256	0.000000	0.000000	0.000228	0.000000	0.000000	0.000000	0.001484
NNW	0.000000	0.002626	0.000571	0.000228	0.000000	0.000000	0.000000	0.000000	0.003425
N	0.000114	0.001484	0.001484	0.001598	0.000114	0.000000	0.000000	0.000000	0.004795
CALM									0.000000
TOTAL	0.000457	0.039840	0.064498	0.067123	0.022831	0.000913	0.000000	0.000000	0.195662

MEAN WIND SPEED (m/s) = 4.38
NUMBER OF OBSERVATIONS = 1714

PASQUILL STABILITY CLASS 'E'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000000	0.000685	0.006507	0.001598	0.000000	0.000000	0.000000	0.000000	0.008790
NE	0.000000	0.000799	0.000342	0.000000	0.000000	0.000000	0.000000	0.000000	0.001142
ENE	0.000000	0.002169	0.000799	0.000000	0.000000	0.000000	0.000000	0.000000	0.002968
E	0.000000	0.000685	0.001598	0.000228	0.000000	0.000000	0.000000	0.000000	0.002511
ESE	0.000000	0.003196	0.003653	0.001484	0.000000	0.000000	0.000000	0.000000	0.008333
SE	0.000000	0.002397	0.009018	0.005365	0.000000	0.000000	0.000000	0.000000	0.016781
SSE	0.000000	0.000685	0.016324	0.002283	0.000000	0.000000	0.000000	0.000000	0.019292
S	0.000000	0.000228	0.012671	0.002854	0.000000	0.000000	0.000000	0.000000	0.015753
SSW	0.000000	0.000571	0.009589	0.001484	0.000000	0.000000	0.000000	0.000000	0.011644
SW	0.000000	0.000228	0.004795	0.000913	0.000000	0.000000	0.000000	0.000000	0.005936
WSW	0.000000	0.000000	0.004224	0.001027	0.000000	0.000000	0.000000	0.000000	0.005251
W	0.000000	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000114
WNW	0.000000	0.000000	0.000457	0.000000	0.000000	0.000000	0.000000	0.000000	0.000457
NW	0.000000	0.000000	0.000228	0.000000	0.000000	0.000000	0.000000	0.000000	0.000228
NNW	0.000000	0.000228	0.002854	0.000685	0.000000	0.000000	0.000000	0.000000	0.003767
N	0.000000	0.000913	0.011530	0.004452	0.000000	0.000000	0.000000	0.000000	0.016895
CALM									0.000000
TOTAL	0.000000	0.012785	0.084703	0.022374	0.000000	0.000000	0.000000	0.000000	0.119863

MEAN WIND SPEED (m/s) = 3.90
NUMBER OF OBSERVATIONS = 1050

PASQUILL STABILITY CLASS 'F'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.007192	0.012785	0.000799	0.000000	0.000000	0.000000	0.000000	0.000000	0.020776
NE	0.004795	0.007991	0.000228	0.000000	0.000000	0.000000	0.000000	0.000000	0.013014
ENE	0.003539	0.007763	0.000228	0.000000	0.000000	0.000000	0.000000	0.000000	0.011530
E	0.004338	0.009817	0.001256	0.000000	0.000000	0.000000	0.000000	0.000000	0.015411
ESE	0.003196	0.013356	0.000571	0.000000	0.000000	0.000000	0.000000	0.000000	0.017123
SE	0.003311	0.016895	0.002511	0.000000	0.000000	0.000000	0.000000	0.000000	0.022717
SSE	0.002968	0.017466	0.004566	0.000000	0.000000	0.000000	0.000000	0.000000	0.025000
S	0.002854	0.021233	0.005137	0.000000	0.000000	0.000000	0.000000	0.000000	0.029224
SSW	0.001598	0.026598	0.004110	0.000000	0.000000	0.000000	0.000000	0.000000	0.032306
SW	0.002626	0.024315	0.003653	0.000000	0.000000	0.000000	0.000000	0.000000	0.030594
WSW	0.002511	0.021689	0.002740	0.000000	0.000000	0.000000	0.000000	0.000000	0.026941
W	0.002626	0.010274	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.013014
WNW	0.003767	0.007078	0.000457	0.000000	0.000000	0.000000	0.000000	0.000000	0.011301
NW	0.004566	0.011073	0.000228	0.000000	0.000000	0.000000	0.000000	0.000000	0.015868
NNW	0.005137	0.018721	0.001598	0.000000	0.000000	0.000000	0.000000	0.000000	0.025457
N	0.003995	0.014041	0.002968	0.000000	0.000000	0.000000	0.000000	0.000000	0.021005
CALM									0.002511
TOTAL	0.059018	0.241096	0.031164	0.000000	0.000000	0.000000	0.000000	0.000000	0.333790

MEAN WIND SPEED (m/s) = 2.16
NUMBER OF OBSERVATIONS = 2924

ALL PASQUILL STABILITY CLASSES

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.009247	0.022374	0.023174	0.012329	0.001142	0.000000	0.000000	0.000000	0.068265
NE	0.006507	0.019521	0.017466	0.002626	0.000000	0.000000	0.000000	0.000000	0.046119
ENE	0.005708	0.017237	0.011301	0.000571	0.000000	0.000000	0.000000	0.000000	0.034817
E	0.006279	0.024886	0.015411	0.004338	0.000000	0.000000	0.000000	0.000000	0.050913
ESE	0.004452	0.029795	0.025913	0.012900	0.001484	0.000000	0.000000	0.000000	0.074543
SE	0.005023	0.026370	0.049201	0.054566	0.010731	0.000000	0.000000	0.000000	0.145890
SSE	0.005365	0.023059	0.047603	0.026142	0.006393	0.000342	0.000000	0.000000	0.108904
S	0.003881	0.027740	0.029452	0.011986	0.000685	0.000000	0.000000	0.000000	0.073744
SSW	0.003196	0.040639	0.026484	0.004338	0.000000	0.000000	0.000000	0.000000	0.074658
SW	0.006393	0.038014	0.017808	0.005479	0.000228	0.000000	0.000000	0.000000	0.067922
WSW	0.004909	0.029909	0.014954	0.007192	0.002854	0.000685	0.000000	0.000000	0.060502
W	0.005594	0.016553	0.003995	0.001598	0.001370	0.000342	0.000000	0.000000	0.029452
WNW	0.006050	0.010502	0.002397	0.000913	0.000228	0.000000	0.000000	0.000000	0.020091
NW	0.007534	0.016553	0.002055	0.000571	0.000228	0.000000	0.000000	0.000000	0.026941
NNW	0.007306	0.029795	0.011301	0.002626	0.000000	0.000000	0.000000	0.000000	0.051027
N	0.006050	0.023630	0.023402	0.007420	0.000114	0.000000	0.000000	0.000000	0.060616
CALM									0.005594
TOTAL	0.093493	0.396575	0.321918	0.155594	0.025457	0.001370	0.000000	0.000000	1.000000

