



Appendix E Air Quality Assessment

Bulk Liquids Berth No. 2 - Port Botany



AIR QUALITY IMPACT ASSESSMENT

- Final
- 7 November 2007



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1. Introduction

1.1 General Introduction

Vopak Terminals Sydney Pty Ltd ('the Applicant') is a company that provides bulk liquid services (storage, transport, bulk handling, packaging and distribution) and access to distribution facilities to independent operators and large corporations. These bulk liquids include fuel-based products used for energy and transport functions throughout NSW. Vopak operates two bulk liquid storage terminals in Port Botany, approximately 13 km south of the Sydney CBD. The first is known as the Site A Terminal and is located at 49 Friendship Road. The second facility, known as the Site B Terminal, is located at 20 Friendship Road. Site A stores chemicals and Site B stores petroleum products. Vopak is proposing to obtain approval for the construction and operation of a second Bulk Liquids Berth (BLB2) at Port Botany, NSW on behalf of Sydney Ports Corporation (SPC).

The existing Bulk Liquids Berth (BLB1) is owned and managed by SPC. As with BLB1, BLB2 will be an open access/common user facility for the use of all potential bulk liquids customers. In order to minimise the duplication of facilities between BLB1 and BLB2, the proposal for BLB2 will augment existing BLB1 infrastructure for access control, administration and port officers accommodation, together with a new berth structure and ancillaries (user pipelines, fire protection system, hose handling gantries, berthing and mooring equipment).

BLB2 development would take place adjacent to SPC land at the privately accessed Fishburn Road side (western) of the Site B Terminal, adjacent to the boundary with the Elgas Caverns.

Aspects of the BLB2 proposal consist of the following main elements:

- Central working platform providing a work area, with berthing face (including bollards and fenders) and pipe manifold/ marine loading arm (MLA) arrangements;
- Adjacent berthing dolphins on each side of working platform designed to accommodate up to the maximum length vessel;
- Two mooring dolphins on each side of the working platform (four in total). Mooring dolphins would be required on the northern side of the working platform, instead of the existing land based mooring point arrangement used for the BLB1 due to the geometry of the existing shoreline.
- Walkways (catwalks) connecting the dolphins and working platform;
- An access bridge structure connecting the working platform with the shore and providing for vehicle access and pipeline support structures;
- Support infrastructure including fire control facilities (pumps, foam/water monitors and associated tanks, gatehouse and amenities (the need for a gatehouse is dependant on site security arrangement); and

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- Berth fitout, including fire fighting monitors, services such as water, sewer, electrical and communications, amenities and blastproof Operator Shelter.

1.2 Study Objectives

The objective of this air quality study is to review existing air quality in the Port Botany area and to provide an assessment of the likely impacts on air quality during construction and operation of the proposed BLB2. To achieve these objectives the following tasks have been undertaken:

- A review of air quality issues relevant to the construction and operation of the proposed BLB2;
- An outline of the ambient air quality objectives relevant to the project;
- Description of prevailing meteorology and existing air quality in the Port Botany area;
- Quantification of emissions and assessment of air quality impacts once the BLB2 becomes operational; and
- Provision of general recommendations for the mitigation of any adverse air quality impacts.



2. Air Quality Issues

2.1 Overview

This section of the report provides a summary of the characteristics and health effects of pollutants associated with shipping and port operations.

2.2 Project Air Quality Issues

The main air pollutants emitted due to ship activities are nitrogen oxides (NO_x), sulphur dioxide (SO₂), carbon monoxide (CO) and particulates. Emissions of sulphur oxides (SO_x) from shipping due to combustion of marine fuels with high sulphur content contribute to air pollution in the form of sulphur dioxide and particulate matter. Volatile organic compounds are also generated during loading operations, these are addressed in the report but considered minimal.

Construction emissions are considered localised and minimal, predominantly comprising particulate dust emissions. Construction emissions are considered qualitatively in **Section 6**.

2.3 Air Quality Effects

2.3.1 Oxides of Nitrogen

The production of NO_x occurs in most combustion processes due to the oxidation of nitrogen in fuel and air. A number of nitrogen oxides are formed including nitric acid (NO) and NO₂. Generally at the point of emission NO to NO₂ ratio is 90:10 by volume of NO_x. Ultimately all the NO emitted into the atmosphere is oxidised to NO₂ and to other oxides of nitrogen. The rate at which this conversion occurs depends on a number of factors including temperature, topography, local meteorological circulation patterns, the presence of an inversion, and the presence of ozone. This conversion rate is important because the rate of conversion can affect ground level concentrations of NO₂.

2.3.2 Ozone

Ozone is a secondary pollutant, formed by a complex series of chemical reactions between NO_x and reactive organic compounds in the presence of sunlight. Ozone is a major constituent of photochemical smog. As such ozone is an accepted indicator of smog level.

2.3.3 Sulphur Dioxide

SO₂ is generated during the combustion process of fuels containing sulphur, e.g. coal, oil or diesel. Emissions of SO₂ in the metropolitan area are generally low, with emission sources including petroleum refining, chemical manufacturing, shipping and motor vehicles.



2.3.4 Air Borne Particulate Matter

Air borne particulate matter is any material, except uncombined water, that exists in a solid or liquid state in the atmosphere or gas stream at standard condition. Air borne particles generally range in size from 0.001-500µm, with the bulk of the particulate mass in the atmosphere ranging from 0.1-10 µm.

Common size related terms are the classes Total Suspended Particulate Matter (TSP) and PM₁₀. TSP refers to the concentration of all particles in the atmosphere, while PM₁₀ refers to all particles with aerodynamic sizes less than 10 µm. Particulate matter is generated by industry, motor vehicles, refuse disposal, ocean salt, volcanic ash, products of wind erosion, roadway dust, bush fires and plant pollen and seed.

2.3.5 VOCs

Benzene, toluene, ethylbenzene and xylenes are among a wide range of toxic organic compounds that typically exist in relatively low concentrations in ambient air. They are of concern because of their potentially significant effects on the health of humans and the environment at low concentrations that may be found in the ambient environment.

Air toxics are emitted from a wide range of sources including combustion sources such as vehicle engines, coal fired power plants, incinerators, industry, domestic solid fuel heaters, cigarette smoking, and bushfires. Non-combustion sources includes industry, vehicle fuels, cleaning products, paints and solvents.

2.4 Health Effects Associated with Various Air Pollutants

A summary of health hazards associated with the pollutants emitted or produced as a result of the emissions from ships are listed in **Table 2-1**.

■ **Table 2-1: Health hazards from air pollutants associated with the port activities**

Pollutant	Health Effect
Oxides of Nitrogen	Can contribute to problems with heart and lungs; links to decreased resistance to infection. Has harmful effects on plants by decreasing the rate of photosynthesis.
Ozone	Coughing and wheezing, eye irritation, respiratory problems (particularly for those with conditions such as asthma). Has harmful effects on plants, and damages materials and textiles.
Sulphur Dioxide	Effects include respiratory problems, illness and cardiovascular disease, with asthma sufferers or people with chronic lung or heart disease being the most susceptible. At high levels it may result in the burning of the nose and throat. It also can damage trees and crops, and can be a precursor to acid rain.
Particulate Matter	Particulate enhances chemical reactions in the atmosphere, reduces visibility, increases the possibility of precipitation, fog and clouds and reduces solar radiation. Particulate matter also represents a health hazard to the lungs.
VOCs	Eye irritation; respiratory problems; some compounds are carcinogens.



3. Local Environmental Setting

3.1 Overview

This section of the report provides a description of the geography and topography of the surrounding area, as well as a study of the meteorological and air quality conditions in the Port Botany area.

3.2 Local Setting

The BLB2 site would be located on the southern side of the port area at Port Botany. Sydney (Kingsford Smith) Airport is located north-west of the port, with the Parallel Runway situated 1 km due west of the Patrick Terminal. The proposed BLB2 would be situated to the south of the existing BLB1 (refer to **Figure 3-1**).

■ Figure 3-1: Location of the Proposed BLB2 at Port Botany





Botany Bay is located on the eastern fringe of the Sydney Basin, with the Sydney Central Business District (CBD) located approximately 11 km north of the Port. The location lends itself to morning westerly winds (particularly during the cooler months) associated with morning drainage flows from the higher regions west of Sydney and across Parramatta. In the afternoon, winds reflect the sea breeze, and come on shore.

The local topography is generally flat with surrounding suburban areas rising to 20-30 m above sea level. There is however, an elevated area at the northern head of Botany Bay, with relatively sharp land inclination rising up to the NSW Golf Club. There are some small coastal cliffs with slight elevation in land around Little Bay, Tupia Head and Boora Point, which may provide some protection from off-shore winds heading to the site from the east and south-east.

3.3 Local Land Use

The predominant land use in the vicinity of the port facilities is the Sydney (Kingsford Smith) Airport located within 5 km from the Port. The Botany Freight Rail line is located to the north and north-east of the proposed development area. Botany Road (a major arterial road) passes the rail line at the Beauchamp Road intersection at the north-east of the existing Patrick Terminal.

The major land use of the northern Botany Bay region around Banksmeadow and Matraville is predominantly industrial. The main industries within this area are:

- Orica Australia, Banksmeadow;
- Amcor Paper Mill, Botany;
- BP Oil Terminal, Botany;
- Exxon Mobil Oil Terminal, Botany;
- Caltex Terminal, Banksmeadow;
- Metal Recyclers;
- A.C Hatrick;
- Johnson & Johnson;
- Kelloggs;
- Port-Air Industrial Estate, Botany; and
- Caltex Refineries, Kurnell (southern shore of Botany Bay), and associated wharf/shipping operations.



Other land uses within the area include:

- Commercial - mainly along the western shores of the Bay around Brighton Le Sands; and
- Recreational - such as fishing (including beach fishing), picnicking, sight-seeing and bird watching in the reserves around Phillip Bay and the Botany Bay National Park on the north head, boating, swimming, golf courses, water sports, and cycling.

There are also residential areas around Port Botany. The suburb of Botany is located closest to the Port, located 0.5-1 km to the north. East Botany is approximately 2.5 km to the north of the port. Approximately 2.5 km to the east of the site, and extending to the coast, is a relatively large residential area consisting of Hillsdale, Matraville and Maroubra. This area is approximately 2.5 km from the proposed development area.

Sensitive receivers such as schools, hospitals, and sensitive populations within residential areas include:

- Banksmeadow Primary School (800 m north);
- Botany Nursing Home (1.2 km north-west);
- Matraville Primary School (1.8 km north-east);
- Chifley Public School (2.5 km east);
- St Agnes Primary School, Matraville (2.6 km east-north-east);
- Matraville High School (2.7 km east);
- Matraville Soldiers' Settlement Public School, Matraville (2.8 km east-north-east);
- Botany Primary School (2.8 km north-west);
- St Spyridon High School, Matraville (2.9 km east);
- Malabar Primary School (3 km east);
- Long Bay Correctional Centre, Malabar (3 km east-south-east);
- La Perouse Primary School (3.2 km south-east);
- University of NSW, Chifley campus (3.4 km south-east); and
- Prince Henry (The Coast) Hospital and Primary School, Little Bay (3.5 km south east).



3.4 Climatology and Dispersion Meteorology

The Bureau of Meteorology (BoM) operates an Automatic Weather Station (AWS) at Sydney Airport (Kingsford Smith) (BoM station ID 066037). It is located at 33°56' S, 151°10' E and at an elevation of 6 m. The following sections provide a summary of the climatic conditions recorded at this station since 1929, with a summary table provided in **Table 3-1**.

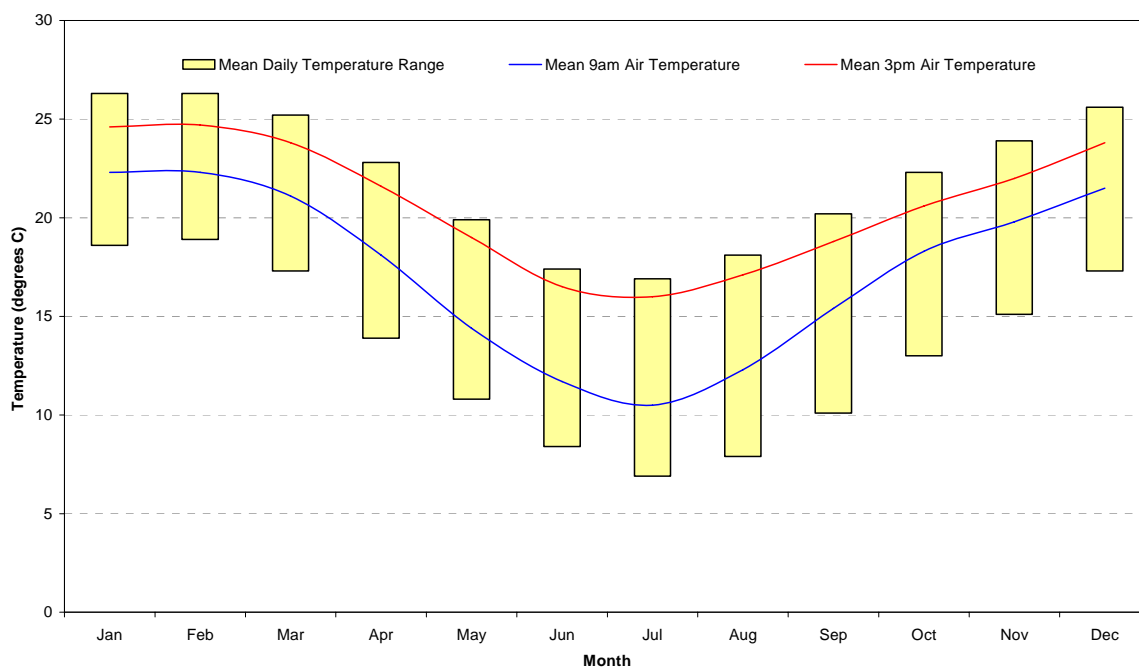
3.4.1 Temperature

The BoM has recorded temperature at Sydney Airport over a period of at least 65 years. As shown in **Figure 3-2** the Botany area experiences a warm to mild climate with quite a mild range in temperatures throughout the year.

The 9am mean daily temperature range between 22.3°C in January to 10.5°C in July. The 3pm mean temperature range is between 24.7°C in February and 16.0°C in July. Overall, the warmest months of the year are January and February, which receive mean daily maximum temperatures of 26.3°C.

July is the coolest month, experiencing a mean daily maximum temperature of 16.9°C. These daily temperature ranges are indicative of a relatively mild climatic conditions experienced within the Botany area.

■ Figure 3-2: Mean Monthly Temperature at Sydney Airport

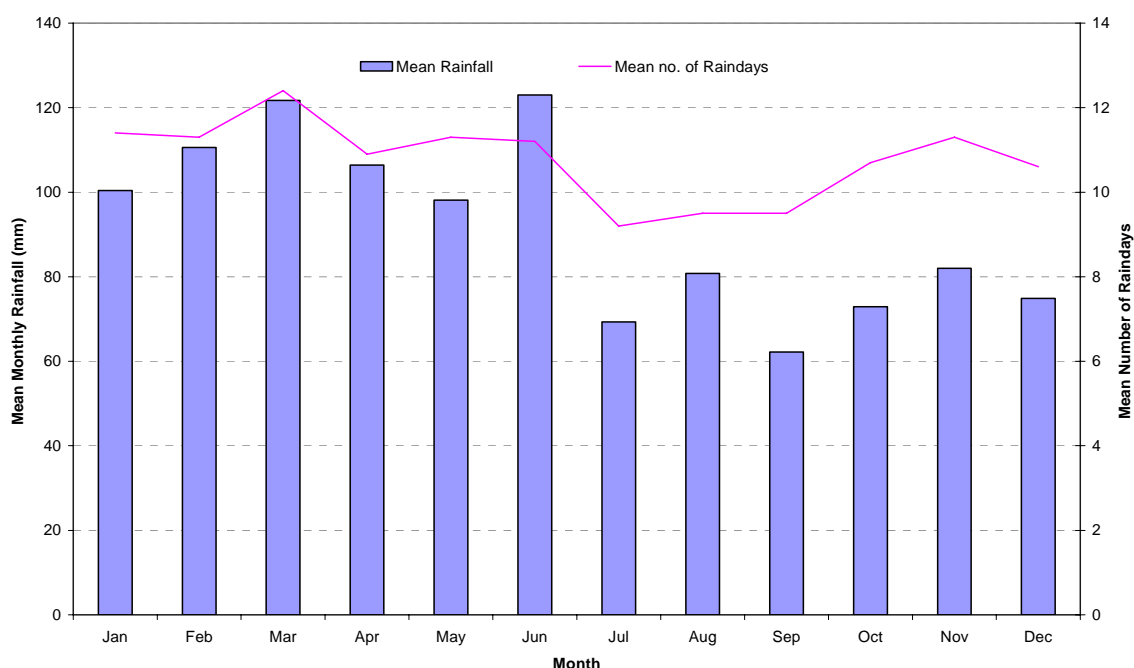




3.4.2 Rainfall

The rainfall data presented in **Figure 3-3** shows that the Botany area experiences a mild seasonal variation in the distribution of rain, with most rain falling during the late summer and autumn months. The mean annual rainfall at Sydney Airport is approximately 1,106 mm, which occurs over an average of approximately 129 days. The driest month is September, which receives a mean monthly rainfall of 62 mm. The wettest months of the year are March and June, receiving 122 mm and 123 mm respectively. Rain typically falls on at least 9 days per month throughout the year, with the highest number of rain days (12) occurring during March.

