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Air Quality Impact Assessment

Modification of Project Approval 08_0129

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Modification of Project Approval 08_0129

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Executive Summary

Orica Australia Pty Ltd (Orica) commissioned AECOM Australia Pty Ltd (AECOM) to conduct an air quality impact assessment (AQIA) as part of the expansion and modification of its Kooragang Island (KI) facility. Specifically this AQIA has been prepared to assess the potential air quality impacts associated with:

- Three flares proposed for the ammonia plant, ammonia storage tank and nitrates plants; and
- The operation of a proposed 10,000 tonne nitric acid import tank (NA import tank) and associated scrubber.

Nitrogen dioxide (NO_2) and ammonia (NH_3) were identified as the pollutants of interest and were assessed as part of this AQIA

Modelling for the site was initially undertaken by AECOM in 2009 (ENSR 2009) using CALPUFF. The NO_2 results from the assessment were compared to the measured values at the Stockton monitoring station and indicated the potential for significant over estimations at the monitoring site (a factor of 2 over observed results). On this basis, the Ausplume model was investigated using the same emissions inputs and representative meteorological data and predicted results closer to the observed results, although still conservative. Given the conservative nature of the emissions data, this difference was considered to be more acceptable than the CALPUFF results and the Ausplume model was adopted for the study with discussions and approval from the NSW EPA. Ausplume was, therefore, used in this current AQIA.

Meteorological data used in this study consisted of 12 months' worth of hourly averaged meteorological data collected in 1995 and used in past Orica modelling assessments. The data has been used on a number of impact assessments in the Newcastle Harbour and has previously been accepted by the NSW EPA. The data was also used in order to provide a clear comparison with past dispersion modelling undertaken for the site. To further establish the data's appropriateness for use in the assessment, the data was reviewed against long-term data from the Williamtown BoM weather station and the Stockton monitoring station. All three sets of data show a strong correlation with respect to distribution of wind direction and speed and confirmed that the 1995 data are appropriate for use in this assessment.

The assessment utilised background pollutant data to cumulatively asses the site's impacts. The closest ambient air quality station to the facility is at Fullerton Street Stockton NSW. The current available data on the website is for the period October 2012 to August 2013 and has been used in the assessment. It was noted that Orica already contributes to the background air quality against which it is to be assessed, resulting in a "double counting" of pollutant concentrations; this is likely to result in conservative predicted air quality impacts.

In order to adequately assess the potential background concentration of pollutants in the future, measures were taken to review the potential contribution from the Incitec Pivot Limited (IPL) expansion proposed for land to the north of the Orica site. The inclusion of the IPL expansion air quality assessment data provides a conservative estimate of future potential impacts.

Two modelling scenarios were selected for the assessment: routine operations (routine operating conditions at the site with no flaring) and non-routine operations (routine operating conditions at the site with flaring (all three flares operating at once)). Both scenarios include the addition of scrubber emissions from the 10,000 t NA import tank.

The non-routine operation (flaring) scenario is considered highly conservative due to the following:

- It is unlikely that the plant would continue to operate at full operational capacity if the flaring was to occur i.e. a flaring event would occur when a problem arises at the site and other operations would be inhibited;
- The three flares are for separate operational sections of the site and are unlikely to be utilised at the same time, although this is a possibility; and
- It is expected that a flaring event would only occur under exceptional circumstances, with a predicted occurrence frequency of once every two years.

The 1 hour average NO_2 and NH_3 results for both routine operations and non-routine operation (with flaring) are predicted to meet the NSW EPA criteria.

The annual average NO_2 and NH_3 results for both the routine operation and non-routine operation (with flaring) are predicted to meet the NSW EPA criteria.

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1.0 Introduction

1.1 Overview

Orica Australia Pty Ltd (Orica) commissioned AECOM Australia Pty Ltd (AECOM) to conduct an air quality impact assessment (AQIA) as part of the expansion and modification of its Kooragang Island facility, specifically regarding additional ammonia flaring infrastructure. Orica operates a manufacturing facility on Kooragang Island (KI) near Newcastle, which produces ammonia, nitric acid and ammonium nitrate. An Environmental Assessment (EA) (AECOM, 2009) was prepared for the expansion of the site's ammonium nitrate manufacturing capability from 500ktpa to 750ktpa, and was approved by the Minister under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) on 1 December 2009 (DA 08_0129). A full project description is provided in Section 2 of the EA, while a site location and facility plan are provided in **Figure 1** and **Figure 2** respectively.

Central to the approval of the expansion project were a series of design improvements to the site's existing ammonia management infrastructure (AMI). The AMI programme of work is aimed at improving the management of ammonia at the KI facility. A key objective of this programme is that the community is not adversely impacted by the use of ammonia onsite, including potential releases to the environment.

Risk reduction will be achieved through the transition of the site's ammonia management systems to a new design philosophy for which potential ammonia release points are captured and reused, or recycled through the process where practicable, or treated via a flare capable of managing non-routine ammonia release volumes, prior to being discharged. These improvements are further described in Section 2 of the EA.

Orica's assessment of options for treatment of non-routine ammonia discharges indicated that flares were preferable compared to the installation of a new larger scrubbing system. A flare is less complex than a scrubbing system, would have greater availability, does not require site power or cooling water systems and is inherently more reliable. Overall the operation of the proposed flares would see a reduction in the hazard and risk associated with the ongoing operation of the KI facility.

Orica is also seeking approval for an additional modification of the approved project to install a new 68% nitric acid import tank with a capacity of 10,000 tonnes (t). The nitric acid import tank (NA import tank) would be filled by ship utilising the existing wharf pipeline. The venting of vapours from the head space of the NA import tank would be mitigated using a new wet nitric acid fume scrubber.