MEAN WIND SPEED (m/s) = 3.22
NUMBER OF OBSERVATIONS = 8760

FREQUENCY OF OCCURENCE OF STABILITY CLASSES

A : 1.3%
B : 13.8%
C : 20.0%
D : 19.6%
E : 12.0%
F : 33.4%

STABILITY CLASS BY HOUR OF DAY

Hour	A	B	C	D	E	F
01	0000	0000	0000	0039	0080	0246
02	0000	0000	0000	0041	0076	0248
03	0000	0000	0000	0037	0080	0248
04	0000	0000	0000	0039	0080	0246
05	0000	0000	0000	0039	0077	0249
06	0000	0000	0045	0105	0057	0158
07	0000	0031	0093	0177	0012	0052
08	0000	0047	0186	0132	0000	0000
09	0002	0114	0186	0063	0000	0000
10	0010	0144	0160	0051	0000	0000
11	0033	0183	0107	0042	0000	0000
12	0032	0188	0105	0040	0000	0000
13	0022	0200	0110	0033	0000	0000
14	0010	0154	0160	0041	0000	0000
15	0001	0085	0209	0070	0000	0000
16	0000	0056	0214	0095	0000	0000
17	0000	0007	0150	0208	0000	0000
18	0000	0001	0022	0211	0028	0103
19	0000	0000	0005	0087	0093	0180
20	0000	0000	0000	0028	0113	0224
21	0000	0000	0000	0031	0096	0238
22	0000	0000	0000	0031	0090	0244
23	0000	0000	0000	0035	0083	0247
24	0000	0000	0000	0039	0085	0241

STABILITY CLASS BY MIXING HEIGHT

Mixing height	A	B	C	D	E	F
<=500 m	0000	0059	0157	0240	0149	2860
<=1000 m	0012	0259	0335	0462	0685	0064
<=1500 m	0058	0598	0725	0504	0191	0000
<=2000 m	0036	0275	0490	0409	0025	0000
<=3000 m	0004	0019	0045	0099	0000	0000
>3000 m	0000	0000	0000	0000	0000	0000

MIXING HEIGHT BY HOUR OF DAY

Hour	0000 to 0100	0100 to 0200	0200 to 0400	0400 to 0800	0800 to 1600	1600 to 3200	Greater than 3200
01	0078	0041	0097	0085	0056	0008	0000
02	0087	0043	0092	0088	0046	0009	0000
03	0095	0042	0093	0084	0043	0008	0000
04	0091	0037	0102	0087	0041	0007	0000
05	0092	0039	0101	0089	0036	0008	0000
06	0074	0042	0101	0097	0044	0007	0000
07	0030	0033	0071	0129	0089	0013	0000
08	0000	0000	0054	0118	0173	0020	0000
09	0000	0000	0009	0079	0216	0061	0000
10	0000	0000	0001	0052	0268	0044	0000
11	0000	0000	0000	0017	0286	0062	0000
12	0000	0000	0000	0005	0276	0084	0000
13	0000	0000	0000	0001	0246	0118	0000
14	0000	0000	0000	0001	0231	0133	0000
15	0000	0000	0000	0002	0230	0133	0000
16	0000	0000	0000	0022	0219	0124	0000
17	0013	0005	0020	0074	0187	0066	0000
18	0040	0026	0049	0084	0136	0030	0000
19	0054	0039	0077	0094	0081	0020	0000
20	0056	0044	0099	0080	0074	0012	0000
21	0056	0044	0108	0083	0062	0012	0000
22	0064	0047	0104	0076	0066	0008	0000
23	0064	0056	0100	0074	0063	0008	0000
24	0080	0041	0092	0084	0061	0007	0000