■ **Figure 3-3: Mean Monthly Rainfall at Sydney Airport**

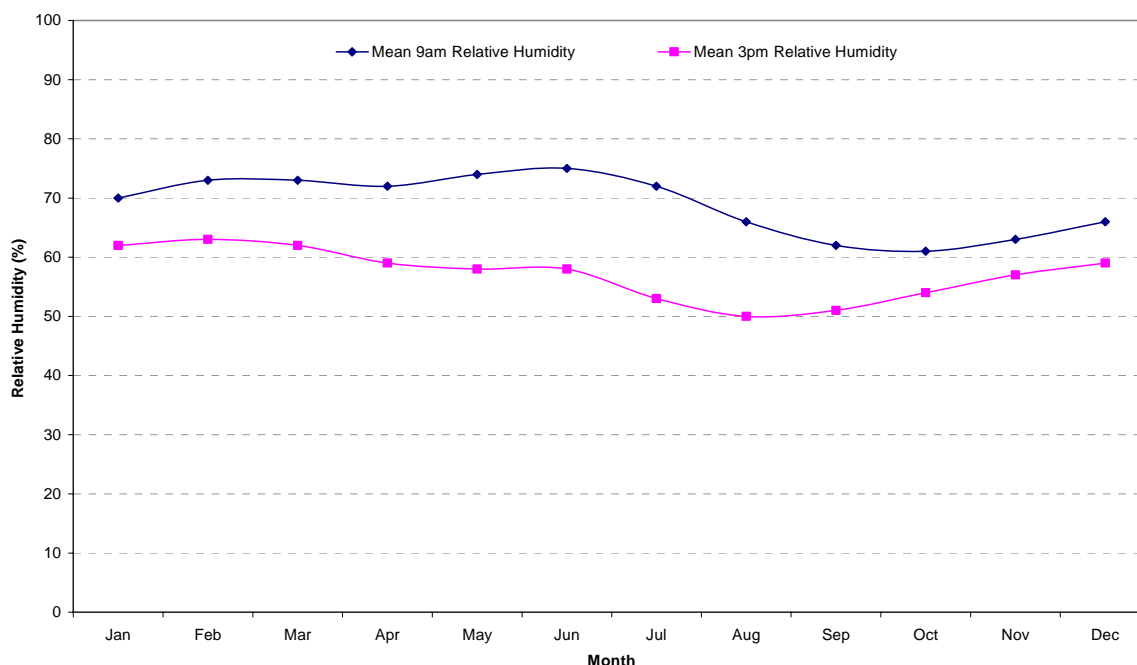


3.4.3 Relative Humidity

The 9am and 3pm relative humidity readings recorded at Sydney Airport are shown in **Figure 3-4**. Relative humidity varies on both a daily and seasonal cycle. At 9am humidity is highest during the cooler months from April to July. The annual range in 9am humidity is between 75% in June to 61% in October. The 3pm relative humidity readings are typically lower than the 9am values, and are generally greatest during the warmer summer months. The 3pm readings range between 63% in February to 50% in August.



■ **Figure 3-4: Mean Monthly Relative Humidity at Sydney Airport**



3.4.4 Wind Speed and Direction

A description of wind speed and direction is provided in windroses generated from data collected at the Sydney Airport station since 1939. The 9am windroses are presented in **Figure 3-5** and the 3pm windroses are in **Figure 3-6**.

Summer 9am winds are predominantly from the south (approximately 27% occurrence), however a full range of directions can be experienced. By mid afternoon (as seen from the 3pm windroses) winds tend to move to more easterly directions.

Late autumn and winter 9am windroses show a very high percentage of winds from the west (35% in July) and north-west (40%), with afternoon winds coming from a variety of directions but predominantly from the south to west. There are some afternoon winds that begin to come from the north-east by late winter.

The percentage of winds from the north-east during the afternoon increases to approximately 27% in spring, and then by summer this direction represents the highest percentage of wind directions during the afternoon.

Afternoon winds during autumn are from the north-east through to the south, with only a very small percentage of winds blowing from westerly directions. By late autumn, afternoon wind



directions from these westerly (and other) directions increase in percentage occurrence, however winds from the south still dominate.

During winter, afternoon winds are generally either from the south or west, however winds from all directions are often experienced.

Wind speeds are greatest during spring, with the highest monthly mean 9am wind speed occurring during October of 4.4 m/s. November and December experience the highest mean 3pm wind speed, being 6.8 m/s. For all months of the year, wind speeds are lower in the morning, and then pick up in speed by the afternoon. This is as expected with air differentials increasing throughout the day due to heating of the land surface.

3.4.5 Meteorological Data used in Modelling

The BoM AWS at Sydney Airport is located 5 km north-west of the study area. The study site is in a similar topographical and geographical location as Sydney Airport. Both sites are located on the northern shoreline of Botany Bay. As such, the meteorological conditions experienced at Sydney Airport can be used to sufficiently describe the conditions expected at the proposed BLB2.

Meteorological data used in dispersion modelling has been obtained from the BoM, generated from data collected at Sydney Airport for the period January to December 2000.

The seasonal 9am and 3pm windroses 2000 are shown in **Figure 3-7** and **Figure 3-8** respectively. Analysis of the windroses indicate that the 2000 meteorological data collected at Sydney Airport generally compares well with the longer-term data. Summer 9am winds during 2000 showed 31% of all winds were from the south to south-east, comparing to similar proportions for the longer-term windroses. Autumn 9am winds are comparable, except that the high proportion of southerlies evident during March (long-term) did not occur to the same extent in 2000. Winter 9am and spring winds correlate well with the longer term conditions, although the high proportion of 9am winds from the north-north-east during spring 2000 are not experienced to the same extent under normal spring conditions.

Seasonal 3pm windroses plotted from 2000 conditions correlate very well with the longer-term conditions, except that the longer-term spring windrose shows an approximate 18% occurrence of southerly winds for all spring months that only represent 4.4% occurrence during 2000.

The 2000 windroses are generally a very good representative of longer-term meteorological conditions expected at Sydney Airport and Port Botany. As such, the use of the 2000 data is sufficient for the purpose of undertaking the air dispersion modelling and impact assessment.

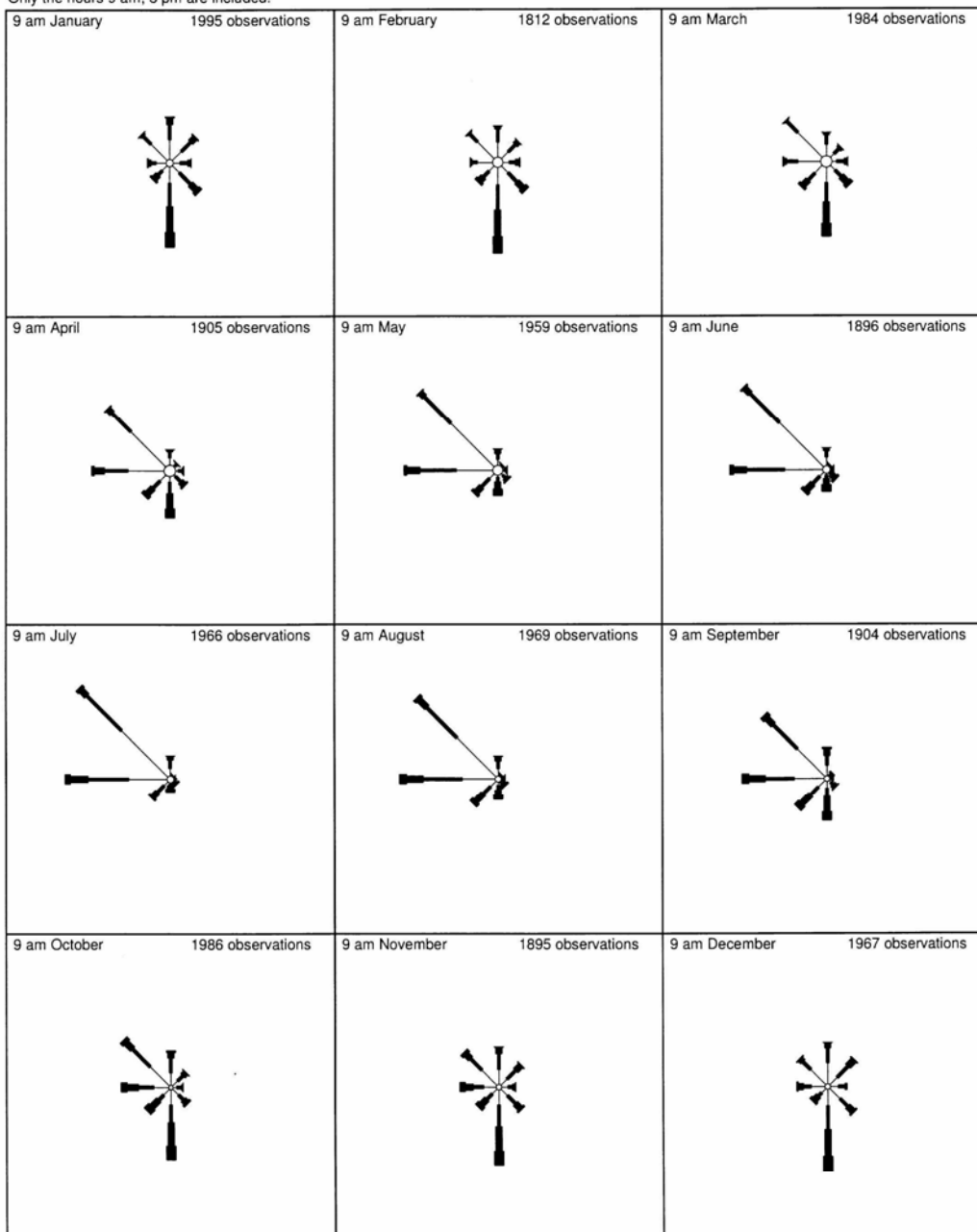
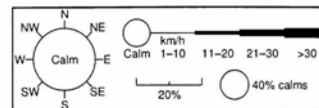


■ **Figure 3-5: Long Term 9am Windroses for Sydney Airport**

Wind Roses using available data between 1939 and 2002 for Sydney Airport AMO

Site Number 066037 • Locality: Sydney Airport • Opened Jan 1929 • Still Open
 Latitude 33°56'28"S • Longitude 151°10'21"E • Elevation 6m

Only the hours 9 am, 3 pm are included.



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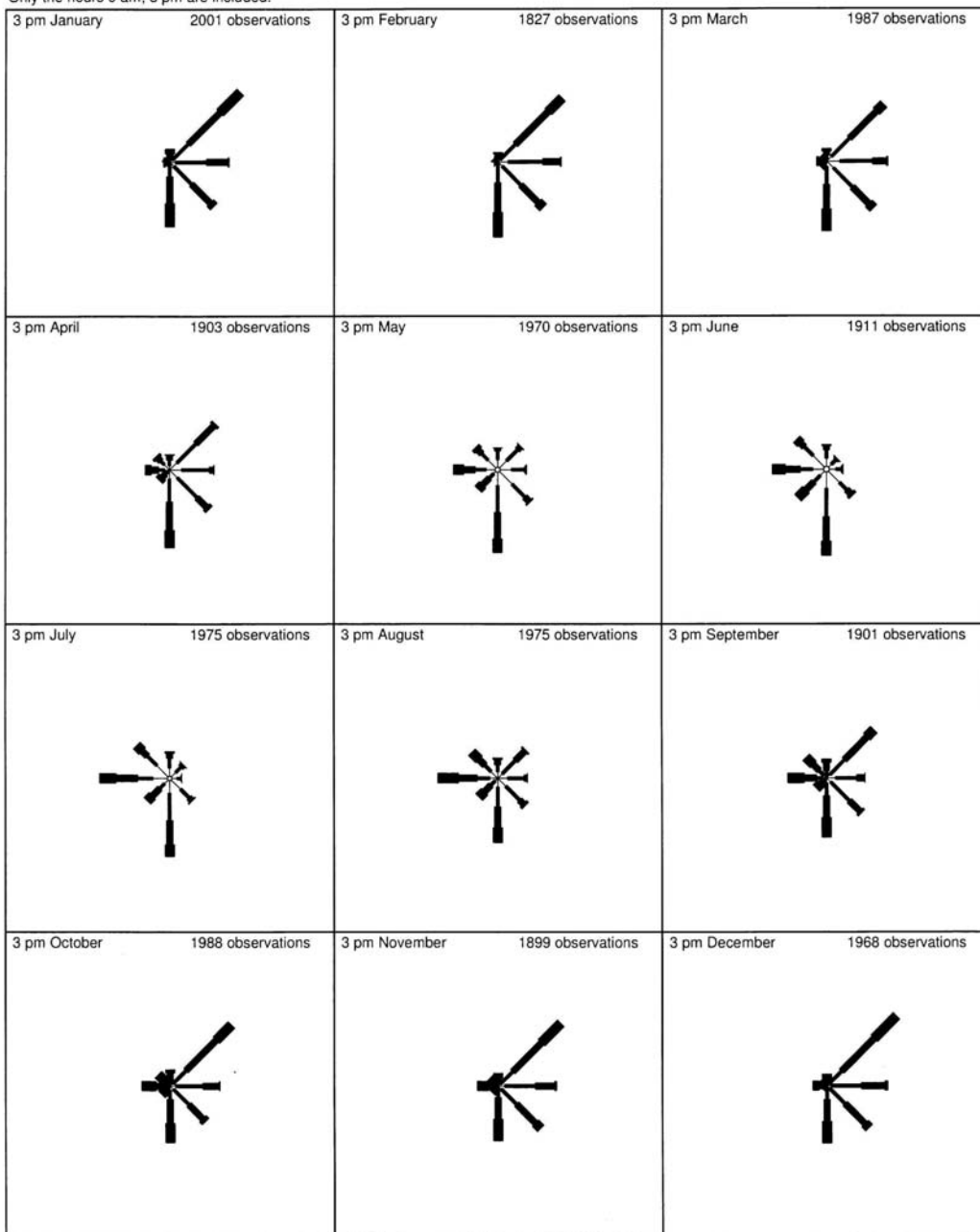
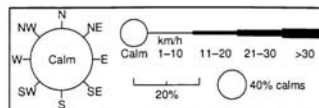


■ **Figure 3-6: Long Term 3pm Wind Roses for Sydney Airport**

Wind Roses using available data between 1939 and 2002 for Sydney Airport AMO

Site Number 066037 • Locality: Sydney Airport • Opened Jan 1929 • Still Open
 Latitude 33°56'28"S • Longitude 151°10'21"E • Elevation 6m

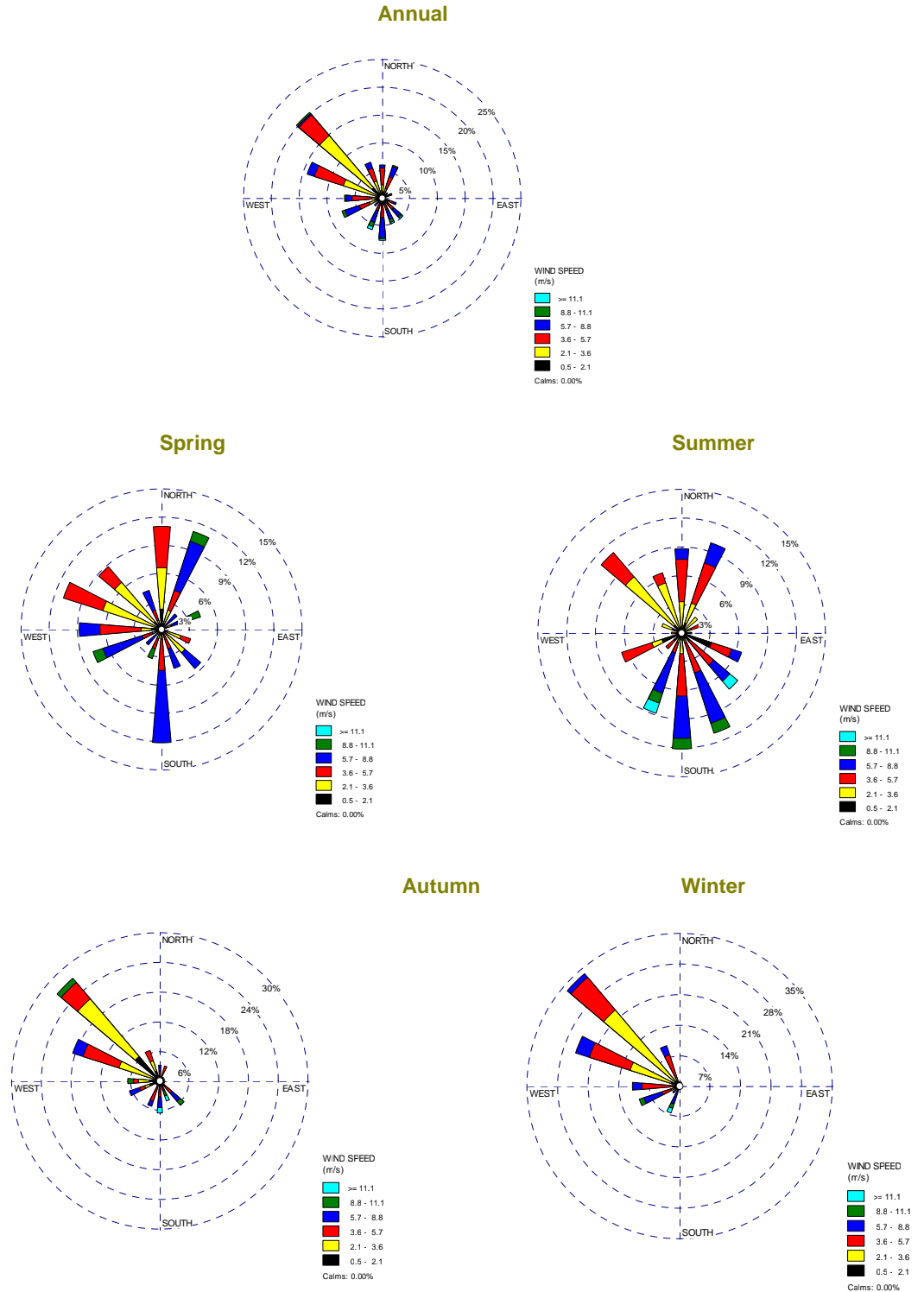
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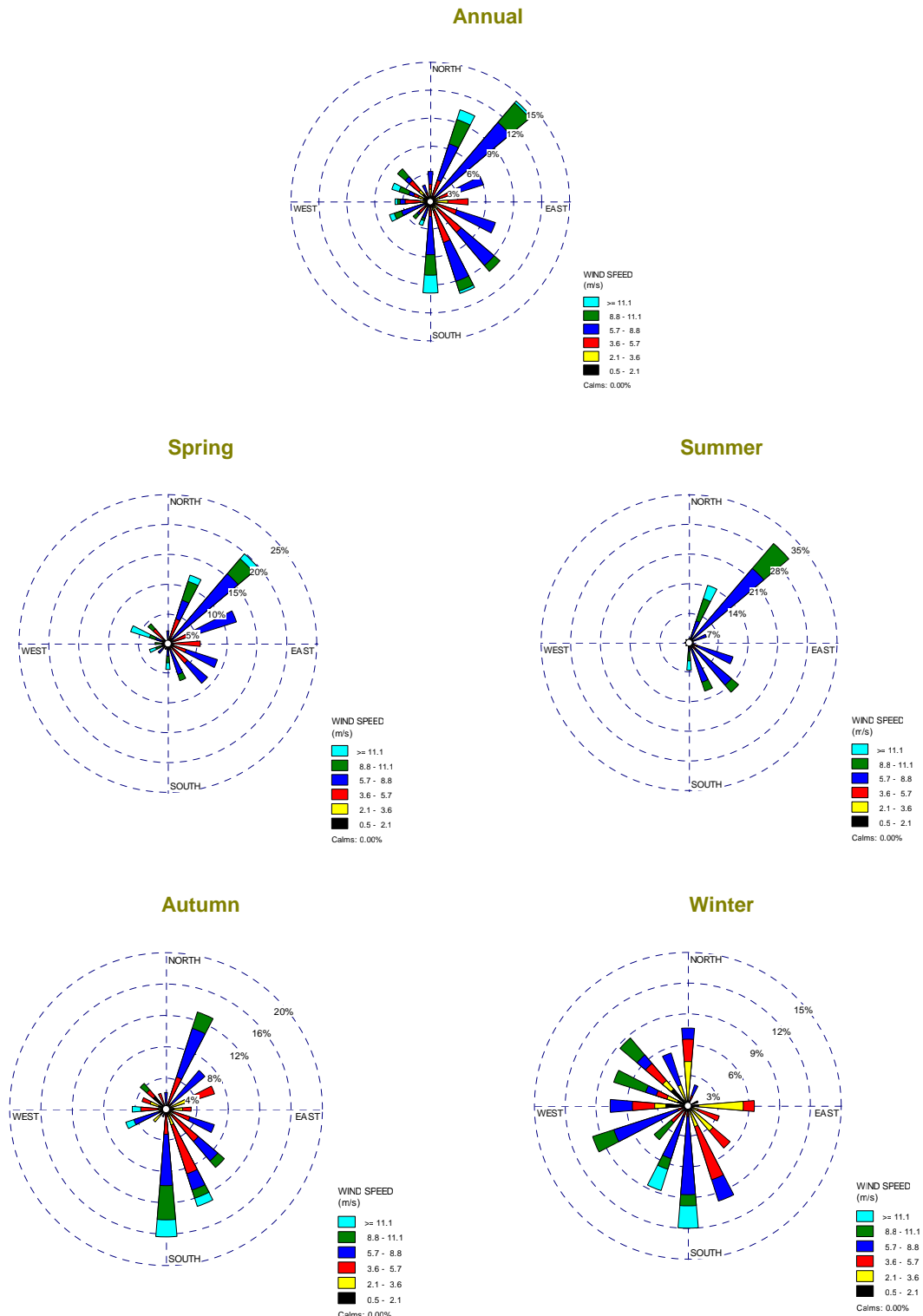