This AQIA has been prepared to assess the potential air quality impacts associated with the Ammonia Plant, Nitrates and Ammonia Storage ammonia flares, together with the site's existing operations including a 10,000 t NA import tank and appropriate background pollutant concentrations. The report describes the approach taken in assessing the potential effects of the project and provides a quantitative assessment of the air quality impacts of the development on the surrounding receivers in accordance with the applicable guidelines and the specific project requirements of the various government agencies.

1.2 Development Location

Kooragang Island is located within the Port of Newcastle, approximately 3 km north of Newcastle CBD and is shown in **Figure 1**. The Island was developed in 1951 as part of the Hunter River Islands Reclamation Scheme, which joined islands within the Hunter River with dredged sand and fill material. The manufacture of ammonia, nitric acid and ammonium nitrate has occurred at the site since the facility was commissioned in 1969. Existing industrial developments on the Island include Port Waratah Coal Service, wharf facilities, coal and woodchip loaders, Incitec Pivot Ltd, Sims Metal Ltd, Cargill, Cleanaway, Boral and Transfield Pty Ltd. The Hunter Estuary National Park is located approximately 1.5 km north of the site.

The nearest residential premises are located at Stockton, approximately 760m east of the Orica property boundary. There are also residential properties 1.5 km to the southwest at Carrington and 2 km to the west at Mayfield.

The land adjacent to the Orica site is used for industrial and port related activities including the following:

- North: Incitec Pivot Limited operates a fertiliser storage and despatch facility.
- West: Newcastle Port Corporation and its lessees operate bulk goods importing/exporting operations on the western side of Heron Rd.
- South: Patricks and Bulk Grain Terminals operate storage and despatch facilities.
- East: whilst the land to the east of the site is currently vacant there is a proposed development for the storage of hydrocarbon products proposed on a portion of this land.

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SITE LOCATION

Proposed Modification, Greenleaf Road, Kooragang Island

FIGURE 1

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Existing Infrastructure Key

1 Ammonia Plant
2 Utilities Area
3 Acid Storage (Dilution infrastructure will be contained in the Tank 1 bund)
4 Nitric Acid Plant 3
5 Nitric Acid Plant 2
6 Nitric Acid Plant 1
7 Boiler Plant
8 ANS
9 AN Plant 2
10 AN Plant 1
11 AN Bulk Storage
12 Bagged Product Storage

Infrastructure Key (1 - 16)

1 New demin water system
2 New ammonia storage nitrate pumps
3 New instrument air compressor and dryer
4 Extension to No.2 11kV substation
5 New NA storage
6 New pipe rack
7 11kV trident switchroom
8 New boiler
9 Cooling water supply pumps
10 New cooling water treat,emt skids
11 New cooling towers
12 New NAP4/AN3 switchroom and transformer
13 New NAP4 plant
14 Ammonia compressor
15 Contaminated condensate tank
16 Clean process condensate tank

Infrastructure Key (17 - 32)

17 New No.6 ammonia bullet
18 New emergency generator and switchroom
19 New control room
20 New entry
21 New workshop
22 New entry security gate
23 New office
24 New weighbridge
25 New concentrator plant
26 New ANS/WANS loadout
27 New first flush pi
28 New dispatch office and amenities
29 New bag store
30 New AN road bulk loadout and weighbridges
31 2x 1.05/1.2t bag lines and 1x 25/40kg bag line
32 Switchroom

Infrastructure Key (33 - 38)

33 Transformers
34 Container bag loading area
35 New bulk store
36 New weighbridge
37 New office
38 New exit security gate
39 New FEL workshop and forklift parking
40 Transtank
41 Proposed AN# plant
42 New container storage
43 Nitrogen tie in
44 New ammonia plant nitrates pump

Key

Site boundary
Existing infrastructure location
OBL Stage 1A
OBL Stage 1B
OBL Stage 2
NAP4 & ANS
AN3

Note:
Information derived from Hatch EMA plan HEN2561-0000-00-014-0012 (**05/04/2011**)

0 100 200m

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AECOM

APPROVED FACILITY PLAN

Proposed Modification, Greenleaf Road, Kooragang Island

FIGURE 2

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2.0 Pollutants of Interest and Existing Air Quality

2.1 Pollutants of Interest

The pollutants of interest for this modification are oxides of nitrogen (NOx) (as nitrogen dioxide NO_2) and ammonia (NH_3). These pollutants are expected to be contributors to the local atmosphere from the site's operations, specifically the flare operations and NA import tank scrubber. A brief description of the health and environmental effects of the two pollutants is provided in **Appendix A**.

2.2 Existing Air Quality

The closest ambient air quality and meteorological station to the facility is at Fullerton Street Stockton NSW. The station continuously monitors general air quality as well as wind speed and direction for the Stockton community. Air quality parameters measured are dust (PM_{10} and $PM_{2.5}$), Oxides of Nitrogen (NO_x) (including NO_2) and NH_3 levels. The data is publically available at the following web address http://www.stocktonairqualitymonitoring.com/ .

The currently available data on the website is for the period October 2012 to August 2013. The following table presents a summary of the monitored data for NO_2 and NH_3 for the data period October 2012 to August 2013.