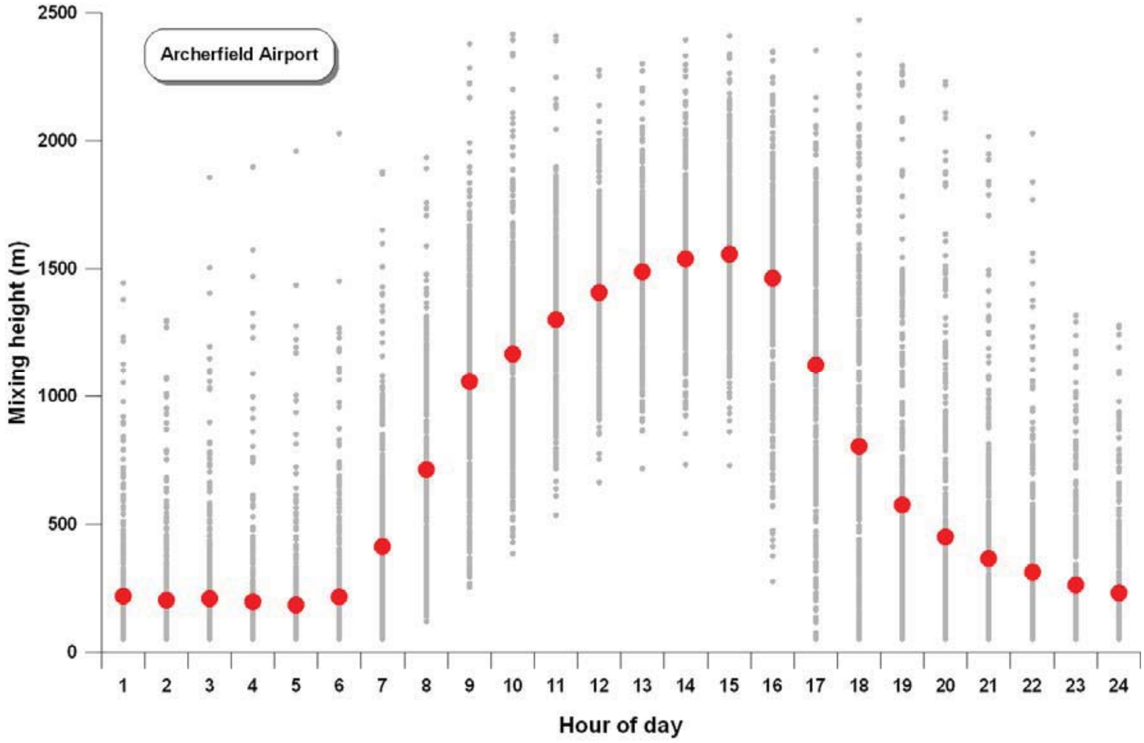


Figure 26 Average mixing height by hour of day for Archerfield Airport

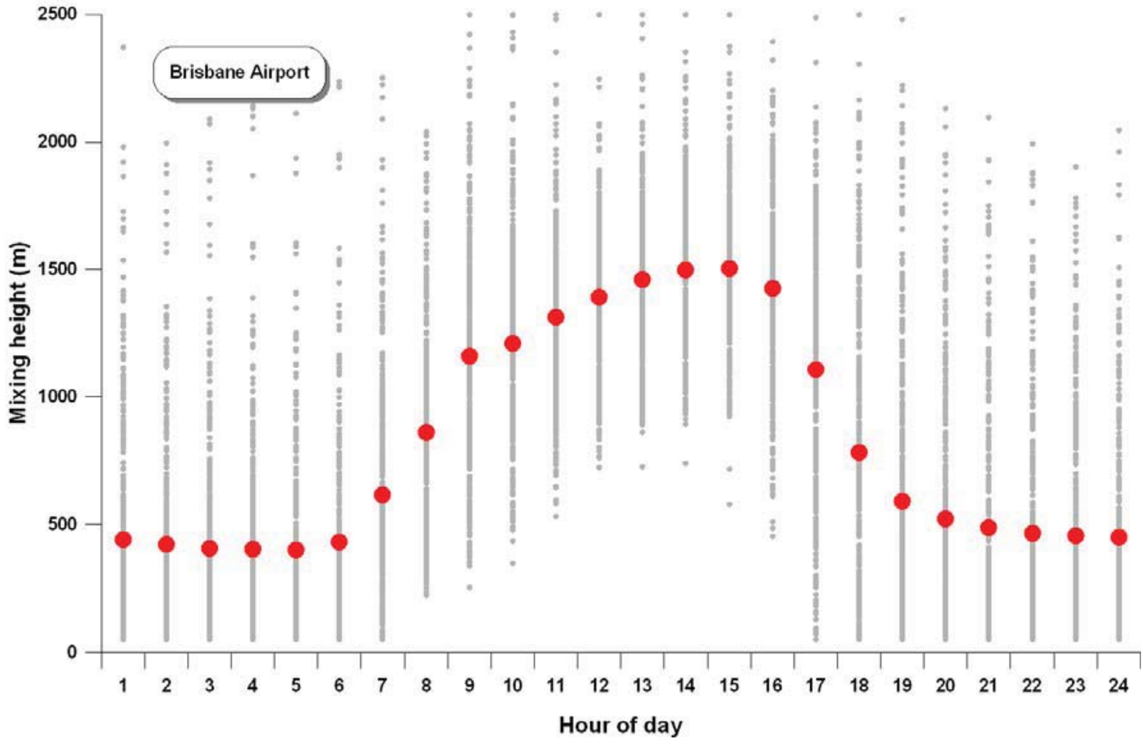
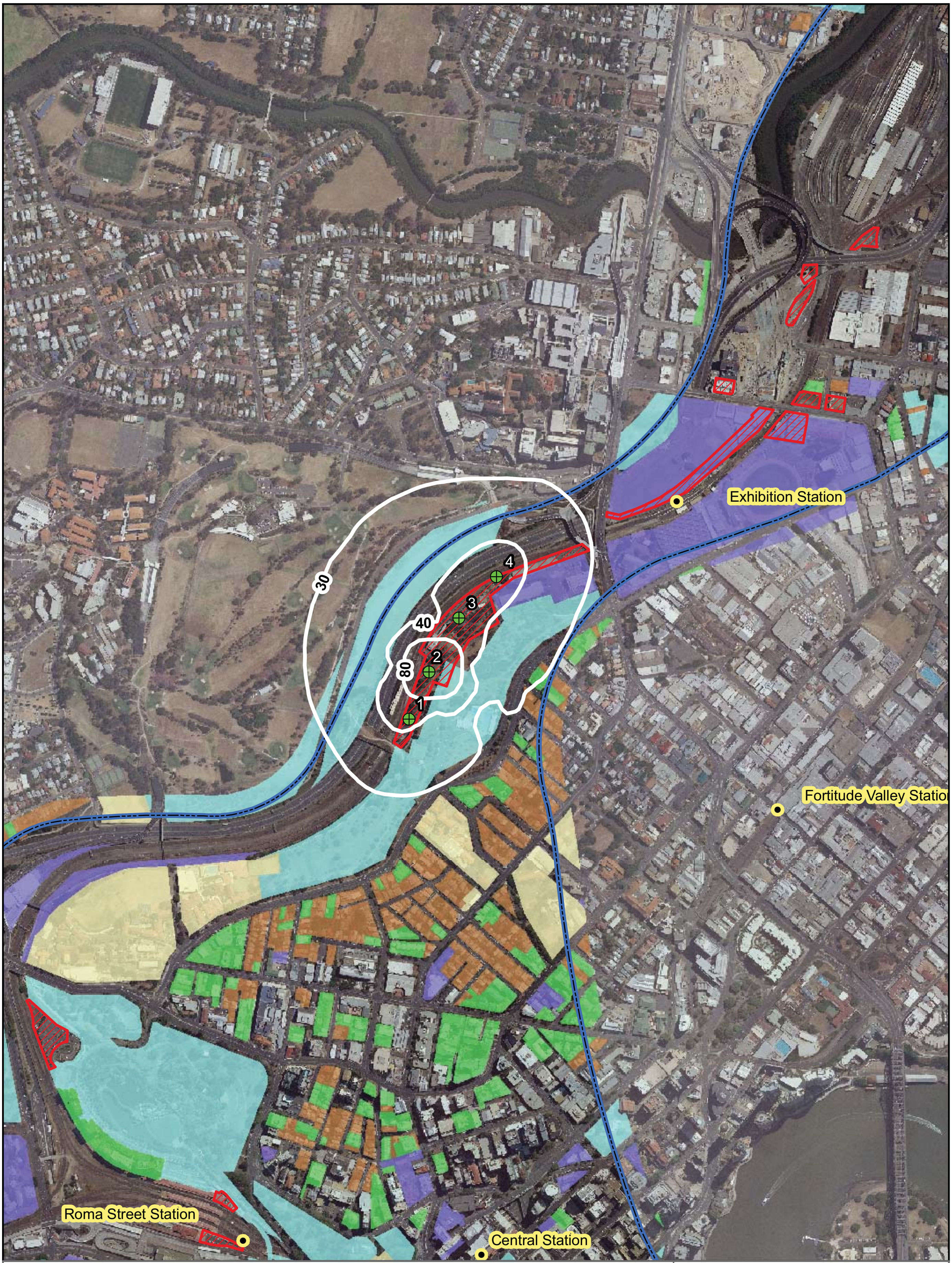


Figure 27 Average mixing height by hour of day for Brisbane Airport

Appendix B Dispersion modelling results



LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure B1

Maximum cumulative TSP concentrations (annual average) for Northern Portal (including background of 28 µg/m³)