■ Figure 3-7: Annual and Seasonal 9am Windroses for Sydney Airport (2000)





■ **Figure 3-8: Annual and Seasonal 9am Windroses for Sydney Airport (2000)**



■ **Table 3-1: Climate Summary for Sydney Airport**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean Daily Max Temp (°C)	26.3	26.3	25.2	22.8	19.9	17.4	16.9	18.1	20.2	22.3	23.9	25.6	22.1
Highest Max Temp (°C)	43	42.6	41.2	35.7	30	26.8	26.7	31.1	35.6	38.2	43.4	43.2	43.4
Mean Daily Min Temp (°C)	18.6	18.9	17.3	13.9	10.8	8.4	6.9	7.9	10.1	13	15.1	17.3	13.2
Lowest Min Temp (°C)	9.7	11.2	7.4	6.1	3	1	-0.1	1.2	2.3	4.8	5.9	8.2	-0.1
Mean 9am Air Temp (°C)	22.3	22.3	21.1	18.1	14.4	11.7	10.5	12.3	15.4	18.3	19.8	21.5	17.3
Mean 9am Dew Point Temperature (°C)	16.2	16.9	15.8	12.6	9.6	7.2	5.4	5.8	7.7	10.2	12.1	14.6	11.2
Mean 9am Relative Humidity (%)	70	73	73	72	74	75	72	66	62	61	63	66	69
Mean 9am Wind Speed (m/s)	3.9	3.7	3.5	3.4	3.3	3.5	3.5	3.8	4.1	4.4	4.3	4	3.8
Mean 3pm Air Temp (°C)	24.6	24.7	23.8	21.6	19	16.5	16	17.1	18.8	20.6	22	23.8	20.7
Mean 3pm Dew Point Temp (°C)	16.2	16.7	15.5	12.6	9.9	7.6	5.6	5.6	7.5	9.9	12.1	14.4	11.1
Mean 3pm Relative Humidity (%)	62	63	62	59	58	58	53	50	51	54	57	59	57
Mean 3pm Wind Speed (m/s)	6.5	6.2	5.8	5.1	4.5	4.8	4.9	5.6	6.2	6.6	6.8	6.8	5.8
Mean Rainfall (mm)	100.4	110.6	121.7	106.4	98.1	123	69.3	80.8	62.2	72.9	82	74.9	1102.4
Mean no. of Raindays	11.4	11.3	12.4	10.9	11.3	11.2	9.2	9.5	9.5	10.7	11.3	10.6	129.4
Highest Monthly Rainfall (mm)	400.4	596.9	393	476.2	421.7	465.9	253.7	387.8	249.4	271.3	396.1	359.2	-
Lowest Monthly Rainfall (mm)	5.4	2.5	6.4	8	2.9	2.5	0	0.2	1.6	0	5.7	4.8	-
Highest Daily Recorded Rain (mm)	157	216.2	202	174	165.9	151.2	132.6	207	115.4	112.3	143.3	182.1	216.2
Mean no. of Clear Days	6.5	5.7	7.6	8.8	8.8	8.9	11.9	13	10.8	7.9	6.2	6.3	102.4
Mean no. of Cloudy Days	13.4	12.2	12.2	10.6	11.2	10.8	8.4	8	8.6	11.3	11.7	12.4	130.7
Mean Daily Evaporation (mm)	7.1	6.5	5.3	4.1	2.9	2.5	2.7	3.7	4.7	5.7	6.5	7.4	4.9
Mean Daily Sunshine (hrs)	7.4	7.3	6.9	6.8	5.8	5.9	6.6	7.8	7.8	7.9	7.7	8	7.2
Maximum Wind Gust (km/hr)	151.9	107.6	127.8	122.4	129.6	129.6	109.4	114.8	111.2	126	151.9	126	151.9

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3.5 Existing Air Quality

Air quality within the area surrounding Port Botany is influenced by both local and regional pollutant sources, including road traffic, domestic sources, aircraft and a variety of industrial emissions. The proximity to local pollutant sources and the influence of sea breezes play significant roles in the dispersion of pollutants around Botany Bay.

As part of the NSW DECC's air quality monitoring network, PM₁₀ (1-hour, TEOM), SO₂ (1-hour), ozone (1-hour) and NO₂ (1-hour) are monitored at Randwick station, located approximately 5.3 km north-east of Port Botany at the Randwick Barracks.

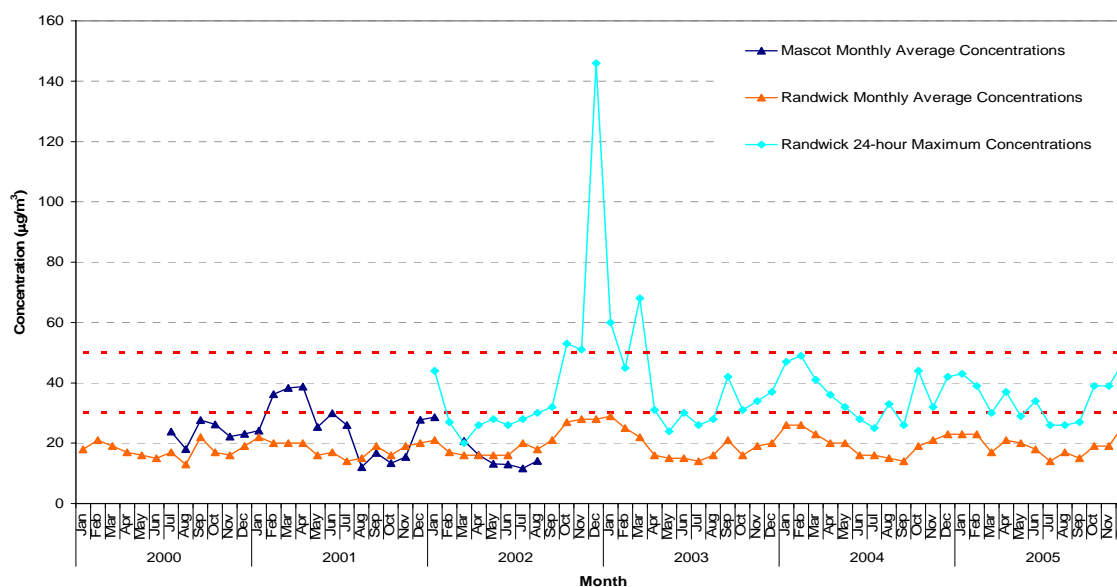
An AQMS is also located at Sydney Airport located approximately 4.9 km to the north west of the site. The site monitors a number of air pollutants including PM₁₀ (1-hour, TEOM), SO₂ (1-hour), ozone (1-hour) and NO₂ (1-hour). VOCs are not monitored at either station.

3.5.1 Particulate Matter

Maximum 24-hour and monthly average PM₁₀ concentrations are presented graphically in **Figure 3-9**. Generally higher concentrations of particulate matter are experienced during the summer months, often due to the hot dry conditions which leads to airborne dust. In particular, the annual average DECC criteria of 30 µg/m³ is reached at the Randwick site during the October to January 2002/2003 reflecting bushfire smoke from fires in the Sydney as well as Canberra region.

Mean monthly concentrations are similar between the two sites, with the exception being February, March and April 2001 where much higher PM₁₀ concentrations were recorded at the Mascot site.

■ **Figure 3-9: Maximum 24-hour and Mean Monthly PM₁₀ Concentrations**

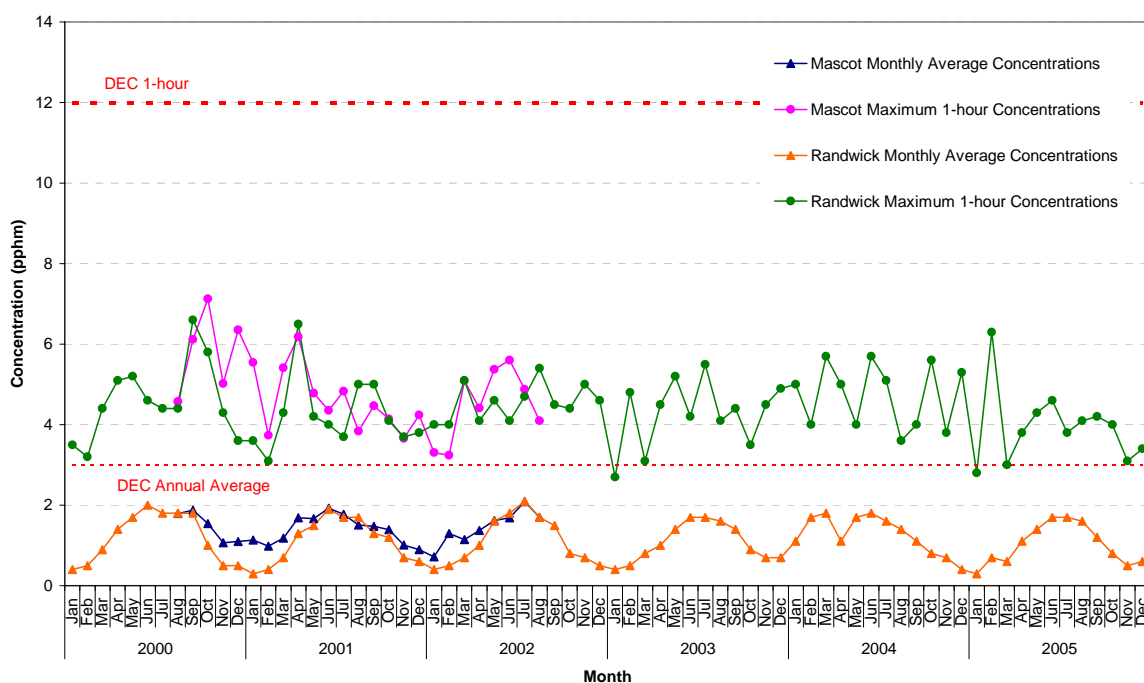




3.5.2 Nitrogen Dioxide

Mean monthly average and maximum 1-hour NO₂ concentrations are displayed graphically in **Figure 3-10**. Here it can be seen that mean monthly NO₂ concentrations vary on a seasonal basis, with higher NO₂ concentrations being recorded during the warmer months of the year. Maximum 1-hour concentrations are well below the DECC criteria of 12 pphm at both sites. Mean monthly average concentrations and maximum 1-hour concentrations are similar at both sites and are also below the relevant DECC criteria.

■ **Figure 3-10: Maximum 1-hour and Mean Monthly NO₂ Concentrations**



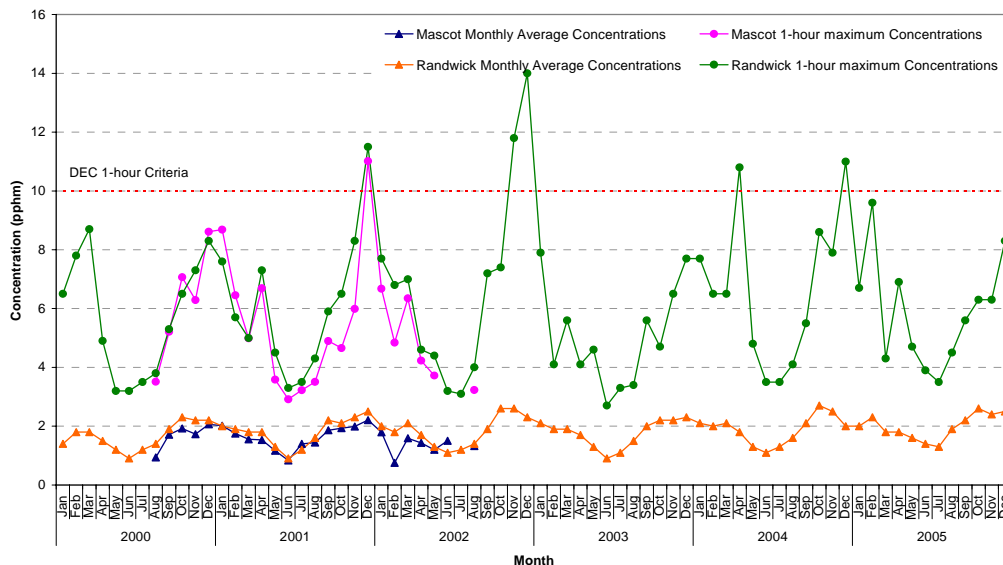
3.5.3 Ozone

Mean monthly ozone concentrations are displayed graphically in **Figure 3-11**. Ozone concentrations vary on a seasonal basis, with higher concentrations being recorded during the warmer months of the year.

Maximum 1-hour ozone concentrations at both sites are generally below the DECC criteria of 10 pphm. However, exceedances were recorded at both sites between 2000 and 2005. These were up to 14 pphm at Randwick, and 11 pphm at Sydney Airport.



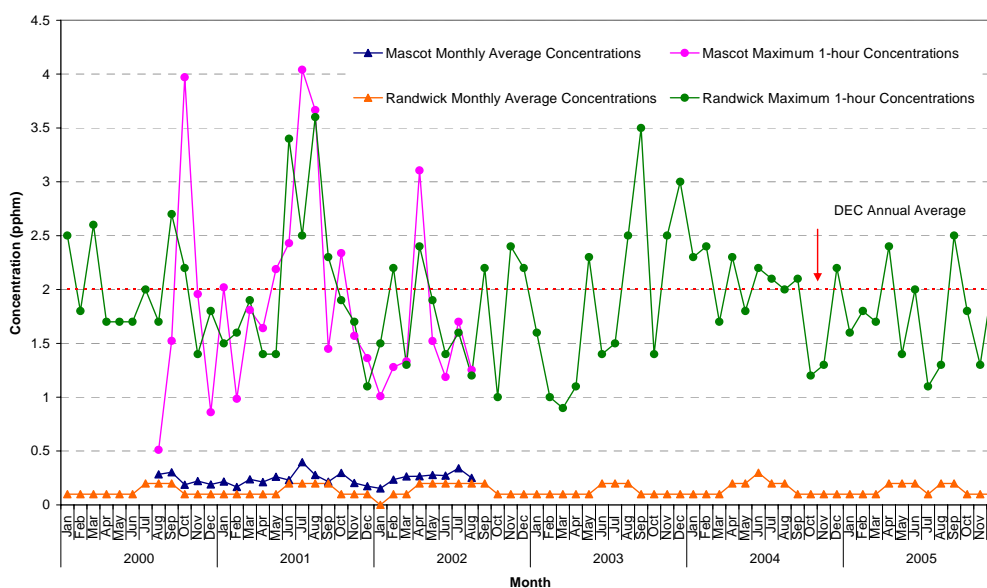
■ **Figure 3-11: Maximum 1-hour and Mean Monthly O₃ Concentrations**



3.5.4 Sulphur Dioxide

Mean monthly and maximum 1-hour SO₂ concentrations recorded at Randwick and Sydney Airport are presented graphically in **Figure 3-12**. Mean monthly average concentrations are well below the annual average DECC criteria of 2 pphm. Maximum 1-hour concentrations are also well below the DECC criteria of 20 pphm.