Table 1 Stockton Monitoring Station Ambient Air Quality Data; October 2012 to August 2013

Parameter	NO_2 (ug/m3)	NH_3 (ug/m3)
Minimum	0	0
Average	15	11
Maximum	91	391
95th Percentile	49	52
70th Percentile	20	8

The 95th percentile data provided in the above table has been used as the background values in the assessment. The 95th percentile has been selected to remove any peaks in background caused by episodic events (such as bush fires, dust storms and accidental industrial incidents) while still maintaining a high quality set of data representative of typical ambient conditions. The 95th percentile is well above the annual average, over three times higher, so is likely to be higher than that typically present in the environment. EPA Victoria recommends the use of the 70th percentile for this function, so using the 95th percentile is considered conservative, particularly given that the 70th percentile is less than half the 95th percentile used in this assessment.

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3.0 Assessment Methodology

The following sections outline the models used and their inputs, modelling scenarios assessed, emissions estimation methodology and emission rates entered into the models. The modelling was prepared and conducted in accordance with the NSW EPA Approved Methods (DEC 2005).

3.1 Dispersion Model Selection

The Orica site is located in a coastal environment with relatively flat terrain. Typically for air quality assessments in coastal locations the CALPUFF dispersion model is used. CALPUFF is a non steady-state three dimensional Gaussian puff model developed for the US Environmental Protection Agency (US EPA) for use in situations where basic Gaussian plume models are not effective, such as areas with complex meteorological or topographical conditions, including coastal areas with re-circulating sea breezes. Modelling for the site was initially undertaken by AECOM in 2009 (ENSR 2009) using CALPUFF. The NO_2 results from the assessment were compared to the measured values at the Stockton monitoring station. The results from the 2009 CALPUFF model indicate the potential for significant over estimations at the monitoring site (a factor of 2 over observed results).

On the basis of the results from CALPUFF, the Ausplume model was investigated using the same emissions inputs and representative meteorological data. The Ausplume model predicted results approximately 25% higher than the observed results (full details of the study are provided in ENSR 2009). Given the conservative nature of the emissions data (assumed constant operation and the likelihood of double counting on background NO_2 concentrations), this difference was considered to be more acceptable than the CALPUFF results and the Ausplume model was adopted for the study. The study’s conclusion was discussed with the NSW EPA, who confirmed that the use of Ausplume for site assessments was acceptable.

As a result of the previous study’s findings, all subsequent dispersion modelling has been undertaken using Ausplume, including this current assessment.

Ausplume is an advanced Gaussian plume dispersion model with algorithms based on the Industrial Source Complex – Short Term (ISCST3) model approved by the US EPA for use in regulatory assessments undertaken within the United States. Ausplume was developed by the Victorian EPA to enhance the ISCST3 model and make it applicable to Australian conditions. Ausplume is approved by the NSW EPA for use in regulatory assessments undertaken in NSW. A complete description of the model is provided in the Ausplume user manual, which is available upon request.

The model uses the Gaussian dispersion model equation to simulate the dispersion of a plume from point, area or volume sources. Mechanisms for determining the effect of terrain on plume dispersion are also provided. Ausplume operates on an hourly time step, and therefore, requires hourly wind speed, wind direction and other dispersion parameter data. The dispersion of each pollutant plume is determined for each hour using conventional Gaussian model assumptions.

Input parameters used for the Ausplume dispersion modelling is summarised in **Table 2**.

Table 2 Summary of Ausplume Input Parameters

Parameter	Input
Ausplume Version	6.0
Modelling Domain	15 km x 15 km
Ausplume Modelling Grid Resolution	0.15 km
Number of Sensitive Receptors	40
Terrain Data	Not incorporated
Building Wake Data	Entered via Ausplume’s Building Profile Input Program (BPIP)
Dispersion Algorithm	PG (rural ISC curves) & MP Coeff. (Urban)
Hours Modelled	8736 hours (364 days)
Meteorological Data Period	Jan 1995 – Dec 1995

All dispersion modelling was undertaken in accordance with the Approved Methods for Modelling and Assessment of Air Pollutants published by NSW EPA (DEC, 2005). The document prescribes calculation modes to account for terrain effects, building wake effects, horizontal and vertical dispersion curves, buoyancy effects, surface roughness, plume rise, wind speed categories and wind profile exponents.

3.2 Model Inputs

AUSPLUME requires six main categories of data to determine the dispersion of air emissions:

- Meteorology;
- Terrain effects;
- Building wake effects;
- Modelling scenarios;
- Source characteristics; and
- Emissions inventory.

The above inputs are addressed separately in the following sections.

3.2.1 Meteorology

Meteorology in the area surrounding KI is affected by several factors such as terrain and land use. Wind speed and direction are largely affected by topography at the small scale, while factors such as synoptic scale winds (which are modified by sea breezes near the Newcastle coast in the daytime) and complex valley drainage flows that develop during night hours, affect wind speed and direction on the larger scale.

Meteorological data used in this study consisted of 12 months' worth of hourly averaged meteorological data collected in 1995 and used in the past Orica modelling air quality assessments. The data was used in order to provide a clear comparison with past dispersion modelling undertaken for the site and has previously been accepted by the NSW EPA for modelling at the site.

Despite the historical acceptance of the data by NSW EPA, questions may arise as to whether the year is representative of long-term average meteorological conditions and representative of expected regional behaviour. Selected long-term parameters for the Williamtown Bureau of Meteorology (BoM) weather station have been compared with the same parameters from the meteorological data set. In addition, the Stockton monitoring station has also been compared against the assessment data set. All three sets of data show a strong correlation with respect to distribution of wind direction and speed and confirmed that the 1995 data is appropriate for use in this assessment. The review is provided in **Appendix B**.