0 100 200 300 400 m

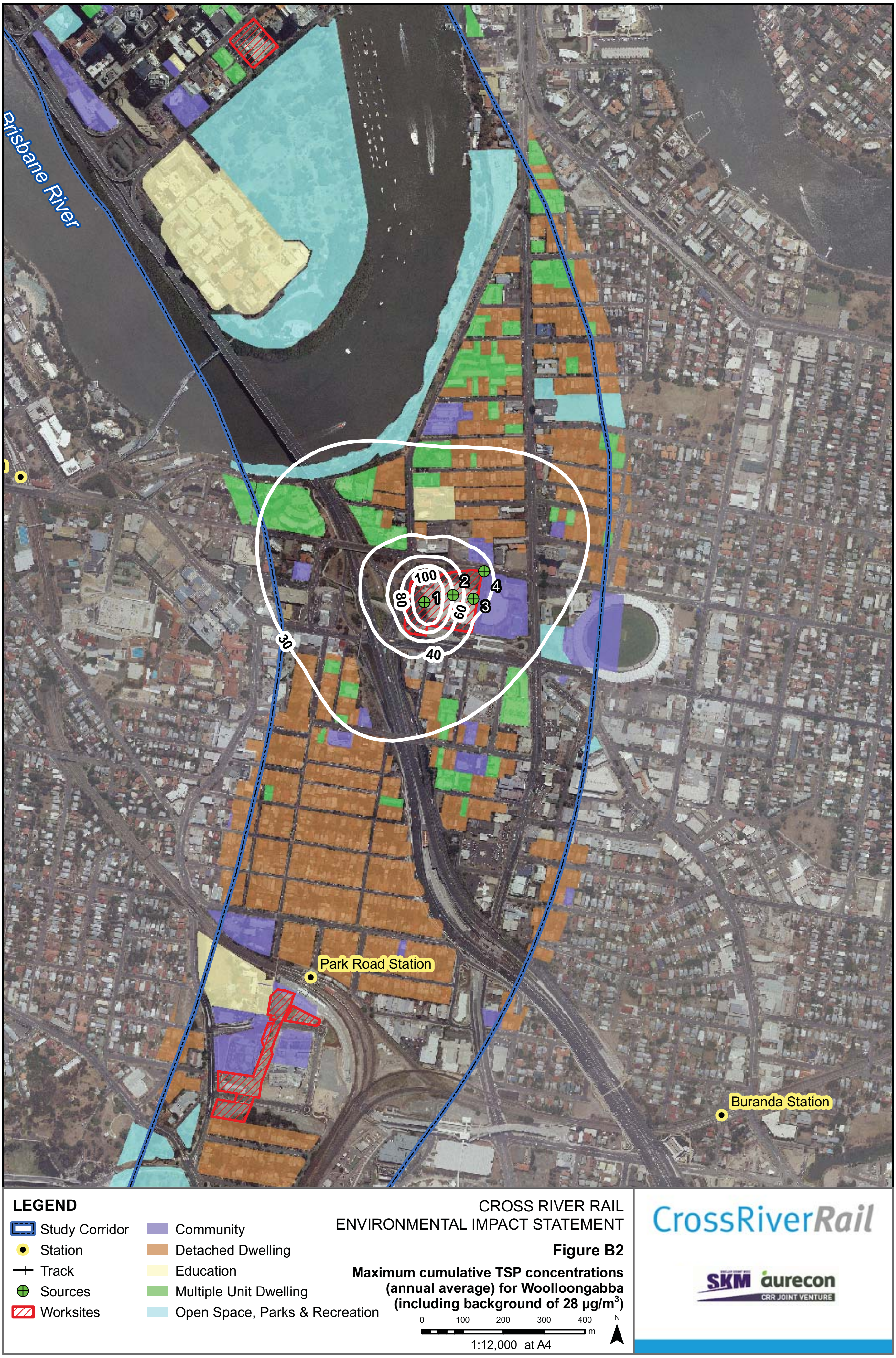
N

1:12,000 at A4

CrossRiverRail

SKM aurecon
CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKMSpatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_B1_AQ_TSP_Annual_NorthPortal.mxd 07/07/2011 15:14



CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure B2

Maximum cumulative TSP concentrations (annual average) for Woolloongabba (including background of 28 µg/m^3)

CrossRiverRail

SKM aurecon CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_B2_AQ_TSP_Annual_Woolloongabba.mxd 07/07/2011 15:14

LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure B3

Maximum cumulative TSP concentrations (annual average) for Boggo Road (including background of 28 μg/m^3)

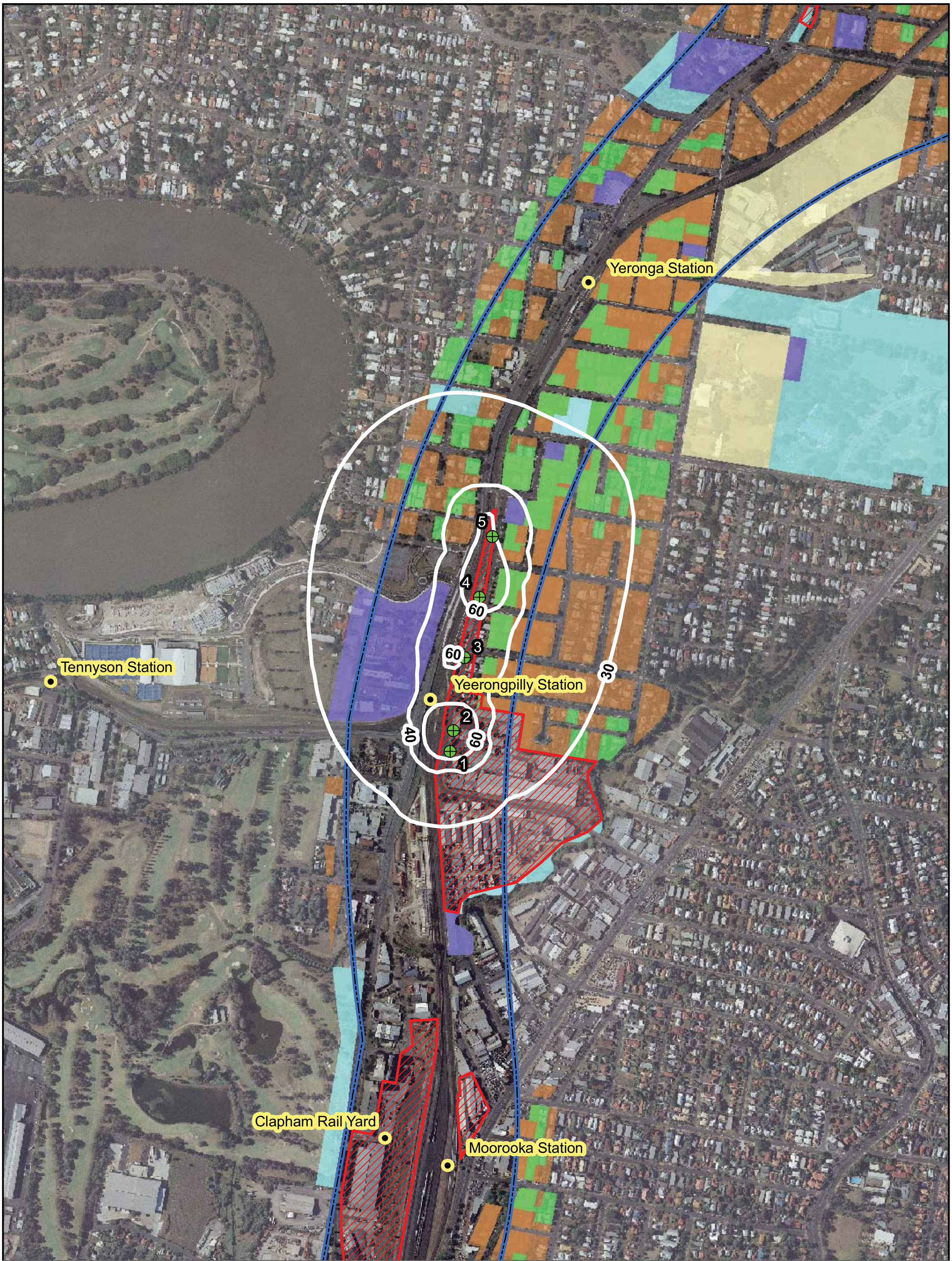
0 50 100 150 200 m

1:6,000 at A4

CrossRiverRail

SKM aurecon
CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_B3_AQ_TSP_Annual_Boggo_Rd.mxd 07/07/2011 15:19