■ **Figure 3-12: Maximum 1-hour and Mean Monthly SO₂ Concentrations**





A summary of background data for Randwick is provided in **Table 3-2**.

■ **Table 3-2: Summary of Background Air Quality Monitoring Data (bold represent exceedances)**

Pollutant	Ave Period	2000		2001		2002		2003		2004		2005	
		µg/m ³	pphm	µg/m ³	pphm	µg/m ³	pphm	µg/m ³	pphm	µg/m ³	pphm	µg/m ³	pphm
Randwick													
PM ₁₀	24-hour	-	-	-	-	146	-	68	-	49	-	47	-
	Annual	18	-	18	-	20	-	19	-	20	-	19	-
NO ₂	1-hour	124	6.6	122	6.5	102	5.4	103	5.5	107	5.7	118	6.3
	Annual	23	1.2	21	1.1	21	1.1	21	1.1	24	1.3	19	1.0
SO ₂	1-hour	71	2.7	94	3.6	63	2.4	92	3.5	63	2.4	65	2.5
	24hour	-	-	-	-	13	0.5	18	0.7	18	0.7	16	0.6
	Annual	3	0.1	3	0.1	3	0.1	3	0.1	5	0.2	3	0.1
Ozone	1-hour	171	8.7	226	11.5	275	14	155	7.9	216	11	188	9.6
	4-hour	-	-	-	-	239	12.2	139	7.1	165	8.4	151	7.7

Overall it was considered that use of the local Sydney Airport air monitoring data for this study would be representative of the background air quality in the Port Botany area, and is comparable to the NSW DECC monitoring data.



4. Air Quality Criteria

4.1 Overview

This section of the report outlines the relevant air quality criteria as described by the Department of Environment and Climate Change (DECC) in their *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in New South Wales* (2005). Emission standards which are relevant to shipping are also discussed.

4.2 Ambient Air Quality Objectives

The DECC regulates air quality objectives in NSW to ensure that air quality is maintained at an acceptable level for health and the environment. Air quality impact assessment criteria quoted below have been sourced from the DECC publication - *Approved Methods and Guidance for the Modelling of Air Pollutants in New South Wales* (DECC, 2005).

The key air emissions relating to this project that have potential to impact on the local environment are from ship exhausts including fine particulate matter, NO_x and SO₂. Emissions of volatile organic compounds (VOCs) may also be emitted when liquids are being discharged. Air quality objectives relevant to the project are provided in **Table 4-1**.

■ **Table 4-1: Ground Level Impact Assessment Criteria (DECC, 2005)**

Pollutant	Averaging Period	Concentration (pphm)	Concentration (µg/m ³)
Sulphur Dioxide	10 minutes	25	712
	1 hour	20	570
	24 hours	8	228
	Annual	2	60
Nitrogen Dioxide	1 hour	12	246
	Annual	3	62
PM ₁₀	24 hours	50	50
	Annual	30	30
TSP	Annual	90	90
		ppm	mg/m³
Benzene	1 hour	0.009	0.029
Toluene	1 hour	0.09	0.36
Ethylbenzene	1 hour	1.8	8
Xylenes	1 hour	0.04	0.19

It should be noted that this criteria refers to the total impact from all sources in the area i.e. emissions from the port as well as emission from motor vehicles, airport activities and other industry.



4.3 Ship Emission Standards

The *Protection of the Environment Operations (Clean Air) Regulation 2002* (POEO) replaces the *Clean Air (Domestic Solid Fuel Heaters) Regulation 1997*, *Clean Air (Motor Vehicles and Motor Vehicle Fuels) Regulation 1997* and *Clean Air (Plant and Equipment) Regulation 1997*.

The POEO regulation covers emissions from a variety of sources including stack emissions from power stations, industry, motor vehicle exhaust etc, but does not cover ship emissions. Ship emissions are covered in Marine Air Pollution 1973/1978 (Marpol 73/78), the International Convention for the Prevention of Pollution From Ships, and covers ship emissions for NO_x. Marpol 73/78 is one of the most important international marine environmental conventions and is designed to minimise pollution of the seas, including dumping, oil and exhaust pollution.

Annex VI, the Prevention of Air Pollution from Ships, came into force in 2005. The regulations in this annex sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances. The annex includes a global cap of 4.5% m/m on the sulphur content of fuel oil and calls on IMO to monitor the worldwide average sulphur content of fuel.

Regulation 13 of Annex VI represents the NO_x Technical Code: *Technical Code on Control of Emissions of Nitrogen Oxides from Marine Diesel Engines*. The Code applies to all engines installed on ships constructed after 1 January 2000 or engines which undergo a major conversion after 1 January 2000. Ship engines are required to operate such that NO_x emissions are within the following limits:

- 17.0 g/kWh for engines less than 130 rpm (slow speed engines);
- $45.0 * n^{-0.2}$ g/kWh, when $130 < n$ (engine rating) $< 2,000$ rpm; and
- 9.8 g/kWh for engines greater than 2,000 rpm (high speed engines).



5. Current and Proposed Activities

5.1 Current Activities at BLB1

BLB1 is located west of the P&O terminal, and is adjacent to Brotherson Dock which services the containerised import and export sector.

The three main product groups which are imported and exported at the BLB1 are:

- Hydrocarbons, such as LPG;
- Chemical products, such as organic chemicals, caustic soda; and
- Petroleum products, such as petroleum, diesel, naphtha and jet fuel.

Biodiesel products are expected to be handled in the future.

Currently BLB1 provides facilities to import products into:

- Vopak terminals Site A and Site B for petroleum and chemical products;
- Exxon Mobil terminal at Stephens Road Port Botany (“Mobil Site”) for petroleum products;
- Terminals Pty Ltd site at 43-45 Friendship Road and 11-13 Simblist Road, at Port Botany (“Terminals Site”) for petroleum and chemical products;
- Elgas Pty Ltd site at 30 Friendship Road, Port Botany (“Elgas Site”) for LPG;
- Qenos Australia Pty Ltd at 39 Friendship Road, Port Botany (“Orica Site”) for LPG; and
- Origin Energy site at 47 Friendship Road, Port Botany (“Origin Site”) for LPG.

It also provides facilities to export products from the following locations:

- Vopak Sites A and B for petroleum and chemical products;
- Exxon Mobil Site for petroleum products;
- Terminals Pty Ltd Site for chemical products;
- Elgas Pty Ltd Site for LPG;
- Origin Energy for Py-Gas and ethylene; and
- Qenos Australia Pty Ltd for LPG (small amounts).

Exports (with the exception of gas exports) currently form only a small portion of the BLB throughput. Based on time at the berth, the major products influencing the berth time are petroleum



products and LPG. The expected total import and export volumes for BLB1 for 2007-2009 are provided in **Table 5-1**.

■ **Table 5-1: BLB1 Expected Total Import and Export Volumes for 2007-2009 (kL)**

Product	2007	2008	2009
Chemicals	140,918	140,918	140,918
Gas	1,000,538	1,034,830	1,054,820
Biodiesel	65,625	112,500	288,719
Refined Petroleum	1,116,603	1,234,053	1,445,652
Total	2,323,684	2,522,301	2,930,109

5.2 Proposed Activities at BLB2

The expected volumes of chemicals, biodiesel and petroleum to pass through BLB2 up to 2022 are provided in **Table 5-2**. The respective number of ship movements at BLB2 are provided in **Table 5-3**.

■ **Table 5-2: Expected Volumes through BLB2 (kL)**

Type	2010	2011	2012	2020	2021	2022
Chemical						
DG Class 3	14 092	14 092	14 092	14 092	14 092	14 092
DG Class 6	3 523	3 523	3 523	3 523	3 523	3 523
DG Class 8	3 523	3 523	3 523	3 523	3 523	3 523
Combustibles	49 321	49 321	49 321	49 321	49 321	49 321
Total Chemical	70 459	70 459	70 459	70 459	70 459	70 459
Biodiesel						
Import	144 710	176 219	176 219	176 219	176 219	176 219
Export	0	48 780	48 780	48 780	48 780	48 780
Total Biodiesel	144 710	224 999	224 999	224 999	224 999	224 999
Petroleum						
DG Class 3	661 611	680 061	903 435	1 333 361	1 427 287	1 523 091
Combustibles	283 547	291 455	387 186	571 441	611 694	652 753
Total Petroleum	945 158	971 516	1 290 621	1 904 802	2 038 981	2 175 844
TOTAL	1,160,327	1,266,974	1,586,079	2,200,260	2,334,439	2,471,302



■ **Table 5-3: Expected Ship Arrivals at BLB2**

2010	2011	2012	2020	2021	2022
Chemical					
30	31	31	31	31	31
Biodiesel					
25	38	38	38	38	38
Petroleum					
32	35	35	61	75	79

Facilities to import/export gas are expected to come on line in 2016. The volume of gas expected to be imported/exported through BLB2 are summarised in **Table 5-4**. The number of ship arrivals associated with gas imports/exports are provided in **Table 5-5**.

■ **Table 5-4: Expected Gas Volumes for BLB2 (kL)**

Ship Type	2016	2017	2018	2020	2021	2022
Import	502 587	501 125	517 777	533 427	541 429	544 850
Export	155 975	158 315	160 690	165 546	168 029	170 550
Total	658 562	668 440	678 467	698 973	709 458	715 400

■ **Table 5-5: Expected Number of Gas Ship Arrivals**

Chemical Type	2016	2017	2018	2020	2021	2022
Import – small ship	13	14	14	14	14	15
Import – large ship	5	6	6	6	6	6
Export	39	40	40	42	42	43
Total	57	60	60	62	62	64



5.3 Future Expected Throughput for BLB1 and BLB2

Expected throughput for BLB1 and BLB2 combined are listed in **Table 5-6** and **Table 5-7**.

■ **Table 5-6: Expected Chemical, Petroleum and Biodeisel Volumes at BLB1 and BLB2 (kL)**

Type	2010	2011	2012	2020	2021	2022
Chemical						
DG Class 3	28 184	28 184	28 184	28 184	28 184	28 184
DG Class 6	7 045	7 045	7 045	7 045	7 045	7 045
DG Class 8	7 046	7 046	7 046	7 046	7 046	7 046
Combustibles	98 643	98 643	98 643	98 643	98 643	98 643
Total Chemical	140 918	140 918	140 918	140 918	140 918	140 918
Petroleum						
DG Class 3	1 102 685	1 113 435	1 290 621	2 666 722	2 854 573	3 046 182
Combustibles	472 579	485 758	553 123	1 142 881	1 223 389	1 305 506
Total Petroleum	1 575 264	1 619 193	1 843 744	3 809 603	4 077 962	4 351 688
Biodeisel						
Import	288 719	352 438	352 438	352 438	352 438	352 438
Export	0	97 560	97 560	97 560	97 560	97 560
Total Biodiesel	288 719	449 998	449 998	449 998	449 998	449 998
TOTAL	2,004,901	2,210,109	2,434,660	4,400,519	4,668,878	4,942,604

■ **Table 5-7: Expected Gas Volumes at BLB1 and BLB2 (kL)**

Type	2016	2017	2018	2020	2021	2022
Import	929 287	933 934	938 603	948 013	952 753	957 517
Export	193 014	198 804	204 768	217 239	223 756	230 469
Total	1 122 301	1 113 738	1 143 371	1 165 252	1 176 509	1 187 986



6. Construction Air Quality Impact Assessment

6.1 Overview

It is anticipated that construction of the BLB2 will take approximately 18 months for maritime structures and 12 months for users infrastructure.

Specialist over-water construction and specialist waterfront contractors would undertake the work. The type of plant required to construct BLB2 include:

- jack-up platform / barge;
- barge-mounted cranes;
- work barges;
- work boats;
- dive boats;
- mobile cranes;
- fork lifts; and
- compressors.

It is possible that both the offshore maritime work and land-based pipeline work could be undertaken concurrently as they are generally independent. Construction of the miscellaneous landbased facilities are minor and would not have a significant impact on the overall construction program.

The pipelines and MLAs would be installed after the structures are completed. This work would be no different to the landside works. To save time and difficulties associated with on site welding, field welds could be minimised by pre-assembling two pipe lengths to form 18 metre lengths that would be transported to the site and then lifted onto the pipe supports. The construction and installation phases for the pipe infrastructure has been estimated to require around 22 months in total. However, this time period is dependant on a more detailed cost estimate being prepared during design development where a closer assessment of the contracting philosophy can be made to identify the number of sub-contract groups that could be effectively used and managed during the construction period. This has a major bearing on the amount of time that would be needed to complete the construction and installation of the new pipelines.

6.2 Air Quality Impacts

Given the nature of construction works (i.e. pipe laying) impacts are expected to be minimal and localised, and there are no sensitive receivers within 1.5 km of the site. There is potential for dust



generation during excavation works, however this can be kept to a minimum by implementing the following mitigation measures:

- Stabilising earthworks as soon as possible;
- Watering earthworks in dry or windy conditions; and
- Keep vehicles to sealed roads to ensure dust is not trafficked onto public roads. If this is not possible, wheels should be washed prior to leaving the site.



7. Operational Air Quality Impact Assessment

7.1 Overview

Air quality in Port Botany is currently impacted by industry, motor vehicles, airport activities, ship movements and dock side equipment. The main air quality impact from the BLB2 would be from an increase in the number of ship visiting the port. Increases in truck movements and dockside equipment are expected to be minimal, as such are not included in the proposed development scenario.

Air dispersion modelling in this assessment builds on modelling previously conducted by SKM as part of the Port Botany Expansion air quality assessment commissioned by SPC (SKM, 2003).

7.2 Emission Estimation and Modelling Methodology

Modelling has been conducted using the AUSPLUME v6.0 dispersion model in accordance with the DECC guidelines as set out in their “*Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW*” (DECC, 2005). A meteorological file for the year 2000 has been used based on data collected by the BoM at Sydney Airport. This year was chosen as it is consistent with previous modelling undertaken for the expansion of Sydney Ports.

A variable background file for pollutants PM₁₀, NO₂ and SO₂ has been used. Hourly average data were missing from the year 2000 dataset, gaps were filled in with the corresponding hours in 2001, and similarly, some data from 2002 was used to fill in the final gaps.

VOC impacts are assessed separately in **Section 7.6**.

7.2.1 Ship Emission Estimations Technique

Ship emissions for existing and future scenarios have been determined using the *National Pollutant Inventory Emission Estimation Manual for Maritime Operations* (DEH, 2001), based on a study undertaken by Lloyd’s Register (1995). Where by emissions from the main engines were calculated using the following equation:

$$E_{\text{Main}} = 0.001 * q * P^r * N$$

Where:

E_{Main} = emissions from the main engine (kg/hr)

q = emission coefficient

r = emission coefficient

P^r = engine power (kW)

N = number of engines

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Emissions from auxiliary engines were calculated using the following equation:

$$E_{\text{Aux}} = 0.0001 * s * A^t * C$$

Where:

E_{Aux} = emissions from auxiliary engines (kg/hr)

s = emission coefficient

t = emission coefficient

A = auxiliary power (assume 600 kW for all vessels)

C = factor to account for sulphur content in fuel

Emission coefficients and sulphur fuel content correction values are provided in **Table 7-1** and **Table 7-2** respectively. All values are sourced from the *National Pollutant Inventory Emission Estimation Manual for Maritime Operations* (DEH, 2001).

■ **Table 7-1: Emission Coefficients**

Substance Emitted	Main Engines		Auxiliary Engines	
	q	r	s	t
Oxides of nitrogen	Medium - 4.25	Medium - 1.15	4.25	1.15
	Slow - 17.5	Slow - 1.00		
Carbon monoxide	Medium - 15.32	Medium - 0.68	15.32	0.68
	Slow - 0.68	Slow - 1.08		
Sulphur dioxide	Medium - 2.31 ^a	Medium - 1.00	2.36	1.00
	Slow - 11.34	Slow - 1.00		
PM ₁₀	Medium - 0.11	Medium - 1.00	0.11	1.00
	Slow - 0.93	Slow - 1.00		
VOCs	Medium - 4.86	Medium - 0.69	4.86	0.69
	Slow - 0.28	Slow - 1.00		

^a for engine <2000 kW, otherwise use 12.47

■ **Table 7-2: Sulphur Fuel Content**

Gross Tonnage of Vessel	C Correction Factor
<1000	1
1000-5000	2
5000-10000	3
10000-50000	4
>50000	5



7.2.2 Ship Inventory

An inventory of ships that visited BLB1 in 2006 has been used as an example of ships likely to visit the bulk liquid terminal in the future. Intertek recorded BLB1 berth occupancy for 2006, with information including:

- Ship name;
- Pilot;
- Time all fast;
- Time off berth; and
- Bunkers.

Further information was collected for each of the ships from the Lloyd's Register Fairplay (Register). The Register maintains a database of over 80,000 ships, including movements, casualties, vessel characteristics, owners and consultancy services. Additional information relevant to this assessment that is recorded by the register include:

- Year of build;
- Ship type;
- Dead weight;
- Gross tonnage;
- Prime mover detail; and
- Auxiliary engines.

The ship information, in particular engine size (kW), was used to estimate ship air pollution emission rates using the equations provided in **Section 7.2.1**. A summary of main and auxiliary engine parameters and emission rates for ships visiting BLB1 in 2006 are provided in **Appendix A**.

7.2.3 NO_x to NO₂ Estimation

An important consideration when assessing impacts of NO₂ is the rate at which nitric oxide (NO) is converted to NO₂, as discussed in **Section 2.3.2**. For this assessment NO to NO₂ conversion is assessed using the method of Janssen et al (1988) which is approved by the DECC methods for assessing NO₂ impacts.