3.2.2 Terrain Effects

Katabatic drainage flow (or valley drainage flow) occurs under light winds and stable meteorological conditions. As air cools at night, it tends to fall and move down-hill in areas of significant topographic relief. As this air moves it tends to create a bulk movement of air, which can cause winds to blow in areas influenced strongly by topography.

Due to the low relative relief in the region surrounding the proposed Orica site, no significant katabatic drainage flows are expected. The regional climatic patterns, which are governed by the coastal meteorological conditions, are likely to dominate the wind patterns in the Newcastle Harbour area. Subsequently, terrain effects were not incorporated into the Ausplume model.

3.2.3 Building Wake Effects

The dispersion of air emissions around the Orica facility are likely to be affected by aerodynamic wakes generated by winds having to flow around buildings and plant equipment. Building wakes generally decrease the distance downwind at which the stack plumes comes into contact with the ground. This may result in higher air emission ground level concentrations closer to the emission source.

PRIME is the US EPA's preferred building wake algorithm. Ausplume includes the PRIME building wake algorithm and uses the Building Profile Input Program (BPIP) for entering the location and dimension of buildings. The location and dimensions of buildings located within a distance of 5L (where L is the lesser of the height or width of the building) from each release point for buildings with a height greater than 0.4 times the stack height were entered in the BPIP and aerodynamic wakes calculated.

3.2.4 Modelling Scenarios

The following modelling scenarios were examined to determine the likely air quality impacts resulting from proposed routine and non-routine operations; specifically addressing the impacts of flaring operations.

Table 3 Modelling Scenarios

ID	Name	Description
1	Routine Operation	Assessment of the sites routine manufacturing operations without flaring
2	Non-routine Operation	Assessment of the sites routine manufacturing operations together with constant operation of all three flares

Scenario 1 was selected to assess the routine operating conditions at the site with all emission sources constantly operational. This scenario assumes that the site is operating as routine with no flaring operations occurring. The scenario includes the addition of scrubber emissions from the 10,000 t NA import tank.

Scenario 2 was selected to assess the non-routine operating conditions at the site that considers all routine emission sources constantly operational **whilst** flaring is simultaneously occurring. The flaring involves all three flares operational at once. The scenario includes the addition of scrubber emissions from the 10,000 t NA import tank. This scenario is considered highly conservative due to the following:

- It is unlikely that the plant will be running at full operational capacity if the flaring is occurring i.e. a flaring event would occur when a problem arises at the site and other operations would be inhibited;
- The three flares are for separate operational sections of the site and are highly unlikely to be utilised at the same time, although there is a slight possibility; and
- It is expected that a flaring event would only occur under exceptional circumstances, with a predicted occurrence frequency of once every two years.

All modelling scenarios outlined above assumed the plants routine operations were at full capacity, running continuously (24 hours per day, 365 days per year). Scenario 2 assumed that the flares were also running 24 hours per day, 7 days per week. The facility is unlikely to operate at this level due to operational restrictions (such as breakdowns, maintenance and scheduled cleaning). The scenarios, therefore, represent worst-case conditions for the facility's operation, and are likely to overestimate the actual short and long-term impacts experienced by receptors surrounding the facility.

3.3 Emissions Inventory

The routine operation emission sources modelled are shown in **Table 4**. These sources are included in the model for both Scenario 1 and 2. The emissions inventory data were gained from the Orica document 'Ammonia Management Improvement Project – Comparison of Stack Discharge Data – EN2690-00-AA-002'; dated 21/10/13.

Table 4 Modelled Routine Operation Emission Sources (Scenarios 1 and 2)

Stack ID	Modelling Stack Description
BS1	Boiler Stack
1NA1	Nitric Acid Plant Stack (NAP1)
2NA1	Nitric Acid Plant Stack (NAP2)
3NA1	Nitric Acid Plant Stack (NAP3)
1AN5	CDC Evaporator Scrubber Stack
1AN6	Prill Tower
2AN4	Granulator Scrubber Stack
A8G2	Reformer Flue Stack
PRF	Pre-Reformer Furnace
E1	Nitric Acid Plant Stack (NAP4)
E5	NFG Boiler Stack
NAITS	NA Import Tank Scrubber

The flare emission sources are provided in **Table 5**.

Table 5 Modelled Flare Emission Sources (Scenario 2)

Stack ID	Modelling Stack Description
FLRS	Ammonia Storage Tank Flare Stack
FLRN	Nitrates Plant Flare Stack
FLRA	Ammonia Plant Flare Stack

3.3.1 Source Parameters

Stack characteristics for the Orica facility routine operations are summarised in the following table. This data has been gained from previously modelled assessments, with the addition of the NA import tank scrubber (NAITS) data that was supplied by Orica in document EN2690-00-AA-002 dated 21/10/13.

Table 6 **Routine Operation Stack Characteristics**

Stack ID	Stack Gas Flow Rate (Nm^3/s)	Stack Tip Area (m^2)	Stack Height (m)	Stack Internal Diameter (m)	Stack Velocity (m/s)	Gas Temp. (°C)
BS1	3.5	1.6	39.47	1.43	3.2	131.0
1NA1	16.7	0.73	83.82	0.965	33.9	133.0
2NA1	10.0	0.44	54.86	0.746	27.1	50.0
3NA1	11.1	0.43	55.1	0.74	41.9	170.0
1AN5	17.3	1.65	19.0	1.448	12.5	52.4
1AN6	8.6	10.31	48.15	3.6	0.9	37.3
2AN4	24.0	1.77	27	1.5	15.3	36.0
A8G2	46.4	5.60	47	2.67	11.1	93.0
PRF	5.3	1.43	27	1.35	5.2	110.0
E1	33.5	2.01	55	1.6	25.5	145.0
E5	19.3	2.01	40	1.6	16.6	200.0
NAITS	0.18	0.07	25.5	0.3	2.79	25

The design characteristics of the three flares are provided in **Table 7** and were provided by Orica. Of these parameters only the stack temperature were inputted directly into the model; the other parameters were modified to better represent flare characteristics; **Section 3.3.1.1** explains the modifications made to the flare parameters.