LEGEND

Study Corridor	Community
Station	Detached Dwelling
Track	Education
Sources	Multiple Unit Dwelling
Worksites	Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure B4

Maximum cumulative TSP concentrations (annual average) for Yeerongpilly (including background of 28 μg/m^3)

0 100 200 300 400 m

1:12,000 at A4

N

CrossRiverRail

SKM aurecon
CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_B4_AQ_TSP_Annual_Yeerongpilly.mxd 07/07/2011 15:20

LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure B5

Maximum cumulative TSP concentrations (annual average) for Clapham Rail Yard (including background of 28 μg/m³)

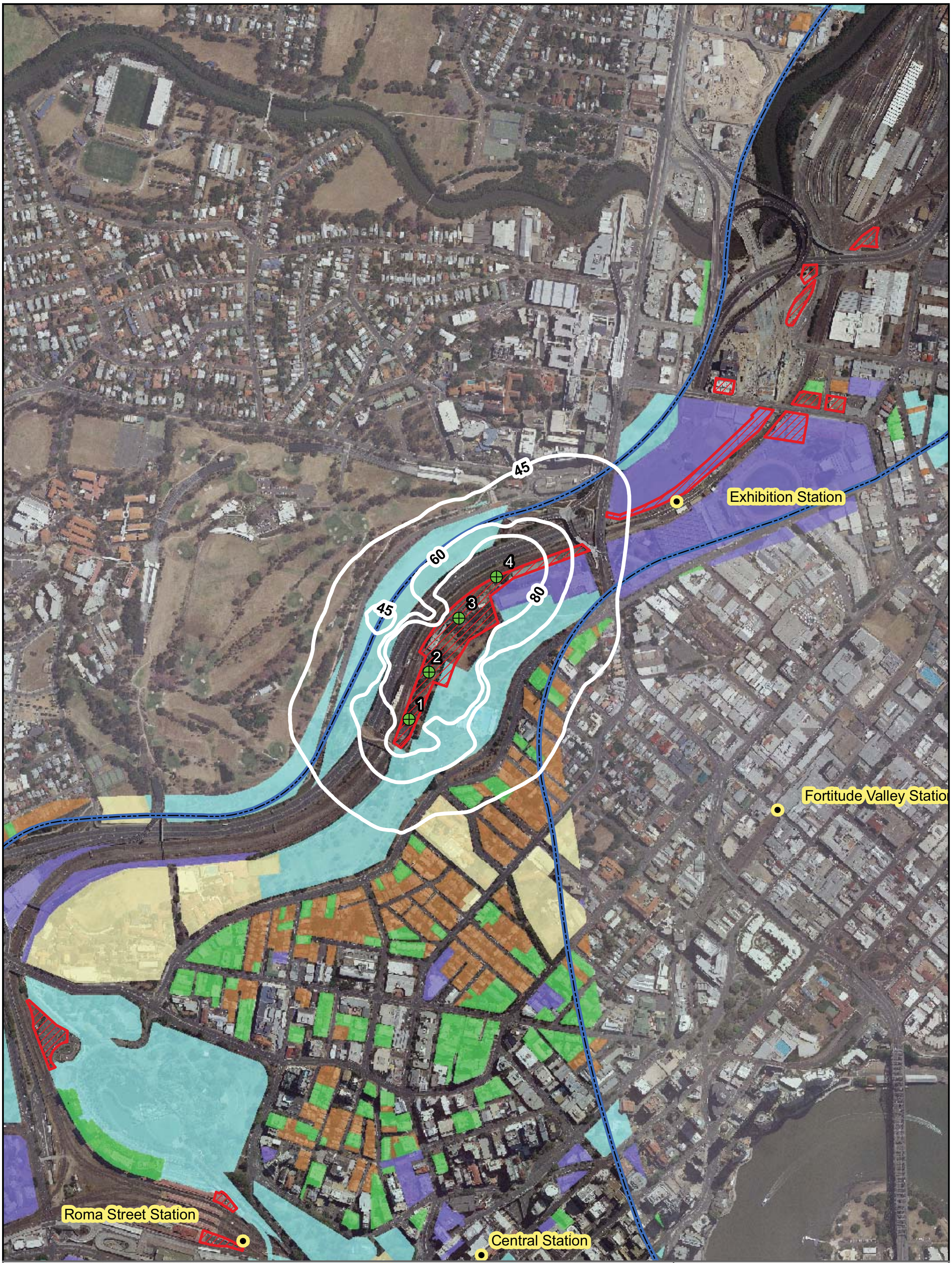
0 100 200 300 400 m

1:12,000 at A4

CrossRiverRail

SKM aurecon CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_B5_AQ_TSP_Annual_Clapham.mxd 07/07/2011 15:21



LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure B6

Maximum cumulative TSP concentrations (24 hour average) for Northern Portal (including background of 29 μg/m^3)

0 100 200 300 400 m

1:12,000 at A4

N

CrossRiverRail

SKM aurecon CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_B6_AQ_TSP_24hr_NorthPortal.mxd 07/07/2011 15:21

LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure B7

Maximum cumulative TSP concentrations (24 hour average) for Woolloongabba (including background of 29 μg/m^3)

0 100 200 300 400 m
1:12,000 at A4

CrossRiverRail
SKM aurecon
CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_B7_AQ_TSP_24hr_Woolloongabba.mxd 07/07/2011 15:22

LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure B8

Maximum cumulative TSP concentrations (24 hour average) for Boggo Road (including background of 29 μg/m³)