NO_x is mostly emitted in the form of NO (approximately 90%), and is typically less than 10% in the form of NO₂. As the plume disperses and reacts with the surrounding atmosphere, in particular ozone (O₃), more of the NO is converted to NO₂.



Janssen et al (1988) Methodology

Janssen et al (1988) provide a relation for the development of a NO_2/NO_x ratio for each season of the year that predicts the conversion of NO_x emissions to NO_2 over a downwind distance from the source of emission. In order to be conservative, an initial 10% NO_2 is assumed at the release point. This is added to the extra NO_2 formed from oxidised NO as the plume travels downwind. As such, the following NO_2/NO_x ratios were calculated for each season of the year, and used in the dispersion modelling of operational NO_x emissions for all wind speeds:

- Summer – 0.21
- Autumn – 0.22
- Winter – 0.20
- Spring – 0.22

These ratios are predicted for a 2 km downwind distance from the source, based on the average O_3 background concentration in the Port Botany region being 1.0 – 2.5 pphm. A distance of 2 km represents a reasonable distance that encompasses nearest sensitive receivers likely to receive maximum NO_2 impacts.

The emissions inventories for each of the source group are summarised in the following sections. The emissions tables present total NO_x emissions. In the AUSPLUME modelling NO_x emission rates have been converted to NO_2 by applying the seasonal NO_2/NO_x ratios listed above.

7.3 Model Scenarios

On the basis that air quality impacts associated with existing and expanded operations at Port Botany were previously assessed as part of the expansion EIS, this assessment considers the incremental impacts of BLB2 and cumulative impacts including BLB2 operations.

Two operational scenarios have been modelled in this assessment and include:

- 1) Scenario 1 – Incremental Impacts from BLB2; and
- 2) Scenario 2 – Total Impacts from all Port Activities, BLB1 and BLB2: impacts have been modelled assuming that the proposed Port Botany Expansion has been finalised and is operating at an expected throughput capacity of 3.2 million twenty foot equivalent containers (TEU) and include the impacts from BLB1 and BLB2 future operations. The modelling scenario includes contemporaneous hourly meteorological and background pollution data as recorded at Sydney Airport in 2000. In this way a full cumulative assessment of impacts is provided.



7.4 Assessment Approach

Impacts were assessed by assuming a worst case scenario in any given hour, and a worst case positioning of ships while at berth at Port Botany (in terms of ship TEU size). As modelled in the PBE EIS (SKM, 2004), peak emissions for the Port have been determined assuming that there would be ten ships docked amongst the three terminals with auxiliary engines operating continuously at 100% MCR, and two of the ships operating their main engines at 30% MCR. This was to represent the scenario of a ship just arriving and a ship simultaneously just ready to depart.

For Scenario 2, it has been assumed that BLB1 and BLB2 are occupied, with the ship's auxiliary engines operating at 100% MCR and the main engine for one ship operating at 30% MCR.

For simplicity annual impacts have been assessed for the worst case scenario, and therefore are considered highly conservative as all berths would not be occupied 100% of the time. In reality 60% utilisation of the BLBs is considered more appropriate.

A summary of the ship inventory used to estimate appropriate ship parameters, and emission scenarios used in this assessment are provided in the following sections.

7.4.1 Scenario 1 – BLB2 Impacts

This scenario models the incremental impact from BLB2 only. A ship emissions inventory was developed by assuming all ships operate their auxiliary engines continuously whilst at berth at 100% MCR, with the main engine operating at 30% MCR. Main engines have been assumed to be slow speed engines using Marine Diesel Oil (MDO) whilst at berth. MDO generally has a fuel sulfur content of approximately 1.5% w/w and below (Rauta, Port Technology International). The Lloyd's Register study has estimated emission factors that are based on main and auxiliary engines using fuel of 2.7% w/w sulfur content.

For this assessment the emissions from the Berge Trader have been used as it represents one of the largest ships to visit the BLB in 2006, thus provide a conservative assumption of emissions.

Table 7-3 provides a summary of the Berge Trader emissions rates.

■ **Table 7-3: BLB Emission Estimations**

Ship	Peak Emission Scenario (g/s)			Hours at Berth (60% of year)	Annual Emission (tonnes/year)		
	SO ₂	NO _x	PM ₁₀		SO ₂	NO _x	PM ₁₀
BLB (Main)	15.1	23.3	1.2	5,256	22.0	34.0	1.8
BLB (Auxiliary)	1.6	7.4	0.07	5,256	2.3	10.8	0.1



Refer to **Appendix A** for a complete list and emission calculations of ships to visit BLB1 in 2006.

Ship stack parameters were difficult to source. The stack parameters provided in **Table 7-4** represent a “best estimate” of parameters based on the air quality assessment for the port expansion (SKM, 2004). These parameters are the same as those used in the Port Botany Expansion EIS for the relevant main engine size (SKM, 2004).

■ **Table 7-4: Ship Stack Parameters**

Parameter	Value
Main Engine	
Stack height (m)	37
Stack diameter (m)	1.75
Stack exit velocity (m/s)	26.6
Stack temperature (°C)	350
Auxiliary Engine	
Stack height (m)	37
Stack diameter (m)	1
Stack exit velocity (m/s)	39.7
Stack temperature (°C)	350

7.4.2 Scenario 2 – Total Impacts from the Port, BLB1 and BLB2

This emission scenario assumes that the Port Botany upgrade has been completed at operating at the expected throughput of 3.2 million TEU. This modelling is based on work previously conducted by SKM for Sydney Ports Corporation (SKM, 2004). Refer to the SKM, 2004 report for full details of this emission scenario. Background concentrations of the pollutants were also included in the modelling, with data sourced from Sydney Airport.

It has been assumed that there would be a ship at both BLB1 and BLB2 for this model scenario. In this instance emissions from BLB2 are the same as those used in Scenario 1 (refer to **Table 7-3**), while emissions from the ship at BLB1 would be from the auxiliary engine only.

The net impact on traffic movements associated with BLB2 operations is expected to be minimal. As such no additional port side traffic has been included in the modelling.

A summary of emissions for this scenario are presented in **Table 7-5**.



■ **Table 7-5: Summary of Emissions for All Source Groups**

Source Group	Peak Model (g/s)			Annual Emission (tonnes/year)		
	NO _x	PM ₁₀	SO ₂	NO _x	PM ₁₀	SO ₂
Ships	381	3.9	162	927.10	9.49	394.20
Trains	2.5	0.08	0.01	6.08	0.19	0.02
Trucks	4.5	0.15	0.03	10.95	0.37	0.07
Dockside	21.1	4.8	21.2	51.34	11.68	51.59
TOTAL	409.1	8.93	183.24	995.48	21.73	445.88

7.5 Results of Air Dispersion Modelling

This section of the report provides an overview of modelling results for the two emissions scenarios listed above. The results are presented for a model domain of 6 km × 5 km, at a grid resolution of 150 metres. Four discrete receptors are identified and air pollution impacts at these locations are compared to DECC criteria. The discrete receptor locations are shown on the locality plan provided in **Figure 3-1**.

7.5.1 Modelled NO₂

Modelled impacts of NO₂ for Scenario 1, using Janssen (1988) methodology are well below the DECC criteria for both 1-hour and annual averaging time periods. Modelled impacts for Scenario 2 also do not result in exceedances of the maximum 1-hour or annual average DECC criteria. Maximum modelled 1-hour impacts in Scenario 2 are 232 µg/m³ at receptor 3. Annual average modelling for Scenario 2 also show compliance with the DECC criteria beyond the port boundary. The highest modelled annual average concentration at a sensitive receiver was 41 µg/m³ at receptor 1.

Modelled NO₂ concentrations are displayed graphically in **Appendix B.1**.



■ **Table 7-6: Modelled NO₂ Concentrations at Discrete Receptors (µg/m³)**

Discrete Receptor	Scenario 1	Scenario 2
1-hour		
1	12.3	162
2	12.6	215
3	11.8	232
4	11.0	218
5	10.5	204
Annual		
1	0.3	41
2	0.2	38
Discrete Receptor	Scenario 1	Scenario 2
3	0.2	37
4	0.2	37
5	0.3	39

7.5.2 Modelled SO₂

Incremental impacts of SO₂ concentrations (Scenario 1) are well below the DECC criteria for all averaging periods.

For Scenario 2 modelled maximum 10-minute SO₂ concentrations are below the DECC criteria of 712 µg/m³ at all residential locations, with a maximum at a discrete receptor in the order of 355 µg/m³ at receptor 4.

Maximum 1-hour SO₂ concentrations are below the DECC criteria of 570 µg/m³ at the residential locations for Scenario 2. The maximum modelled 1-hour SO₂ concentration at a discrete receptor is 336 µg/m³ at receptor 4.

Modelled 24-hour SO₂ concentrations for Scenario 2 are below the DECC criteria of 228 µg/m³ beyond the Port Botany boundary. At the discrete receptors the maximum modelled SO₂ concentration occurred under Scenario 2 at receptor 2 (115 µg/m³).

Conservative modelled annual average SO₂ concentrations show that the DECC criteria of 60 µg/m³ is not exceeded beyond the port in Scenario 2. The maximum modelled concentration at a discrete receptor is 27 µg/m³ at receptor 1.

Results of SO₂ modelling are displayed in **Appendix B.2**.



■ **Table 7-7: Modelled SO₂ Concentrations at Discrete Receptors (µg/m³)**

Discrete Receptor	Scenario 1	Scenario 2
10-minute		
1	56	247
2	78	352
3	89	319
4	53	355
5	75	267
1-hour		
1	43	203
2	43	275
3	40	302
4	37	336
5	36	308
24-hour		
1	8	87
2	7	115
3	7	99
4	7	79
5	9	84
Annual		
1	1	27
2	1	24
3	1	21
4	1	22
5	1	26

7.5.3 Modelled PM₁₀

Modelled incremental impacts in Scenario 1, are well below the DECC criteria for both 24-hour and annual time periods i.e. <1 µg/m³, at all receptor locations outside of Port Botany area (refer to **Table 7-8**).

Modelled cumulative PM₁₀ impacts i.e. including background air quality, all port operations, BLB1 and BLB2 result in exceedances of the DECC 24-hour criteria at residential locations. However, the incremental impacts due to BLB2 are very low i.e. <1 µg/m³ and are unlikely to result in additional exceedances at the residences near the port. Modelled impacts are large due to existing days where PM₁₀ 24-hour criteria is already exceeded. Annual average PM₁₀ concentrations comply with the DECC criteria, although this compliance is marginal. Again, this impact is due to existing activities in the area, with an incremental impact of less than 1 µg/m³.



■ **Table 7-8: Modelled PM₁₀ Concentrations at Discrete Receptors (µg/m³)**

Discrete Receptor	Scenario 1	Scenario 2
24-hour		
1	0.6	72
2	0.5	70
3	0.5	70
4	0.5	70
5	0.7	71
Annual		
1	0.1	28
2	0.1	27
Discrete Receptor	Scenario 1	Scenario 2
3	0.1	27
4	0.1	27
5	0.1	27

7.6 Assessment of VOC Emissions

This assessment considers VOC emissions and potential impacts from the BLB. The proposed Site B3 Bulk Liquids Storage Terminal (i.e. storage tanks) has been assessed previously by GHD (GHD, 2006) and this will be summarised below. Small amounts of vapour will be generated when discharging liquids from the ships to shore based storage tanks. A summary of activities undertaken when pumping from ships to tanks is provided below, and discussion of vapour recovery is given where possible.

7.6.1 Bulk Liquids Storage Terminal Air Quality Assessment Summary

GHD have assessed the air quality impacts from the proposed Site B3 Bulk Liquids Storage Terminal (GHD, 2006). This expansion would allow for an increase in annual throughput from from 2,100, 000 kL to 3,950,000 kL. The assessment considered the following sources of fugitive emissions:

- Storage tank losses – the TANKS v4.09 model was used to estimate hydrocarbon emissions from fixed and floating roof tanks. Emissions were estimated for unleaded petrol as it represents the most volatile products handled at the facility from the existing B1 tank farm, B2 tank farm, and proposed B3 tank farm. Ten turnovers per year were assumed. Estimated annual emissions were in the order of 58,726 kg.
- Pipeline losses – fugitive emissions were estimated from flanges, valves, pump seals and other pipeline fitting, it was assumed that pipeline would carry light fuel (e.g. ULP). Annual emissions were in the order of 822 kg.



- Emissions during truck loading – the assessment considered 1,900 ML to be distributed by road per annum. A vapour recovery unit would be used during loading operations with a removal efficiency of greater than 99.9%. A total loss factor was assumed to be 512 kg per year.
- Transport vehicle emissions – Predicted emission rates from vehicles movements associated with existing and proposed tank farms is in the order of 42,388 kg per year.

Total emissions from the four source type listed above were in the order of 102,448 kg per year.

Dispersion modelling using AUSPLUME v6.0 was undertaken by GHD to predict the maximum ground level concentrations resulting from the transfer and storage of liquids at the storage facility. The 99.9th percentile concentration was modelled using an averaging period of 1 hour. Two scenarios were modelled:

- 1) Scenario 1 – Current Emissions i.e. emissions from the existing B1 and B2 tank farms; and
- 2) Scenario 2 – Future Emissions i.e. emissions from existing B1, B2 and proposed B3 tank farms.

Modelled impacts focused on benzene as it was predicted to have the smallest margin of compliance compared to the other critical constituents of petrol vapour. Other background sources of benzene were also included in the modelling. Scenario 2 modelling showed benzene concentrations were in the order of 0.00608 mg/m³ at the site boundary, which is approximately 21% of the DECC criteria.

Scenario 2 represents an annual throughput of approximately 3,950,000 kL, which is approximately the throughput anticipated for 2012 (refer to **Section 5**). Throughput in 2022 is anticipated to be in the order of 6,130,590 kL, i.e. an increase by 55%. In order to understand the significance of this increase the modelling results have been scaled up accordingly to examine the potential impact in 2022. These impacts are anticipated to be in the order of 0.0094 mg/m³, which represent 32% of the relevant criteria.

7.7 BLB2 VOC Emissions and Management

7.7.1 Chemical Transfers

Chemicals (which includes VOCs) will be discharged to the Chemical Terminals from BLB2 via flexible hoses connecting the Terminal pipelines at BLB2 to the Ship Manifold discharge pipework. The ship's pumps provide the means of transfer.

Following connection of the hoses, and prior to commencement of pumping, a small amount of nitrogen is released to atmosphere during the pressure test. This test is carried out at every hose



connection to ensure that there are no leaks at the hose flanges or wharf/ship connection flanges. Prior to the disconnection of the hoses at the end of the discharge, another small amount of nitrogen together with a small amount of product vapour is released when the hoses are depressurised to atmosphere following purging of the hoses back to the respective Vopak Site A or Terminals Pty Ltd terminals. This operation ensures minimal risk of residual product spillage when the hoses are disconnected and then blanked off prior to removal from the ship and wharf area.

When the Ship is pumping chemicals to the respective Chemical Terminal the volume of product in the ship tank decreases and either the ship tank masthead vents will open to allow air to ingress to prevent a vacuum occurring in the ship tank; or if the product has an inert gas blanketing requirement then the ship's inert gas generator will supply inert gas to the ship tank to prevent a vacuum occurring in the ship tank. Ship tanks are not designed to withstand any significant level of vacuum. A vacuum could cause structural damage (collapse) to the ship tank. In either case there is no significant air emission resulting from the ship discharge operation.

Pigging operations are carried out from the wharf to the terminal using compressed nitrogen supplied to the wharf. Any associated air emissions are controlled at the Terminal end via DECC approved vapour emission controls (usually a carbon bed adsorption system, a vapour return to ship system or a Scrubber designed for the specific chemical).

When there is a chemical export to the ship from a terminal, a relatively rare occurrence, then there is a potential for the ship tank to breathe to atmosphere via its masthead vents. Again, depending on the chemical, a vapour return system (back to the terminal tank) may be utilised.

7.7.2 Petroleum Transfers

Petroleum products (which includes VOCs) will be discharged to the existing Petroleum Terminals from BLB2 via Marine Loading Arms (MLA's) connecting the Terminal pipelines at BLB2 to the Ship Manifold discharge pipework. The ship's pumps provide the means of transfer.

Following connection of the MLA, and prior to commencement of pumping, a small amount of Nitrogen is released to atmosphere during the pressure test. This test is carried out at every MLA connection to ensure that there are no leaks at the MLA to ship connection flange. Prior to the disconnection of the MLA from the ship at the end of the discharge, another small amount of Nitrogen together with a small amount of Product vapour is released when the MLA is depressurised to atmosphere following pumping down of the MLA back to the respective terminals. This operation ensures that the MLA is left empty and thereby effects minimal risk of cross contamination with the next product to be discharged.

When the Ship is pumping petroleum product to the respective petroleum terminal the level of product in the ship tank decreases and the ship tank masthead vents will open to allow air to ingress



to prevent a vacuum occurring in the ship tank. Ship tanks are not designed to withstand any significant level of vacuum. A vacuum could cause structural damage (collapse) to the ship tank. In this case there is no significant air emission resulting from the ship discharge operation.

Pigging operations are carried out from the wharf to the terminal using compressed nitrogen supplied to the wharf. Any air emissions associated with the pigging operation are controlled at the Terminal end via a de-pressuring vessel to atmosphere.

When there is a petroleum product export to the ship from a terminal, a relatively rare occurrence, then there is a potential for the ship tank to breathe to atmosphere via its masthead vents.

7.7.3 Bulk Liquids Transfer Emission Control

LPG ships generally have vapour return systems which provide good emissions controls. Petroleum ships have no vapour emission control systems on board. Vapour return systems (from Shore Tanks) are not used. When a ship tank is emptied the hatches are closed, the vessel will go out to sea and either air blow the tanks dry or it will water wash each tank, drain and then air blow dry so any remaining vapour is left in the ship tank after discharge will one way or the other, be released to atmosphere.

Chemical ships generally do not have any on board vapour emission control/recovery systems other than simple Pressure/Vacuum Vents on each tank. For some products (propylene oxide and hexene) a vapour return system is used and this is usually for product quality maintenance reasons (i.e. not letting moist air into ship/shore tanks). Similar to petroleum ships, any product/vapours left in a ship tank after discharge are removed when the vessel is at sea.