Table 7 **Design Flare Stack Characteristics**

Stack ID	Stack Gas Flow Rate (Am^3/s)	Stack Gas Flow Rate (Nm^3/s)*	Stack Tip Area (m^2)	Stack Height (m)	Stack Internal Diameter (m)	Initial Gas Temp. (°C)	Flame Temp. (°C)
FLRS	2.0	2.2	0.07	5	0.305	30	800
FLRN	4.8	5.4	0.16	8	0.458	30	800
FLRA	24.1	26.8	1.02	20	1.142	30	800

* Calculated using the initial gas temperature provided in the table.

Assist gas is not required for the flare operation so no additional natural gas flow is needed during flaring. A constant purge gas may be used to prevent the back migration of air into the flare header. If required the flow of natural gas is expected to be minor (0.0004 to 0.03 m3/s) and is not considered a significant source. Potential purging of the flare has therefore been omitted from this assessment.

3.3.1.1 Calculation of Flare Parameters

Flares are considered a special type of elevated source that may be modelled as a point source. In a flare, the velocity of the waste stream and the flare temperature are not used to determine the plume rise; rather, the Texas Commission on Environmental Quality (2006) (TCEQ) suggests use of the parameters and formula explained below to calculate the effective stack diameter based upon the net heat release and the average molecular weight of the compounds being burnt. Enclosed vapour combustion units should not be modelled with the provided parameters, but instead with stack parameters that reflect the physical characteristics of the process unit (Orica use open units).

If a flare is to be treated as a point source, accurate determination of all stack parameters is not possible. Since combustion occurs at or beyond the flare tip in the atmosphere, appropriate values for stack exit temperature and exit velocity cannot be accurately determined. The diameter of the pipe leading to the flare tip is not a factor in determining plume rise. The point source algorithm should be used with arbitrary values assigned for stack exit velocity (20 m/s) and temperature (1,000C) to predict dispersion for flare type sources. As the physical Orica flare temperature has been estimated and is less than the arbitrary value provide by the TCEQ, the temperature values presented in **Table 7** have been used in the assessment.

A stack height equal to the height of the flare tip is recommended for flares by TCEQ. The effective flare tip diameter is determined using the following equation (TCEQ 2006):

$$D = \sqrt{((10^{-6})q(1 - 0.048\sqrt{(MW)}\,))}$$

where

D = effective flare tip diameter, meters

q = net or lower heat release, cal/sec

MW = volume average molecular weight, g/g-mole

The net heat release (*q*) from each stack has been calculated based on the Orica document "Ammonia Flares – Design Selection and Operation" (document number EN2690-00-08-009). The document provides the heat release per megawatt (MW) for the three stacks; 20.6 MW for FLRS, 51.5 MW for FLRN and 288.6 MW for FLRA. The heat release values were calculated based on design capacity feed rates, whereas this assessment has been undertaken on slightly inflated values in order to provide a buffer (see **Section 3.3.2**). The heat release values provided in the document have therefore been proportionally increased to account for the inflated values. The net heat release values, converted to calories per second (cal/sec), are provided in **Table 8**. These values were applied to the TCEQ formula above (as *q*), together with the molecular weight values provided in the table, to calculate the modelling stack diameters.

Table 8 Flare Stack Parameters for Modelling

Stack	Net Heat Release (cal/sec) q	Molecular Weight (g/g-mole)	Calculated Stack Diameter (m)	Physical Stack Height (m)*	Estimated Flare Flame Length (m)*	Calculated Stack Height (m)
FLRS	6,154,393	17	2.22	5	10	15
FLRN	14,770,543	17	3.44	8	18	26
FLRA	73,852,717	17	7.70	20	36	56

* Stack height and estimated flame length data supplied by Orica

3.3.2 Source Emission Rates

The routine operational emission rates for the Orica site are provided in **Table 9**. The data has been based on previous site assessments (AECOM 2011), with the addition of the nitric acid import tank data supplied by Orica, and represent the worst case stack emissions based on the maximum individual unit capacities.

The NA import tank scrubber NO_X emission rate has been based on the maximum allowable NO_2 equivalent concentration appropriate for the category 'general activities and plant' for Group 6 activities from the Protection of the Environment Operations (Clean Air) Regulation 2010 (POEO). This stipulates a maximum concentration of 350 mg/Nm^3. The expected routine operation NOx (as NO_2) value is expected to be 200 mg/Nm^3, with a maximum design value of 350 mg/Nm^3. The use of the maximum POEO limit is therefore considered a conservative approach to modelling the scrubber's emissions.

Table 9 Routine Emissions Characteristics

Stack ID	Pollutant Concentration (mg/Nm^3)		Pollutant Emission Rates (g/s)	
	NO_x	NH_3	NO_x	NH_3
BS1	49.5	-	0.17	-
1NA1	559	-	9.31	-
2NA1	431	-	4.31	-
3NA1	381	-	4.23	-
1AN5	-	12	-	0.21
1AN6	-	11	-	1.14
2AN4	-	29	-	0.69
A8G2	234	16	10.9	0.74
PRF	234	-	1.2	-
E1	286	-	9.6	-
E5	234	-	4.5	-
NAITS	350	-	0.063	-

The emission rates for the flares have been generated from the design information provided by Orica. In order to create a buffer for the flare operations and provide a conservative assessment of potential impacts, the design feed rates were increased from 4 t/hr to 5 t/hr for FLRS, 10 t/hr to 12 t/hr for FLRN and 56 t/hr to 60 t/hr for FLRA. The increased rates were applied in the emissions calculations. The information provided to generate the emission rates is provided in **Table 10**.