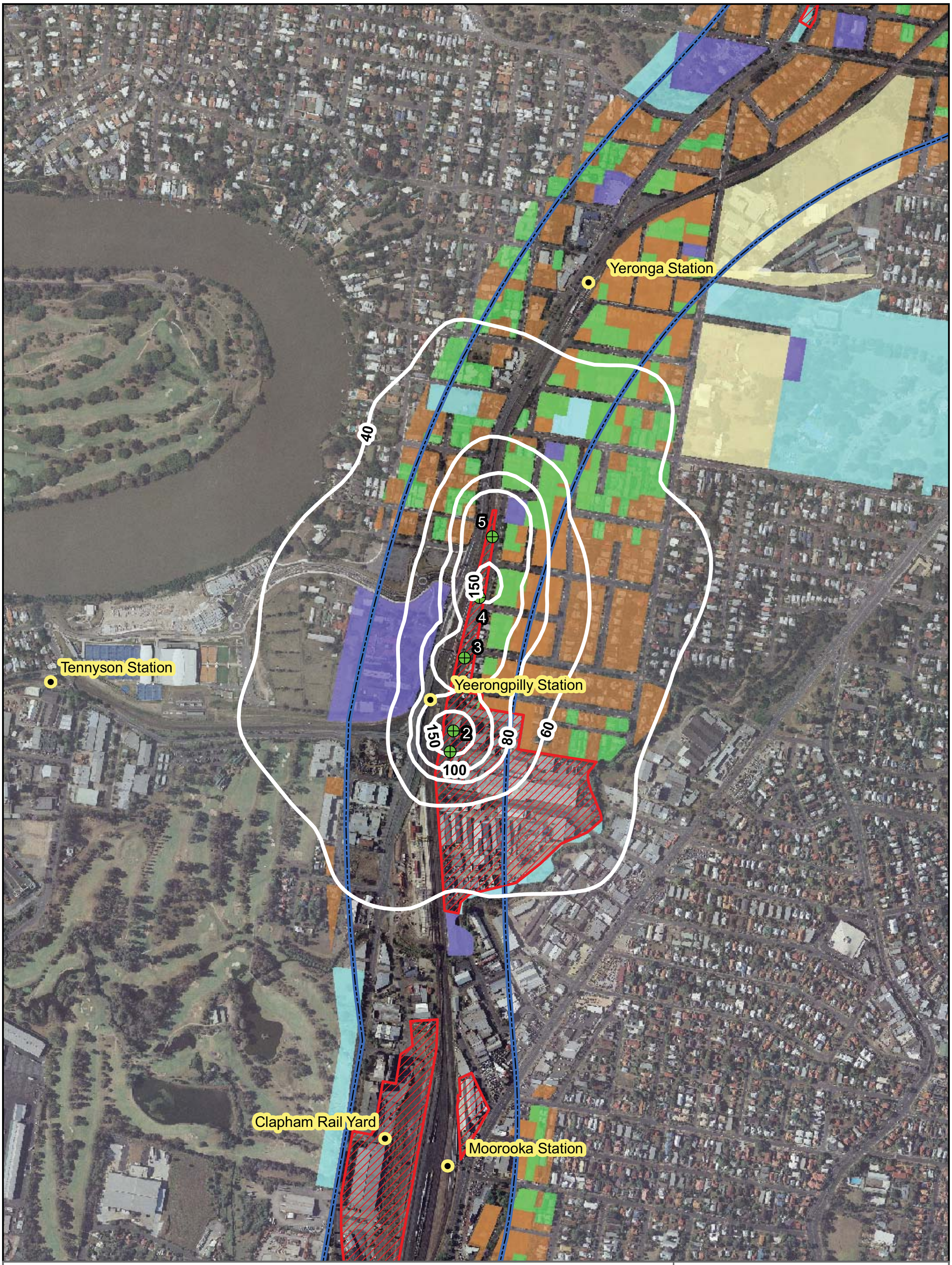
0 50 100 150 200 m

1:6,000 at A4

CrossRiverRail

SKM aurecon CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_B8_AQ_TSP_24hr_Boggo_Rd.mxd 07/07/2011 15:22



LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure B9

Maximum cumulative TSP concentrations (24 hour average) for Yeerongpilly (including background of 29 μg/m^3)

0 100 200 300 400 m

1:12,000 at A4

CrossRiverRail

SKM aurecon
CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_B9_AQ_TSP_24hr_Yeerongpilly.mxd 07/07/2011 15:23

LEGEND

- Study Corridor
- Station
- Track
- Sources
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure B10

Maximum cumulative TSP concentrations (24 hour average) for Clapham Rail Yard (including background of 29 μg/m^3)

0 100 200 300 400 m

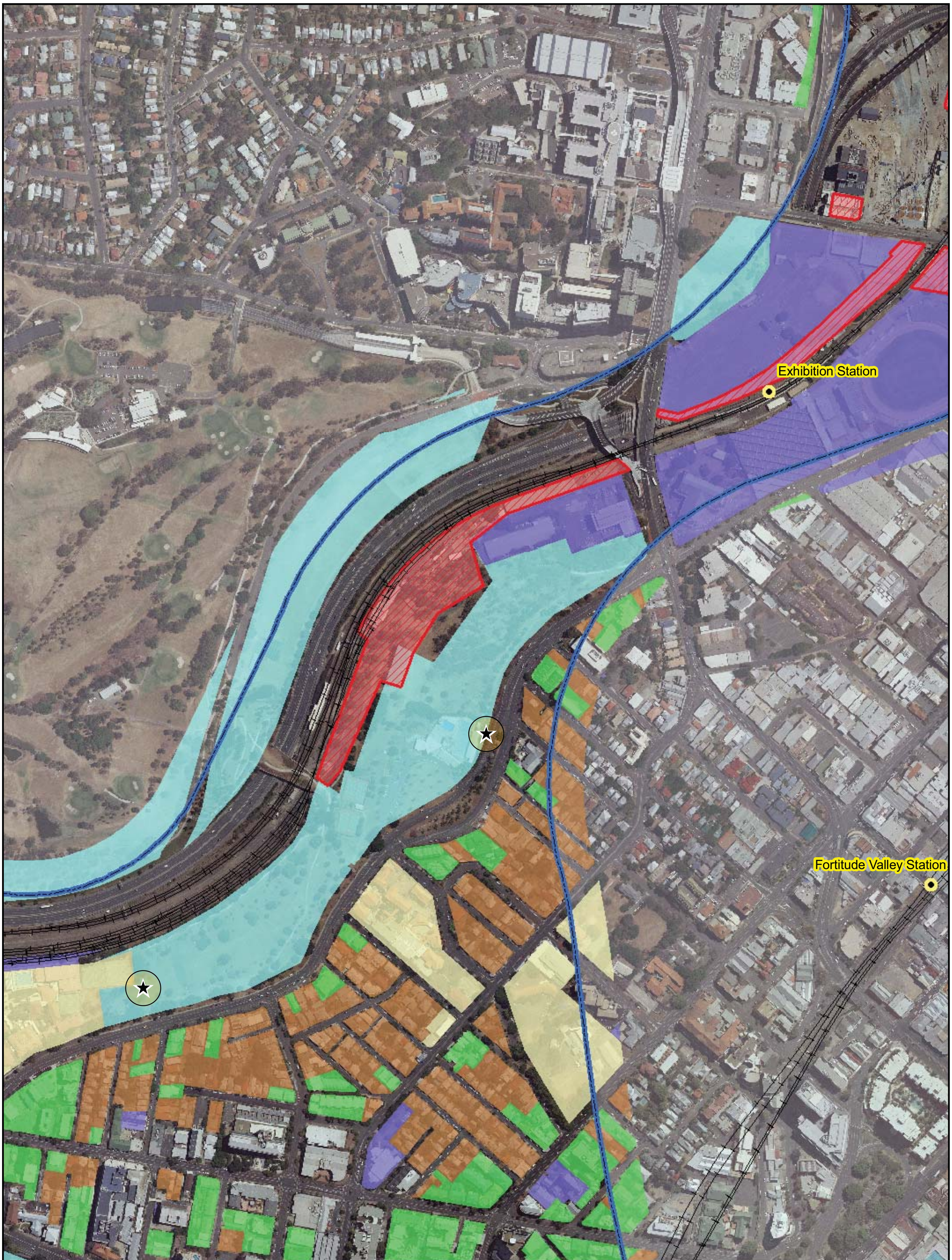
1:12,000 at A4

CrossRiverRail

SKM aurecon CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_B10_AQ_TSP_24hr_Clapham.mxd 07/07/2011 15:24

Appendix C Conceptual construction dust monitoring plans



LEGEND

- Study Corridor
- Station
- Track
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation
- Indicative Construction Monitoring Points