At the completion of Chemical discharges at the BLB, the normal operational practice is to clear the hoses of residual product by blowing with nitrogen (from the ship end to the shore end of the hose). Generally this results in the hose being almost free of liquid which means that minimal vapours are emitted when hoses are disconnected. The hoses are then disconnected from both the Ship Manifold and the Shore Manifold and blank flanges are immediately attached to both the ends of the hoses and blank flanges are re-attached to both the Ship Manifold and Shore Manifold flanges. This process results in minimal vapour emissions at the BLB.

After pipelines are pigged to the respective Terminals the resulting nitrogen/vapour mix remaining in the pipeline can be directed to the Terminal Vapour Emission Control Systems which results in minimal emissions.

7.7.4 VOC Emissions Calculations at BLB2

VOC emissions have been estimated for the valves and flanges associated with BLB2 operations. Emissions were estimated using the *Emission Estimation Technique Manual for Petroleum*



Refining (DEH, 1999). Screening information was not available, and as such average emission factors were used. This methodology involves applying the following generic algorithm to estimate emissions from all sources in a stream, for a particular equipment type:

$$E_{\text{VOC}} = F_A * WF_{\text{VOC}} * N$$

Where:

E_{VOC} = Emission rate of VOC from all sources grouped in a particular equipment type and service (kg/hr);

F_A = Applicable average emission factor for the particular equipment type;

WF_{VOC} = The average weight fraction of VOC in the stream;

N = The number of pieces of equipment grouped in the relevant category according to equipment type, service and weight fraction of VOC.

In this case it has been conservatively assumed that all streams are approximately 100% VOCs, thereby making $WF_{\text{VOC}} = 1$. The emission factor for gas has been used for these calculations as it represents the most conservative emission rate compared to light liquids and heavy liquids.

Table 7-9 provides parameters used to estimate VOC emission rates, and **Table 7-10** provides emission estimates for VOCs from valves and flanges.

■ **Table 7-9: Pipeline Parameters**

Product	2022 Throughput (kL)		Average Pumping Rate (kL/hr)	Average Pipe Utilisation Time (hrs)	
	BLB2	BLB1 + BLB2		BLB2	BLB1 + BLB2
Gas	593992	1187986	691	860	1719
Chemicals	70459	140918	171	412	824
Biodiesel	224999	449998	171	1316	2632
Petroleum Product	2175844	4351688	1875	1160	2321



■ **Table 7-10: Fugitive VOC Emission Factors and Calculations**

Product	Equipment Type	Number of Sources	Emission Factor (kg/hr/source)	Emission Rate (kg/hr)	Annual Emission Rate (kg)	
					BLB2	BLB1 + BLB2
Light Liquids	Valve	92	0.0109	1.0028	2896	5793
	Flange	208	0.00025	0.052	150	300
Gas	Valve	7	0.0268	0.1876	161	323
	Flange	16	0.00025	0.004	3	7
Total					3211	6423

As discussed previously in **Section 7.6.1**, GHD modelled impacts (from tank farms, associated infrastructure and activities) have been scaled up to include a throughput of 6,130,590 kL. In this case predicted impacts are in the order of 0.0094 mg/m³, which represent 32% of the relevant criteria.

Impacts have been further scaled to include emissions from BLB1 and BLB2 in 2022 i.e. an annual emission rate of 6423 kg. In this case impacts are calculated to be in the order of 0.0098 mg/m³, which equates to approximately 34% of the DECC criteria.



8. Conclusion

SPC are proposing to construct a second Bulk Liquids Berth (BLB2) adjacent to the existing Bulk Liquids Berth No. 1 (BLB1) at Port Botany. This new berth is proposed to handle the predicted increase in imported petroleum and gas products into Port Botany.

A brief qualitative assessment of impacts during construction has been provided in this assessment. It is concluded that impacts from construction would be minimal and localised. Any dust generated is unlikely to impact upon residences given the distance from the site to residential locations. Any potential dust emissions can be minimised using appropriate dust control measures as listed in **Section 6**.

Operational impacts have also been assessed. Ship and dockside equipment emissions of PM₁₀, NO₂ and SO₂ were calculated using the *NPI Emission Estimation Technique Manuals* and modelled using AUSPLUME v6.0. This modelling indicates that incremental and cumulative NO₂ and SO₂ impacts comply with the DECC criteria for all averaging periods.

Modelled cumulative 24-hour PM₁₀ impacts exceed the DECC criteria due to high background concentrations included in the modelling. Incremental PM₁₀ impacts from bulk liquid berth activities however are very low for 24-hour averaging periods i.e. <1 µg/m³ and do not result in additional exceedances of the DECC criteria at residential locations. Annual average PM₁₀ concentrations comply with the DECC criteria.

In terms of vapour emissions when transferring liquids from ships to holding tanks, emissions are generally controlled at the terminal end. As chemicals are drawn out of the holding tanks of the ships, air will need to enter the ship holding tanks, and be released from the terminal tanks. Any associated air emissions are controlled at the Terminal end via DECC approved vapour emission controls (usually a carbon bed adsorption system, a vapour return to ship system or a Scrubber designed for the specific chemical). When products are exported, a relatively rare occurrence, then there is a potential for the ship tank to breathe to the atmosphere via its masthead vents. Again, depending on the chemical, a vapour return system (back to the terminal tank) may be utilised. In terms of petroleum transfers any air emissions associated with the pigging operation are controlled at the terminal end via a de-pressuring vessel to the atmosphere.

The GHD assessment of the proposed Site B3 Bulk Liquids Storage Terminal (GHD, 2006) has been used to further quantify potential VOC impacts. In this instance the potential impacts were scaled up to represent throughput in 2022 as well as emissions associated with BLB pipework. Impacts are predicted to be approximately 34% of the relevant DECC criteria.



Overall, operational impacts from the proposed BLB2 would be small for all pollutants modelled as well as potential vapour releases. As such the additional berth is considered acceptable in terms of potential air quality impacts in Port Botany and surrounding suburbs.



9. References

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Department of Environment and Heritage (2001) *National Pollutant Inventory Emission Estimation Technique Manual for Maritime Operations v1.1*

Department of Environment and Heritage (1999) *National Pollutant Inventory Emission Estimation Technique Manual for Aggregated Emissions from Railways*

Department of Environment and Heritage (1999) *Emission Estimation Technique Manual for Petroleum Refining*

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SKM (2004) *Port Botany Upgrade EIS – Air Quality Impact Assessment Commission of Inquiry*

Appendix A Ship Emission Inventory

A.1 Main and Auxiliary Engine Parameters and Emission Estimates

Ship Name	Ship Type	Year of build	No. Engines	Gross Tonnage	Main Engine Power (kW)	Main Engine Power @ 30% (kW)	Main Engine Emission Rate						Auxiliary Engine Emission rate (assume 600 kW)					
							(kg/hr)			(g/s)			(kg/hr)			(g/s)		
							NOx	PM10	SO2	NOx	PM10	SO2	NOx	PM10	SO2	NOx	PM10	SO2
BARRINGTON	Products Tanker	1989	1	21,718	6,032	1,810	31.7	1.7	20.5	8.8	0.5	5.7	26.6	0.3	5.7	7.4	0.07	1.6
BERGE SPIRIT	LPG Tanker	1980	1	44,076	17,247	5,174	90.5	4.8	58.7	25.2	1.3	16.3	26.6	0.3	5.7	7.4	0.07	1.6
BERGE TRADER	LPG Tanker	2006	1	46,632	15,970	4,791	83.8	4.5	54.3	23.3	1.2	15.1	26.6	0.3	5.7	7.4	0.07	1.6
BOUGAINVILLE	LPG Tanker	2001	1	4,229	3,089	927	16.2	0.9	10.5	4.5	0.2	2.9	13.3	0.1	2.8	3.7	0.04	0.8
BOW DE FENG	Chemical/Products Tanker	2002	1	6,843	3,900	1,170	20.5	1.1	13.3	5.7	0.3	3.7	20.0	0.2	4.2	5.5	0.06	1.2
BOW DE JIN	Chemical/Products Tanker	1999	1	6,294	3,884	1,165	20.4	1.1	13.2	5.7	0.3	3.7	20.0	0.2	4.2	5.5	0.06	1.2
BOW DE RICH	Chemical Tanker	2003	1	6,861	3,906	1,172	20.5	1.1	13.3	5.7	0.3	3.7	20.0	0.2	4.2	5.5	0.06	1.2
BOW MASTER	Chemical/Products Tanker	1999	1	4,667	3,600	1,080	18.9	1.0	12.2	5.3	0.3	3.4	13.3	0.1	2.8	3.7	0.04	0.8
BOW MATE	Chemical/Products Tanker	1999	1	4,667	3,600	1,080	18.9	1.0	12.2	5.3	0.3	3.4	13.3	0.1	2.8	3.7	0.04	0.8
BOW WALLABY	Chemical Tanker	2003	1	6,976	4,200	1,260	22.1	1.2	14.3	6.1	0.3	4.0	20.0	0.2	4.2	5.5	0.06	1.2
BOW WEST	Chemical/Products Tanker	2002	1	6,837	3,883	1,165	20.4	1.1	13.2	5.7	0.3	3.7	20.0	0.2	4.2	5.5	0.06	1.2
BRITISH COURTESY	Chemical/Products Tanker	2005	1	29,214	11,626	3,488	61.0	3.2	39.6	17.0	0.9	11.0	26.6	0.3	5.7	7.4	0.07	1.6
BRITISH FIDELITY	Chemical/Products Tanker	2004	1	29,335	9,466	2,840	49.7	2.6	32.2	13.8	0.7	8.9	26.6	0.3	5.7	7.4	0.07	1.6
BRITISH LIBERTY	Chemical/Products Tanker	2004	1	29,335	9,480	2,844	49.8	2.6	32.3	13.8	0.7	9.0	26.6	0.3	5.7	7.4	0.07	1.6
BRITISH UNITY	Chemical/Products Tanker	2004	1	29,335	9,466	2,840	49.7	2.6	32.2	13.8	0.7	8.9	26.6	0.3	5.7	7.4	0.07	1.6

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BRO ALBERT	Chemical/Products Tanker	1995	1	28,226	7,466	2,240	39.2	2.1	25.4	10.9	0.6	7.1	26.6	0.3	5.7	7.4	0.07	1.6
BRO ALEXANDRE	Products Tanker	1995	1	28,226	7,460	2,238	39.2	2.1	25.4	10.9	0.6	7.0	26.6	0.3	5.7	7.4	0.07	1.6
BRO ARTHUR	Products Tanker	1995	1	28,226	7,460	2,238	39.2	2.1	25.4	10.9	0.6	7.0	26.6	0.3	5.7	7.4	0.07	1.6
CHANG CHI	Products Tanker	2003	1	27,155	8,580	2,574	45.0	2.4	29.2	12.5	0.7	8.1	26.6	0.3	5.7	7.4	0.07	1.6
CITRUS EXPRESS	Products Tanker	2006	1	31,433	10,591	3,177	55.6	3.0	36.0	15.4	0.8	10.0	26.6	0.3	5.7	7.4	0.07	1.6
DA CHI	Products Tanker	2005	1	26,955	8,580	2,574	45.0	2.4	29.2	12.5	0.7	8.1	26.6	0.3	5.7	7.4	0.07	1.6
DA QING 452	Products Tanker	2001	1	29,288	8,520	2,556	44.7	2.4	29.0	12.4	0.7	8.1	26.6	0.3	5.7	7.4	0.07	1.6
DEAUVILLE	LPG Tanker	1995	1	3,617	2,648	794	13.9	0.7	9.0	3.9	0.2	2.5	13.3	0.1	2.8	3.7	0.04	0.8
DEAUVILLE	LPG Tanker	1995	1	3,617	2,648	794	13.9	0.7	9.0	3.9	0.2	2.5	13.3	0.1	2.8	3.7	0.04	0.8
FEI CHI	Products Tanker	2005	1	27,235	8,580	2,574	45.0	2.4	29.2	12.5	0.7	8.1	26.6	0.3	5.7	7.4	0.07	1.6
GAN-SURE	Chemical/Products Tanker	2006	1	30,029	9,480	2,844	49.8	2.6	32.3	13.8	0.7	9.0	26.6	0.3	5.7	7.4	0.07	1.6
GAS FRIEND	LPG Tanker	2005	1	46,129	12,356	3,707	64.9	3.4	42.0	18.0	1.0	11.7	26.6	0.3	5.7	7.4	0.07	1.6
GAS TAURUS	LPG Tanker	2001	1	46,021	12,357	3,707	64.9	3.4	42.0	18.0	1.0	11.7	26.6	0.3	5.7	7.4	0.07	1.6
GOLDEN AKANE	Chemical/Products Tanker	1998	1	5,357	3,089	927	16.2	0.9	10.5	4.5	0.2	2.9	20.0	0.2	4.2	5.5	0.06	1.2
GOLDEN DENISE	Chemical/Products Tanker	2006	1	7,142	3,900	1,170	20.5	1.1	13.3	5.7	0.3	3.7	20.0	0.2	4.2	5.5	0.06	1.2
GOLDEN FUMI	Chemical/Products Tanker	1996	1	6,253	3,604	1,081	18.9	1.0	12.3	5.3	0.3	3.4	20.0	0.2	4.2	5.5	0.06	1.2
GOLDEN GEORGIA	Chemical/Products Tanker	1996	1	9,597	5,296	1,589	27.8	1.5	18.0	7.7	0.4	5.0	20.0	0.2	4.2	5.5	0.06	1.2
GOLDEN JANE	Chemical/Products Tanker	1996	1	9,599	5,296	1,589	27.8	1.5	18.0	7.7	0.4	5.0	20.0	0.2	4.2	5.5	0.06	1.2
GOLDEN KAORI	Chemical/Products Tanker	1998	1	5,819	3,604	1,081	18.9	1.0	12.3	5.3	0.3	3.4	20.0	0.2	4.2	5.5	0.06	1.2
GOLDEN TAKA	Chemical Tanker	2004	1	11,594	6,230	1,869	32.7	1.7	21.2	9.1	0.5	5.9	26.6	0.3	5.7	7.4	0.07	1.6
GOLDEN TIFFANY	Chemical/Products Tanker	1998	1	9,599	9,487	2,846	49.8	2.6	32.3	13.8	0.7	9.0	20.0	0.2	4.2	5.5	0.06	1.2
GOLDEN WAVE	Chemical/Products Tanker	2002	1	5,359	3,640	1,092	19.1	1.0	12.4	5.3	0.3	3.4	20.0	0.2	4.2	5.5	0.06	1.2
GOLDEN YASAKA	Chemical/Products Tanker	1998	1	5,360	3,089	927	16.2	0.9	10.5	4.5	0.2	2.9	20.0	0.2	4.2	5.5	0.06	1.2
HELIX	Crude/Oil Products Tanker	1997	1	28,810	8,840	2,652	46.4	2.5	30.1	12.9	0.7	8.4	26.6	0.3	5.7	7.4	0.07	1.6
HIGH CONSENSUS	Products Tanker	2005	1	28,059	9,267	2,780	48.7	2.6	31.5	13.5	0.7	8.8	26.6	0.3	5.7	7.4	0.07	1.6

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HIGH VALOR	Chemical/Products Tanker	2005	1	30,048	9,488	2,846	49.8	2.6	32.3	13.8	0.7	9.0	26.6	0.3	5.7	7.4	0.07	1.6
IVER EXPORTER	Chemical/Products Tanker	2000	1	29,289	8,560	2,568	44.9	2.4	29.1	12.5	0.7	8.1	26.6	0.3	5.7	7.4	0.07	1.6
JASMINE	Chemical/Products Tanker	2002	1	27,335	8,580	2,574	45.0	2.4	29.2	12.5	0.7	8.1	26.6	0.3	5.7	7.4	0.07	1.6
JEANNE-MARIE	LPG Tanker	2005	1	46,632	14,410	4,323	75.7	4.0	49.0	21.0	1.1	13.6	26.6	0.3	5.7	7.4	0.07	1.6
KINNA	LPG Tanker	1989	1	3,901	2,346	704	12.3	0.7	8.0	3.4	0.2	2.2	13.3	0.1	2.8	3.7	0.04	0.8
LA FORGE	LPG Tanker	1981	1	42,501	11,180	3,354	58.7	3.1	38.0	16.3	0.9	10.6	26.6	0.3	5.7	7.4	0.07	1.6
LIZZIE KOSAN	LPG Tanker	1996	1	3,540	2,427	728	12.7	0.7	8.3	3.5	0.2	2.3	13.3	0.1	2.8	3.7	0.04	0.8
MAEA	LPG Tanker	2005	1	3,759	3,398	1,019	17.8	0.9	11.6	5.0	0.3	3.2	13.3	0.1	2.8	3.7	0.04	0.8
MARCELA LADY	Chemical/Products Tanker	2004	1	27,505	8,730	2,619	45.8	2.4	29.7	12.7	0.7	8.2	26.6	0.3	5.7	7.4	0.07	1.6
NAMHAE GAS	LPG Tanker	1991	1	4,236	3,089	927	16.2	0.9	10.5	4.5	0.2	2.9	13.3	0.1	2.8	3.7	0.04	0.8
PACIFIC SERENITY	Products Tanker	2003	1	28,822	9,487	2,846	49.8	2.6	32.3	13.8	0.7	9.0	26.6	0.3	5.7	7.4	0.07	1.6
PING CHI	Products Tanker	2003	1	27,155	8,561	2,568	44.9	2.4	29.1	12.5	0.7	8.1	26.6	0.3	5.7	7.4	0.07	1.6
RESOLVE	Products Tanker	2004	1	30,032	9,480	2,844	49.8	2.6	32.3	13.8	0.7	9.0	26.6	0.3	5.7	7.4	0.07	1.6
STOLT AQUAMARINE	Chemical/Products Tanker	1986	1	23,964	9,179	2,754	48.2	2.6	31.2	13.4	0.7	8.7	26.6	0.3	5.7	7.4	0.07	1.6
STOLT AYAME	Chemical/Products Tanker	1991	1	4,987	3,604	1,081	18.9	1.0	12.3	5.3	0.3	3.4	13.3	0.1	2.8	3.7	0.04	0.8
STOLT AZALEA	Chemical/Products Tanker	1988	1	4,740	2,720	816	14.3	0.8	9.3	4.0	0.2	2.6	13.3	0.1	2.8	3.7	0.04	0.8
STOLT JADE	Chemical/Products Tanker	1986	1	23,964	9,179	2,754	48.2	2.6	31.2	13.4	0.7	8.7	26.6	0.3	5.7	7.4	0.07	1.6
STOLT JASMINE	Chemical/Products Tanker	2005	1	6,868	3,640	1,092	19.1	1.0	12.4	5.3	0.3	3.4	20.0	0.2	4.2	5.5	0.06	1.2
STOLT KIKYO	Chemical/Products Tanker	1998	1	6,426	3,884	1,165	20.4	1.1	13.2	5.7	0.3	3.7	20.0	0.2	4.2	5.5	0.06	1.2
STOLT LILY	Chemical/Products Tanker	1988	1	4,740	2,720	816	14.3	0.8	9.3	4.0	0.2	2.6	13.3	0.1	2.8	3.7	0.04	0.8
STOLT ORCHID	Chemical/Products Tanker	2003	1	5,376	3,900	1,170	20.5	1.1	13.3	5.7	0.3	3.7	20.0	0.2	4.2	5.5	0.06	1.2
STOLT RINDO	Chemical/Products Tanker	2005	1	6,944	3,515	1,055	18.5	1.0	12.0	5.1	0.3	3.3	20.0	0.2	4.2	5.5	0.06	1.2
STOLT SEA	Chemical/Products Tanker	1999	2	14,900	2,320	696	29.2	1.6	18.9	8.1	0.4	5.3	26.6	0.3	5.7	7.4	0.07	1.6
					3,240	972												
STOLT SPRAY	Chemical Tanker	2000	2	14,900	2,427	728	29.7	1.6	19.3	8.25	0.439	5.35	26.6	0.26	5.66	7.40	0.07	1.57