Table 10 Flare Design Information

Stack ID	NH_3 Feed Rate (kg/hr)	Destruction Efficiency (%)	Ratio of remaining NO_X/NH_3	NOX Release Rate (kg/hr)	NH3 Release Rate (kg/hr)
FLRS	5,000	97	50/50	75	75
FLRN	12,000	97	50/50	180	180
FLRA	60,000	97	50/50	900	900

The emission rates for the flares are provided in **Table 11**. The estimated emission rates have been calculated based on the data provided by Orica presented above.

Table 11 Flare Emissions Characteristics

Stack ID	Pollutant Concentration (mg/Nm^3)		Pollutant Emission Rates (g/s)	
	NO_x	NH_3	NO_x	NH_3
FLRS	9,339	9,339	21	21
FLRN	9,339	9,339	50	50
FLRA	9,339	9,339	250	250

3.4 Conversion of NO_X to NO_2 – Ozone Limiting Method (OLM)

Nitrogen oxides are produced in most combustion processes and are formed during the oxidation of nitrogen in the fuel and nitrogen in the air. During high-temperature processes a variety of nitrogen oxides are formed including nitric oxide (NO) and nitrogen dioxide (NO_2). Generally, at the point of emission, NO will comprise the greatest proportion of the emission with 95% by volume of the NO_x. The remaining NO_x will consist of NO_2.

Ultimately, however, all nitric oxides emitted into the atmosphere are oxidised to NO_2 and then further to other higher oxides of nitrogen. The rate at which this oxidisation takes place depends on prevailing atmospheric conditions including temperature, humidity and the presence of other substances in the atmosphere such as ozone. It can vary from a few minutes to many hours.

The rate of conversion is important because from the point of emission to the point of maximum ground level criteria there will be an interval of time during which some oxidation will take place. If the dispersion is sufficient to have diluted the plume to the point where the concentration is very low it is unimportant that the oxidation has taken place. However, if the oxidation is rapid and the dispersion slow then high concentrations of NO_2 can occur.

The USEPA's Ozone Limiting Method (OLM) has been used to predict ground-level concentrations of NO_2. The OLM is based on the assumption that approximately 10% of the initial stack NO_x emissions are emitted as NO_2. If the ozone (O_3) concentration is greater than 90% of the predicted NO_x concentrations, all the NO_x is assumed to be converted to NO_2, otherwise NO_2 concentrations are predicted using the equation $NO_2 = 46/48 * O_3 + 0.1 * NO_x$. This method assumes instant conversion of NO to NO_2 in the plume, which overestimates concentrations close to the source as conversion usually occurs over periods of hours. This method is described in detail in the Approved Methods.

OLM has been applied in the assessment using the maximum predicted NO_x impact and the annual 0_3 value from the Stockton monitoring station.

3.5 Assessment Criteria

Table 12 presents the impact assessment criteria specified in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW DEC, 2005). These criteria apply to the air impacts from the facility alone (isolation) and the combined impacts of the facility and background values (cumulative).

Table 12 Relevant Air Quality Impact Assessment Criteria

Air Emission	Averaging Period	Regulatory Limit ($\mu g/m^3$)	Assessment Percentile
Nitrogen Dioxide (NO_2)	1 hour	246	100^{th}
	Annual	62	100^{th}
NH_3	1 hour	330	99.9^{th}

Applying the annual average criterion against Scenario 2 (non-routine operations that include flaring) modelling results is considered extremely conservative, as the emissions from the flares are expected to be short-term events, however they have been modelled as constant emissions for the entire modelling period.

3.6 Sensitive Receptors

The Ausplume modelling domain incorporates a 15 km by 15 km grid with a resolution was 0.15 km, centred over the Orica facility. Within this gridded modelling domain, discrete sensitive receptors were modelled in addition to the gridded receptors placed over the entire modelling domain. The NSW EPA considers sensitive receptors to be areas where people are likely to either live or work, or engage in recreational activities. On this basis, representative sensitive receptors were positioned at 40 locations surrounding the Orica facility. A summary of the approximate sensitive receptor locations is presented in **Appendix C**.

3.7 Cumulative Assessment Methodology

It needs to be noted that Orica already contributes to the background air quality against which it is to be assessed. Using the methodology described by the NSW EPA Approved Methods results in a “double counting” of pollutant concentrations; the degree to which this double counting influences the cumulative results has not been addressed by this report. As this increases the level of conservativeness in the modelling, it has been included in the assessment.

In order to adequately assess the potential background concentration of pollutants in the future, measures were taken to review the potential contribution from the proposed Incitec Pivot Limited (IPL) expansion on the land to the north of the Orica site. IPL propose to build an ammonia nitrate facility at 39 Heron Road, Kooragang Island as detailed in URS 2012. The lot of land currently includes the existing operations of the IPL fertilizer facility as well as mainly vacant land on which the development would be built. As confirmed in a press release dated 26 September 2012 from IPL, the feasibility study has been suspended, with a likely decision made on whether to proceed with the plant deferred for at least two years (from date of press release).