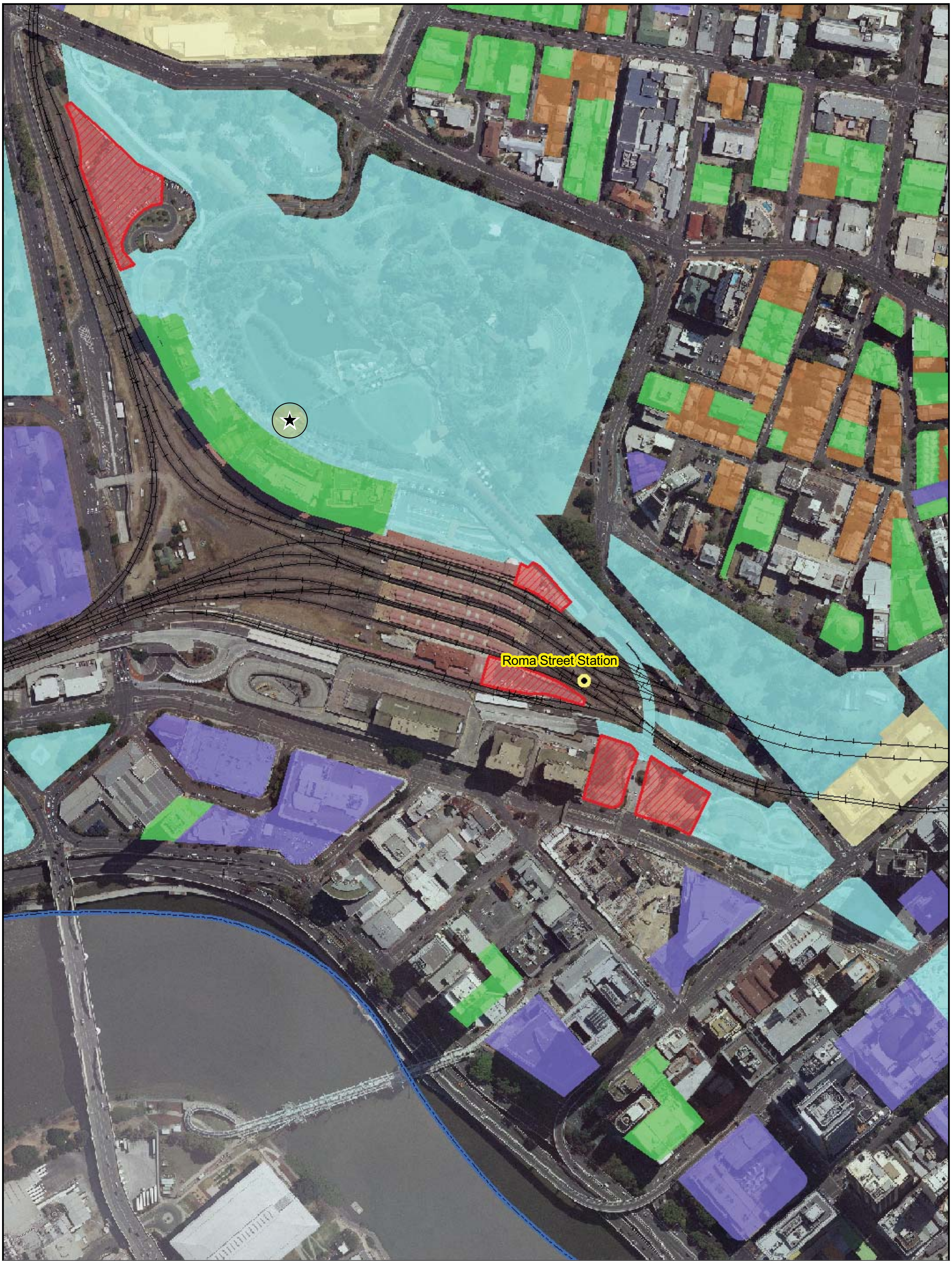
CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure C1

Northern Portal - Indicative Air Quality Monitoring Locations

0 50 100 150 200 250 m
N
1:7,500 at A4

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_C1_AQ_Monitoring_Loc_NorthPortal.mxd 07/07/2011 15:24



LEGEND

- Study Corridor
- Station
- Track
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation
- Indicative Construction Monitoring Points