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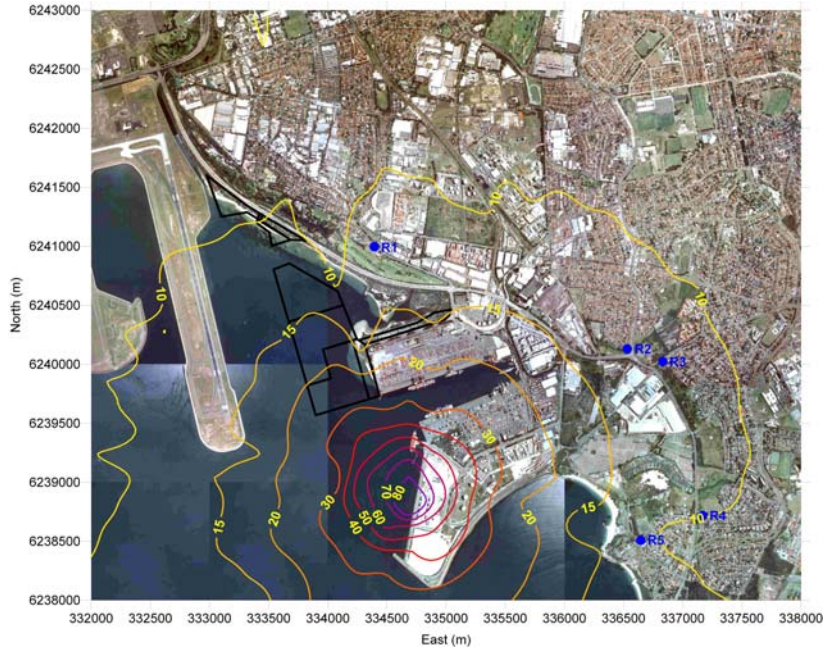
Air Quality Impact Assessment

										9		2	3					
					3,236	971												
STOLT SUISEN	Chemical/Products Tanker	1998	1	6,426	5,280	1,584	27.7	1.5	18.0	7.70 0	0.409	4.99 0	19.9 7	0.20	4.25	5.55	0.06	1.18
VICTOIRE	LPG Tanker	2005	1	3,759	3,398	1,019	17.8	0.9	11.6	4.95 5	0.263	3.21 1	13.3 1	0.13	2.83	3.70	0.04	0.79
YAYOI EXPRESS	Products Tanker	2006	1	28,844	9,480	2,844	49.8	2.6	32.3	13.8 25	0.735	8.95 9	26.6 3	0.26	5.66	7.40	0.07	1.57

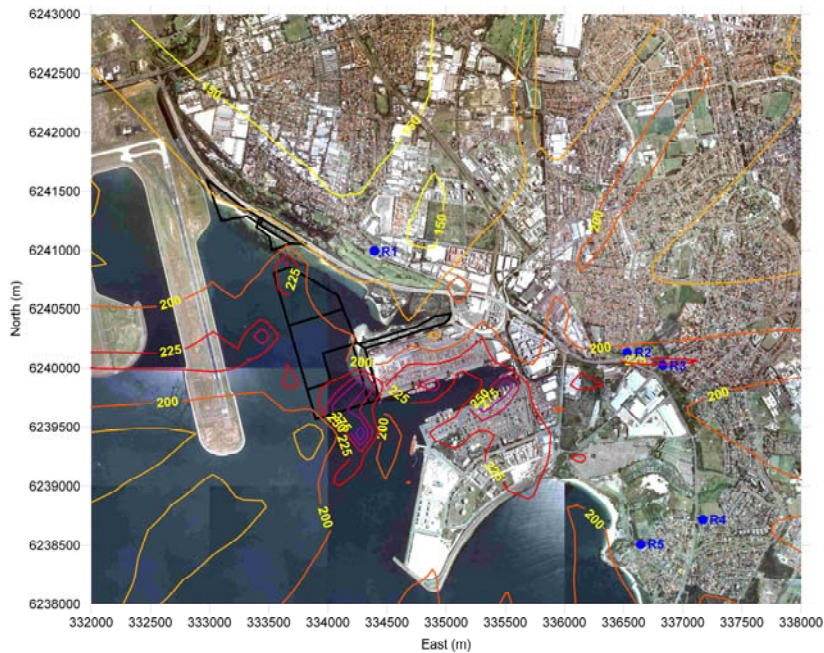
Appendix B Modelling Results

B.1 NO₂ Modelling Results

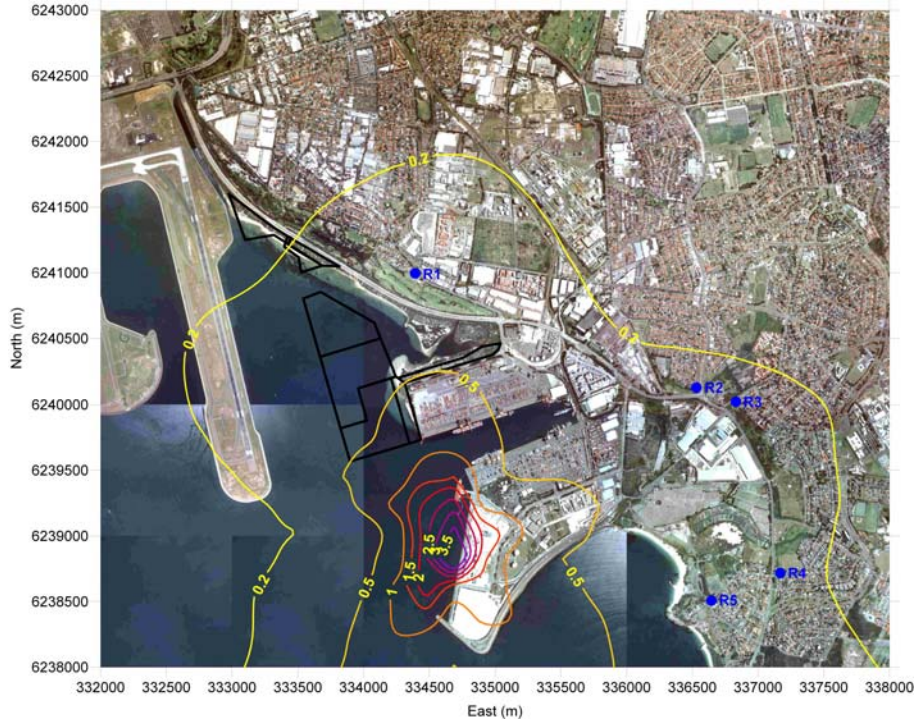
B.1.1 Scenario 1 – Modelled 1-hour NO₂ Concentrations (µg/m³)



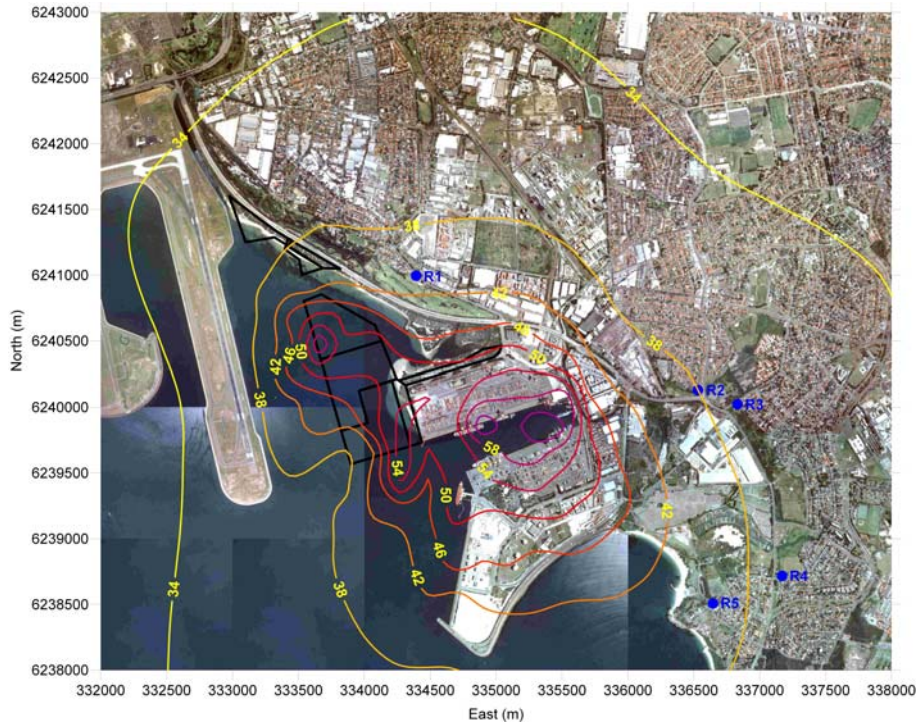
B.1.2 Scenario 2 – Modelled 1-hour NO₂ Concentrations (µg/m³)



B.1.3 Scenario 1 – Annual NO₂ Concentrations (µg/m³)

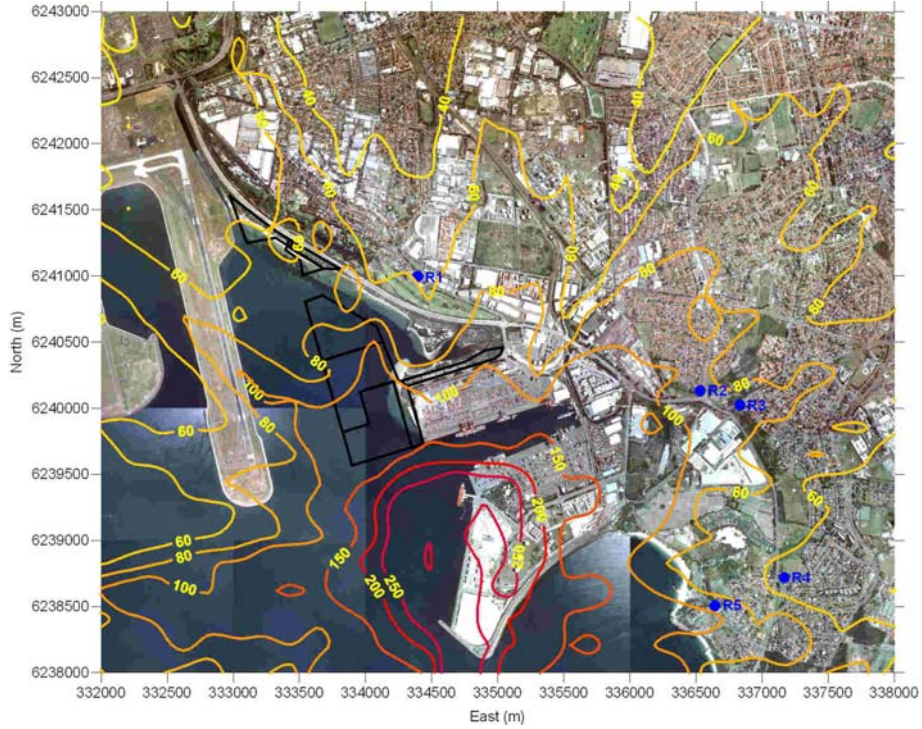


B.1.4 Scenario 2 – Annual NO₂ Concentrations (µg/m³)

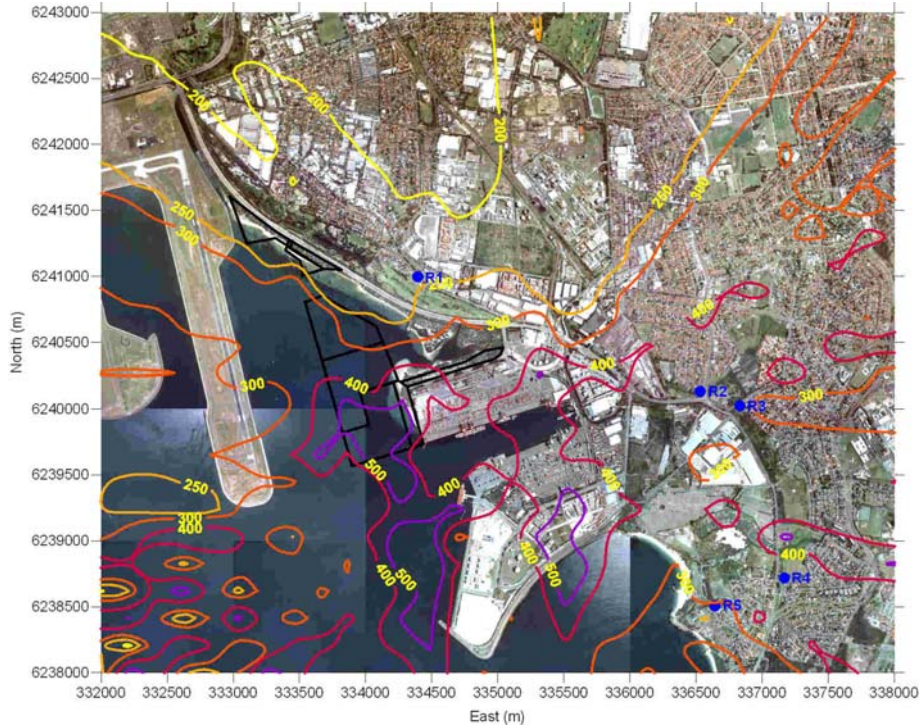


B.2 SO₂ Modelling Results

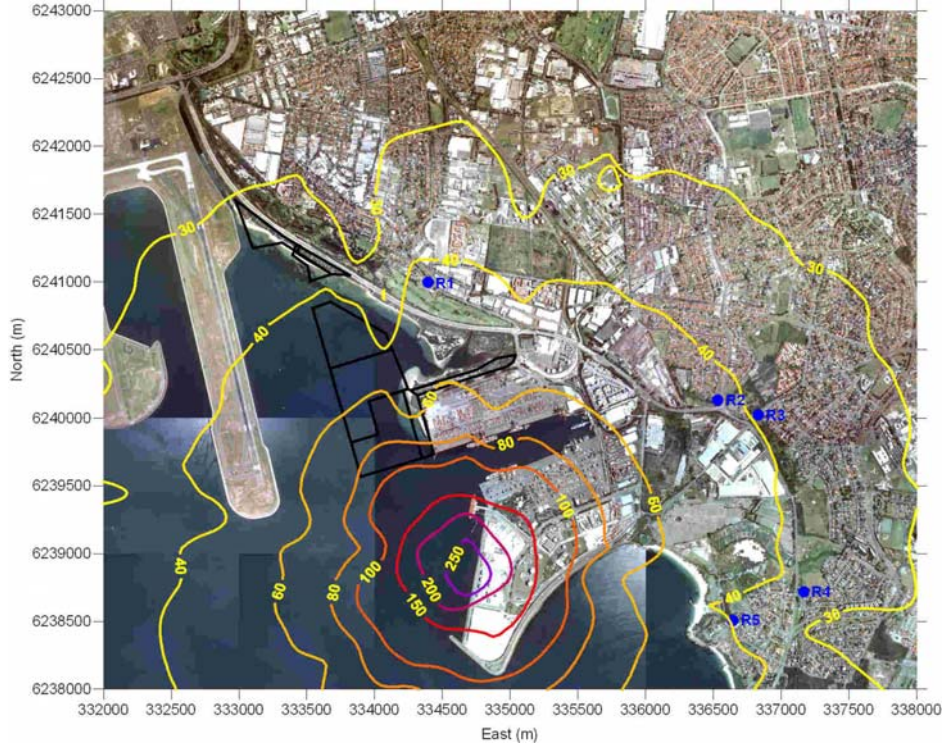
B.2.1 Scenario 1 – Modelled 10-minute SO₂ Concentrations