The IPL report provided predicted impacts for both routine and non-routine operations of the existing facility and expansion. The results of the routine (normal plant) operations have been used in the Orica assessment as this is the most likely scenario when a flaring event may be happening at the Orica site. The IPL incremental data (IPL site operations alone) has been used in the assessment; by doing this the current impacts from the fertiliser portion of the site would be double counted by the background values applied resulting in conservative results. A summary of the maximum IPL routine incremental impacts at a discrete receptor are presented in **Table 13**. Note that the IPL NO_2 data conservatively assumes total conversion of NO_X from the facility to NO_2. The IPL NO_2 result provided is for the 99.9^{th} percentile and the NH_3 is for the 100^{th} percentile.

Table 13 Predicted IPL Routine Discrete Receptor Results (from URS 2012)

Pollutant	1 Hour Impact (µg/m3)	Annual Average Impact (µg/m3)
NO_2	25	0.4
NH_3	1.2	NA

3.8 Limitations of Dispersion Modelling

The atmosphere is a complex, physical system, and the movement of air in a given location is dependent on a number of variables, including temperature, topography and land use, as well as larger-scale synoptic processes. Dispersion modelling is a method of simulating the movement of air pollutants in the atmosphere using mathematical equations. The model equations necessarily involve some level of simplification of these very complex processes, based on our understanding of the processes involved and their interactions, available input data, processing time and data storage limitations.

These simplifications come at the expense of accuracy, which particularly affects model predictions during certain meteorological conditions and source emission types. For example, the prediction of pollutant dispersion under low wind speed conditions (typically defined as those less than 1 m/s) or for low-level, non-buoyant sources, is problematic for most dispersion models. To accommodate these known deficiencies, the model outputs tend to provide conservative estimates of pollutant concentrations at particular locations.

While the models contain a large number of variables that can be modified to increase the accuracy of the predictions under any given circumstances, the constraints of model use in a commercial setting, as well as the lack of data against which to compare the results in most instances, typically precludes extensive testing of the impacts of modification of these variables. With this in mind, model developers typically specify a range of default values for model variables that are applicable under most modelling circumstances.

The results of dispersion modelling, therefore, provide an indication of the likely level of pollutants within the modelling domain. While the models, when used appropriately and with high quality input data, can provide very good indications of the scale of pollutant concentrations and the likely locations of the maximum concentrations occurring, their outputs should not be considered to be representative of exact pollutant concentrations at any given location or point in time.

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4.0 Impact Assessment

4.1 Predicted Nitrogen Dioxide Modelling Results

The maximum predicted sensitive receptor ground level concentrations of NO_2 for the 1 hour average and annual average are presented in **Table 14** and **Table 15** respectively. The impact from the facility alone (incremental) and cumulatively with the Stockton monitoring data and IPL impact are provided.

Table 14 Maximum Sensitive Receptor 1 Hour Average Predicted Ground Level Concentrations – NO_2

Scenario	1 Hour Maximum NO_2 ($\mu g/m^3$)			
	Incremental	Stockton Background	IPL Routine Impact	Cumulative
1 – Routine operations	91	49	25	165
2 – Non-routine operations	137	49	25	212
Criteria	**246**			

The 1 hour average NO_2 results for both the routine and non-routine (with flaring) operations are predicted to meet the NSW EPA criterion. The highest predicted NO_2 1 hour average concentrations occurred at industrial receptors on KI located in proximity to the Orica site.

Table 15 Maximum Annual Average Predicted Ground Level Concentrations – NO_2

Scenario	Annual Maximum NO_2 ($\mu g/m^3$)			
	Incremental	Stockton Background	IPL Routine Impact	Cumulative
1 – Routine operations	7	15	0.4	22
2 – Non-routine operations	9	15	0.4	24
Criteria	**62**			

The annual average NO_2 results for both the routine and non-routine (with flaring) operations are predicted to meet the NSW EPA criterion. The highest predicted cumulative NO_2 annual average concentrations occurred at industrial receptors on KI located in proximity to the Orica site.

4.2 Predicted Ammonia Modelling Results

The maximum predicted sensitive receptor ground level concentrations of NH_3 for the 1 hour average are presented in **Table 16**. The impact from the facility alone (incremental) and cumulatively with the Stockton monitoring data and IPL impact are provided.

Table 16 Maximum Sensitive Receptor 1 Hour Predicted Ground Level Concentrations – NH_3

Scenario	1 Hour Maximum NH_3 ($\mu g/m^3$)			
	Incremental	Stockton Background	IPL Routine Impact	Cumulative
1 – Routine operations	58	52	1.2	111
2 – Non-routine operations	91	52	1.2	144
Criteria	**330**			

The 1 hour average NH_3 results for both the routine and non-routine (with flaring) operations are predicted to meet the NSW EPA criterion. The highest predicted NH_3 1 hour average concentrations occurred at industrial receptors on KI located in proximity to the Orica site.

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5.0 Conclusion

This AQIA has been prepared to assess the potential air quality impacts primarily from the flares proposed for the ammonia plant, ammonia storage tank and nitrates plants, together with the sites routine operations including a 10,000 t NA import tank and associated scrubber and appropriate background pollutant concentrations.

Two modelling scenarios were selected for the assessment: routine operations (routine operating conditions at the site with no flaring) and non-routine operations (routine operating conditions at the site with flaring (all three flares operating at once)). Both scenarios include the addition of scrubber emissions from the 10,000 t NA import tank.

This flaring scenario is considered highly conservative due to the following:

- It is unlikely that the plant will be running at full operational capacity if the flaring is occurring i.e. a flaring event would occur when a problem arises at the site and other operations would be inhibited;
- The three flares are for separate operational sections of the site and are highly unlikely to be utilised at the same time, although this is a possibility; and
- It is expected that a flaring event would only occur under exceptional circumstances, with a predicted occurrence frequency of once every two years.