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure C2

Roma Street - Indicative Air Quality Monitoring Locations

0 50 100 150 m

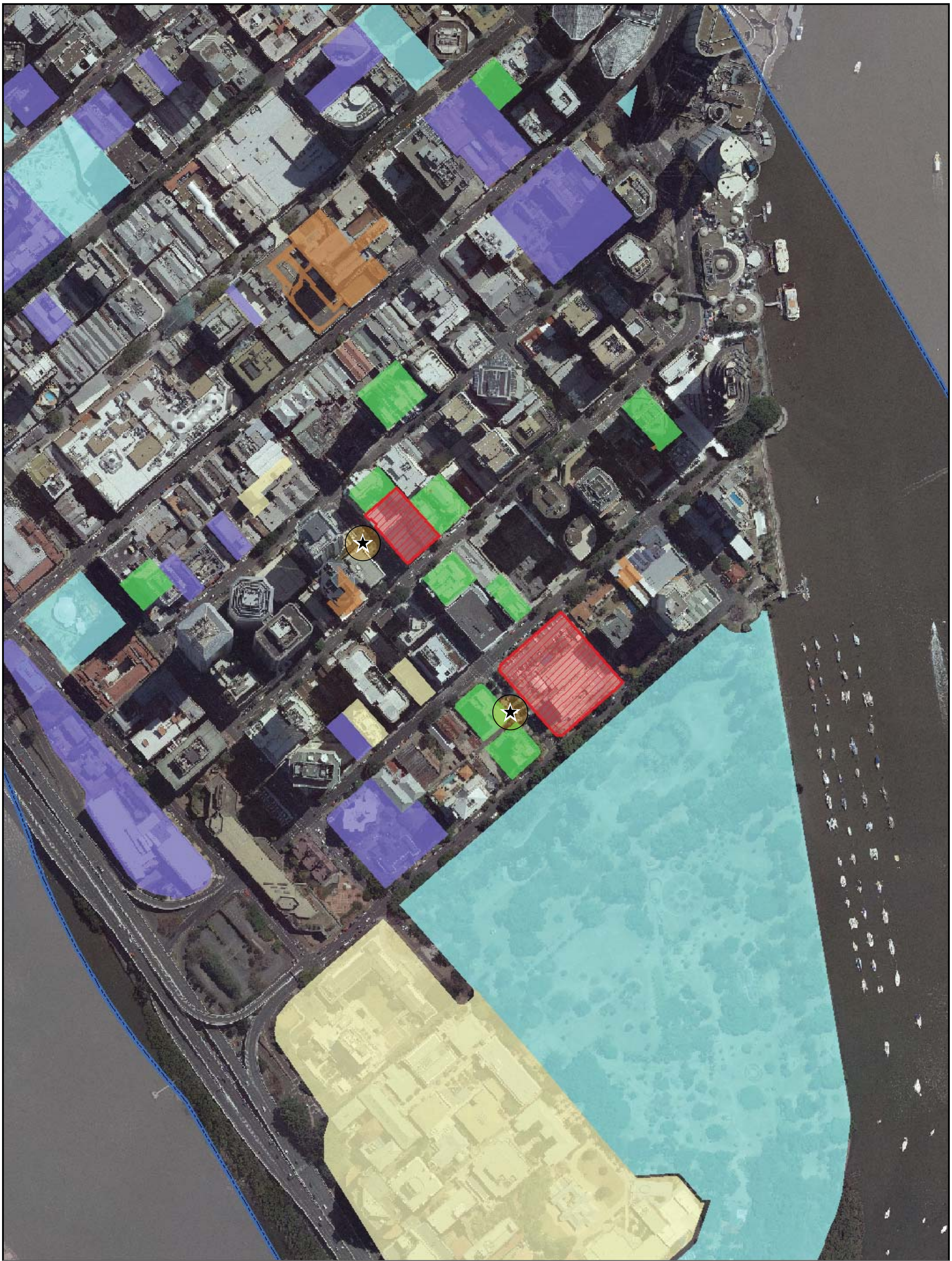
1:5,000 at A4

N

CrossRiverRail

SKM aurecon
CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_C2_AQ_Monitoring_Loc_RomaSt.mxd 07/07/2011 15:25



LEGEND

- Study Corridor
- Station
- Track
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation
- Indicative Construction Monitoring Points

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure C3

Albert Street - Indicative Air Quality Monitoring Locations

0 50 100 150 m
1:5,000 at A4

N

CrossRiverRail

SKM aurecon
CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_C3_AQ_Monitoring_Loc_AlbertSt.mxd 07/07/2011 15:25

LEGEND

- Study Corridor
- Station
- Track
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation
- Indicative Construction Monitoring Points

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

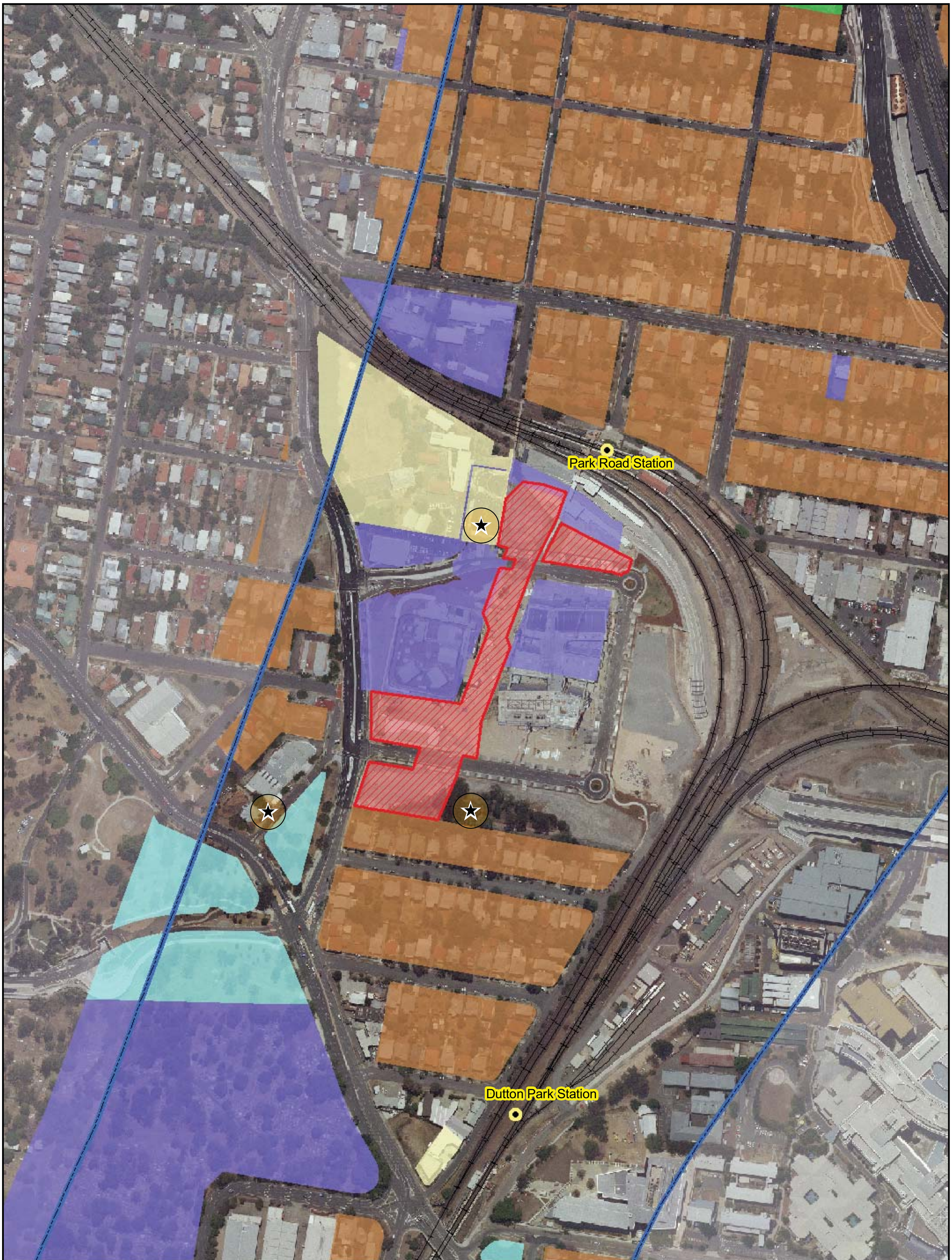
Figure C4

Woolloongabba - Indicative Air Quality Monitoring Locations

0 50 100 150 m

1:5,000 at A4

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_C4_AQ_Monitoring_Loc_Gabba.mxd 07/07/2011 15:26



LEGEND

- Study Corridor
- Station
- Track
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation
- Indicative Construction Monitoring Points

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure C5

Boggo Road - Indicative Air Quality Monitoring Locations

0 50 100 150 m
1:5,000 at A4
N

CrossRiverRail

SKM aurecon
CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_C5_AQ_Monitoring_Loc_BoggoRd.mxd 07/07/2011 15:27

LEGEND

- Study Corridor
- Station
- Track
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation
- Indicative Construction Monitoring Points

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure C6

Southern Ventilation Shaft - Indicative Air Quality Monitoring Locations

0 50 100 150 m

1:5,000 at A4

N

CrossRiverRail

SKM aurecon
CRR JOINT VENTURE

K:\Cross River Rail\600 Environment\619 GIS\SKM\Spatial\ArcGIS\Air_Quality\20110608_Tech_Report_Figures\Fig_C6_AQ_Monitoring_Loc_SouthVentShaft.mxd 07/07/2011 15:27

LEGEND

- Study Corridor
- Station
- Track
- Worksites
- Community
- Detached Dwelling
- Education
- Multiple Unit Dwelling
- Open Space, Parks & Recreation
- Indicative Construction Monitoring Points

0 50 100 150 m

1:5,000 at A4

N

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure C7

Yeerongpilly - Indicative Air Quality Monitoring Locations

CrossRiverRail

SKM aurecon CRR JOINT VENTURE

SINCLAIR KNIGHT MERZ

SKM aurecon

CRR JOINT VENTURE