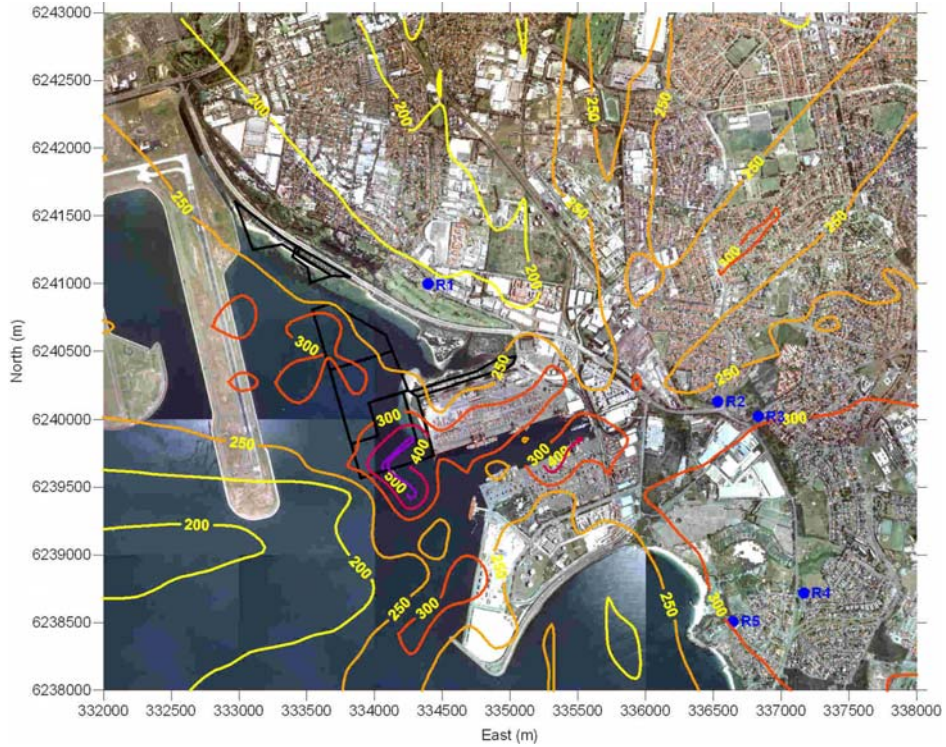
B.2.2 Scenario 2 – Modelled 10-minute SO₂ Concentrations



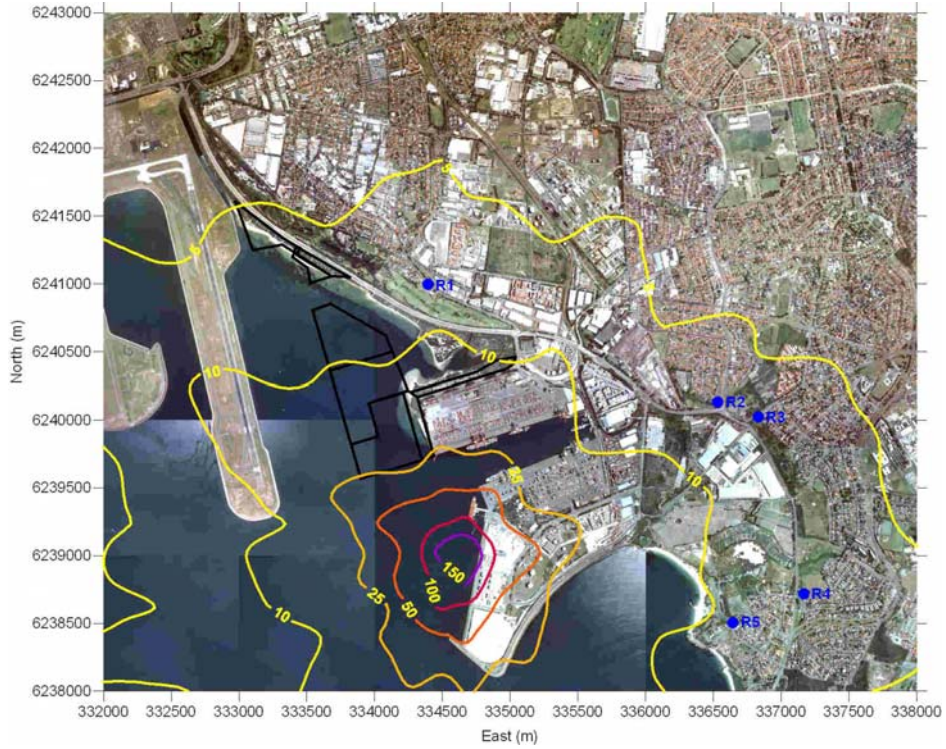
B.2.3 Scenario 1 – Modelled 1-hour SO₂ Concentrations



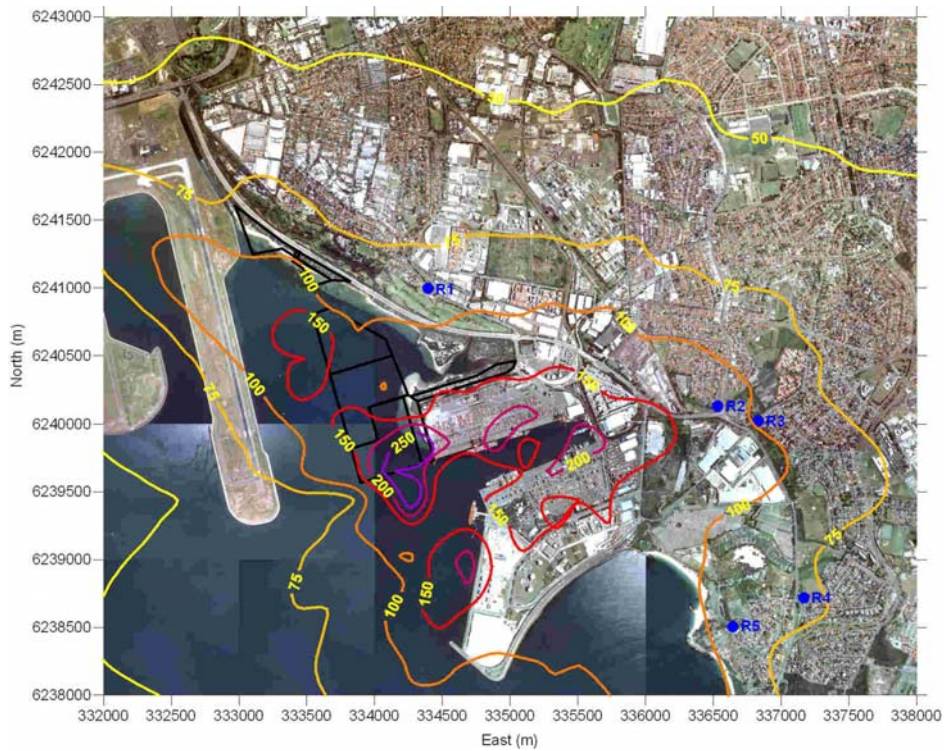
B.2.4 Scenario 2 – Modelled 1-hour SO₂ Concentrations



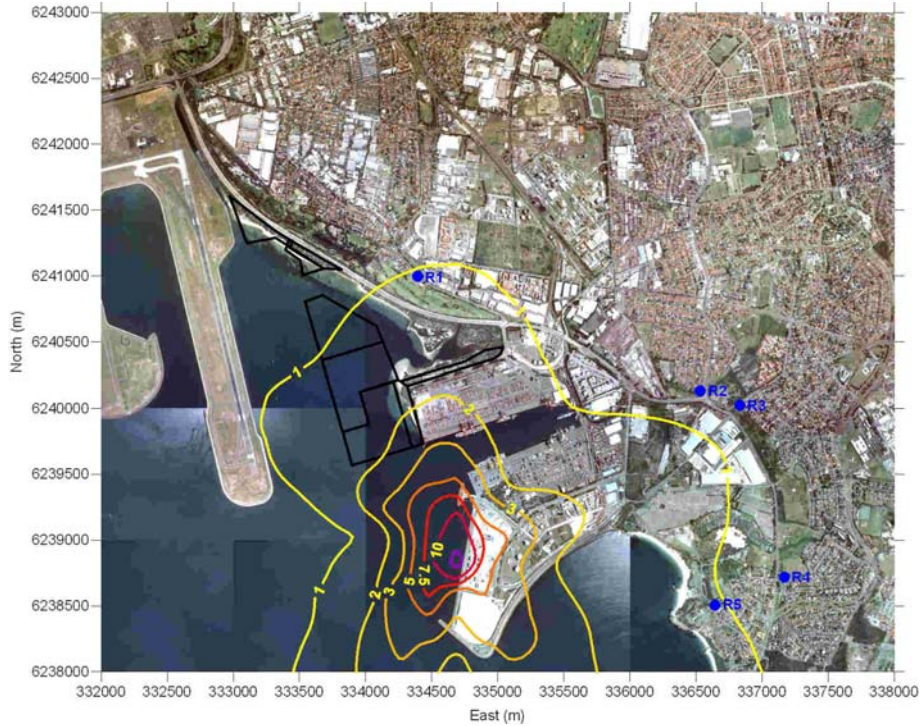
B.2.5 Scenario 1 – Modelled 24-hour SO₂ Concentrations



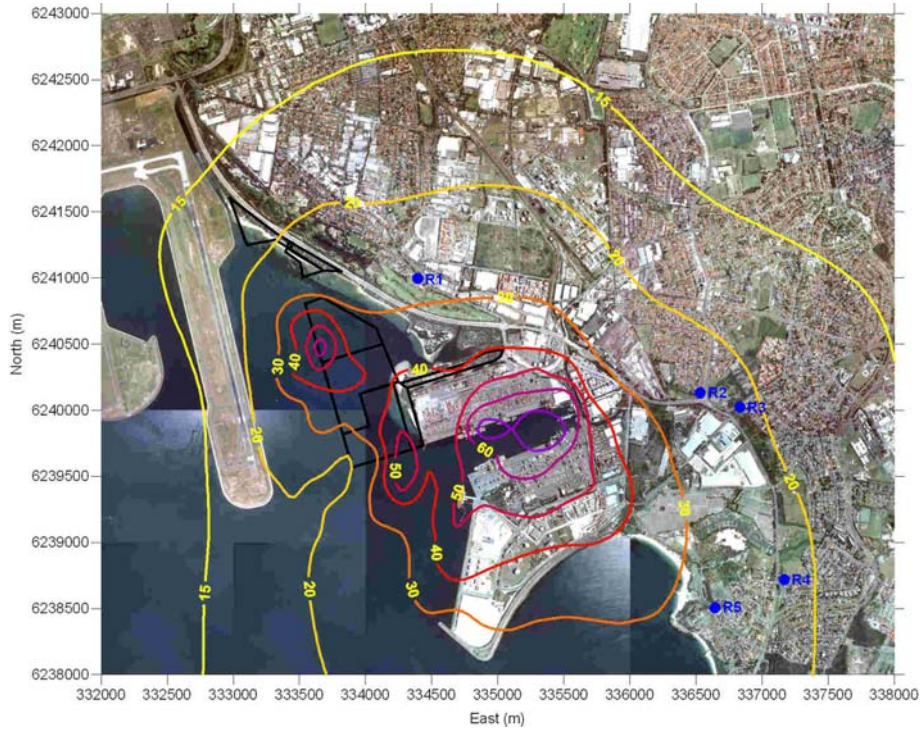
B.2.6 Scenario 2 – Modelled 24-hour SO₂ Concentrations



B.2.7 Scenario 1 – Modelled Annual SO₂ Concentrations

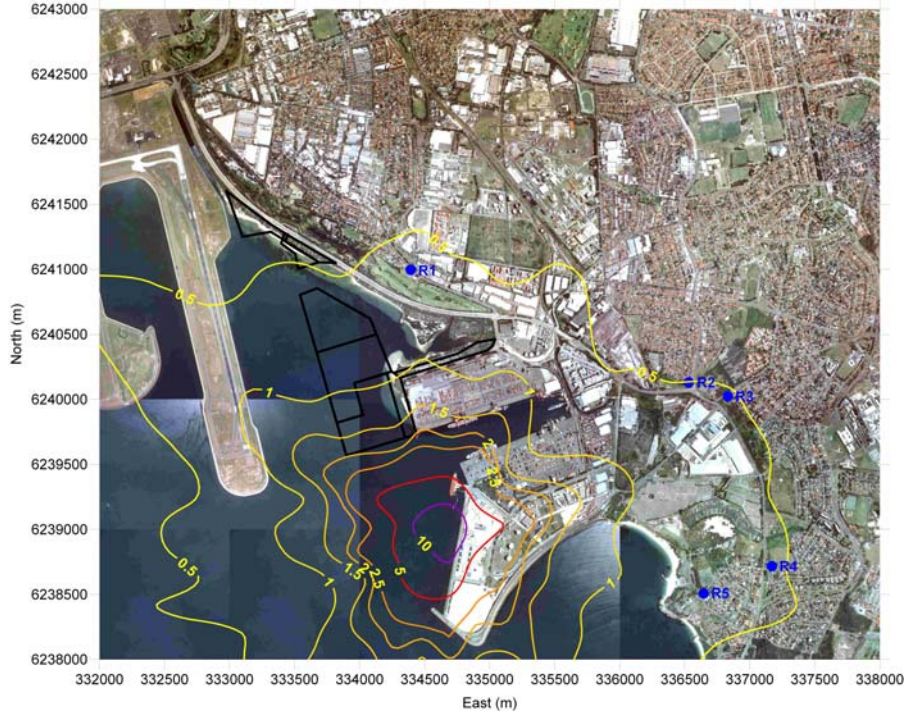


B.2.8 Scenario 2 – Modelled Annual SO₂ Concentrations

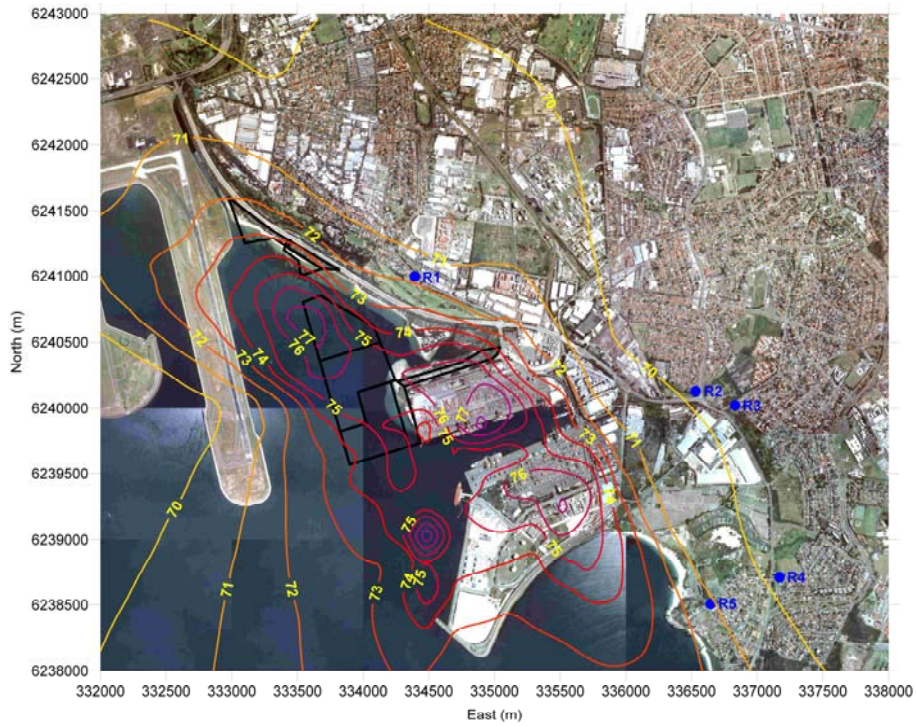


B.3 PM₁₀ Modelling Results

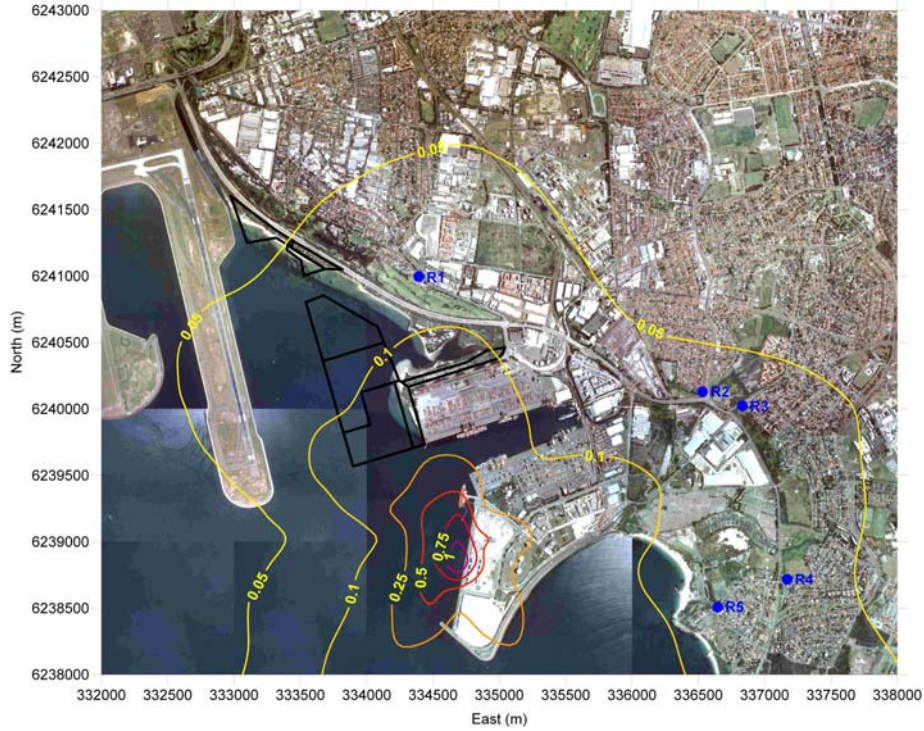
B.3.1 Scenario 1 – Modelled 24-hour PM₁₀ Concentrations



B.3.2 Scenario 2 – Modelled 24-hour PM₁₀ Concentrations



B.3.3 Scenario 1 – Modelled Annual PM₁₀ Concentrations



B.3.4 Scenario 2 – Modelled Annual PM₁₀ Concentrations