The 1 hour average NO_2 and NH_3 results for both the routine and non-routine (with flaring) operations are predicted to meet the NSW EPA criteria.

The annual average NO_2 and NH_3 results for both the routine and non-routine (with flaring) operations are predicted to meet the NSW EPA criteria.

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6.0 References

DEC (2005) *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales,* Department of Environment and Conservation, Sydney, NSW, Australia.

ENSR. (2009). Air Quality Impact Assessment, Kooragang Island NSW. Appendix E of AECOM. (2009). Proposed Ammonium Nitrate Facility Expansion Environmental Assessment, June 2009.

Texas Commission on Environmental Quality (2006); Air Permits Division; New Source Review (NSR) Emission Calculations; Sample Calculations for Flares.

URS (2012). Air Quality Impact Assessment for Proposed Ammonium Nitrate Facility, Kooragang Island.

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Appendix A

Description of Pollutants of Interest

Appendix A Description of Pollutants of Interest

The pollutants of interest for the project are NO_x (as NO_2) and NH_3. These pollutants are expected to be contributors to the local atmosphere from the sites operations, specifically the flare operations and NA import tank scrubber. A brief description of the two pollutants is provided below:

Nitrogen Dioxide

Nitrogen dioxide is a brownish gas with a pungent odour. It exists in the atmosphere in equilibrium with nitric oxide. The mixture of these two gases is commonly referred to as NO_x. NO_x is a product of combustion and oxidation processes. In urban areas, motor vehicles and industrial combustion processes are the major sources of ambient NO_x.

Health Effects

NO_2 may be inhaled or absorbed through the skin. People who live in areas of high motor vehicle usage may be exposed to higher levels of nitrogen oxides. Acute exposure to low levels of NO_2 can irritate eyes, nose, throat and lungs, possibly leading to coughing, shortness of breath, tiredness and nausea. Exposure can also result in a build-up of fluid in the lungs for 1-2 days after exposure. Breathing high levels of NO_2 can cause rapid burning, spasms and swelling of tissues in the throat and upper respiratory tract, reduced oxygenation of tissues, a build-up of fluid in the lungs, and in extreme cases death.

Environmental Effects

Excessive levels of the NO_x, particularly NO_2, can cause death in plants and roots and damage the leaves of many agricultural crops. NO_2 is the damaging component of photochemical smog. Excessive levels increase the acidity of rain (lower the pH), and thus lower the pH of surface and ground waters and soil. The lowered pH can have harmful effects, possibly even death, on a variety of biological systems.

In the atmosphere, NO_x are rapidly equilibrated to NO_2, which eventually forms acid rain. In the stratosphere, oxides of nitrogen play a crucial role in maintaining the levels of ozone. Ozone is formed through the photochemical reaction between nitrogen dioxide and oxygen.

Ammonia

Ammonia is released during intensive livestock production, and from humans and pets. Other sources of ammonia emission include the manufacture of basic chemicals, metals, leather products, cement, lime, plaster and concrete products, glass products, ceramics, beverages, cars and car parts, textile products and paper and paper products. Ammonia is also produced from mining, electricity supply and petroleum refining activities.

Health Effects

Exposure to typical environmental concentrations of ammonia will not affect humans. Ammonia has been used for a long time in human and veterinary medicine and in smelling salts. Exposure to high levels of ammonia can cause irritation and serious burns on the skin, and in the mouth, throat (laryngitis), lungs (pulmonary oedema) and eyes (conjunctivitis). Exposure at very high levels of ammonia can lead to death. Swallowing concentrated solutions of ammonia can cause burns in the mouth, throat and stomach. Splashing ammonia into the eyes can cause burns and blindness. Individuals that may be more sensitive to ammonia are those with reduced liver function, corneal disease, glaucoma or respiratory diseases (e.g. asthmatics).

Environmental Effects

Nitrogen is essential for all forms of life, and ammonia is one of the many forms that nitrogen exists in the environment. At high levels of ammonia, toxic effects can be observed. These may include the death of animals, birds, fish and death or low growth rate in plants.

Long-term effects may include shortened lifespan, reproductive problems, lowered fertility, and changes in appearance or behaviour. These may be seen long after the first exposure to ammonia. Under normal temperature and pH conditions, ammonia has moderate long-term toxicity to aquatic

Appendix B

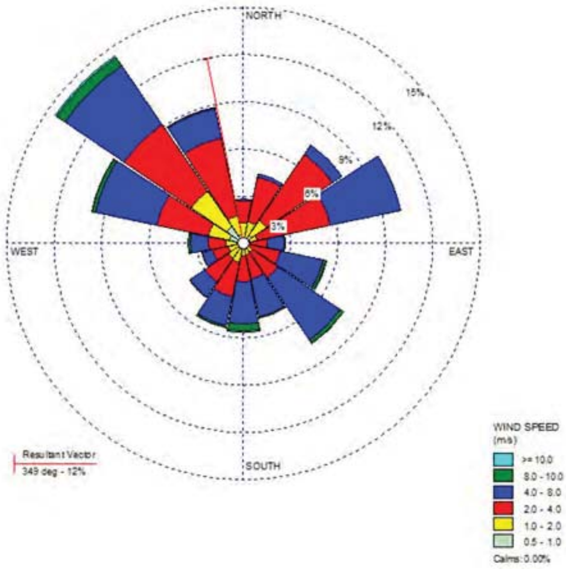
Meteorological Data Comparison

Appendix B Meteorological Data Comparison

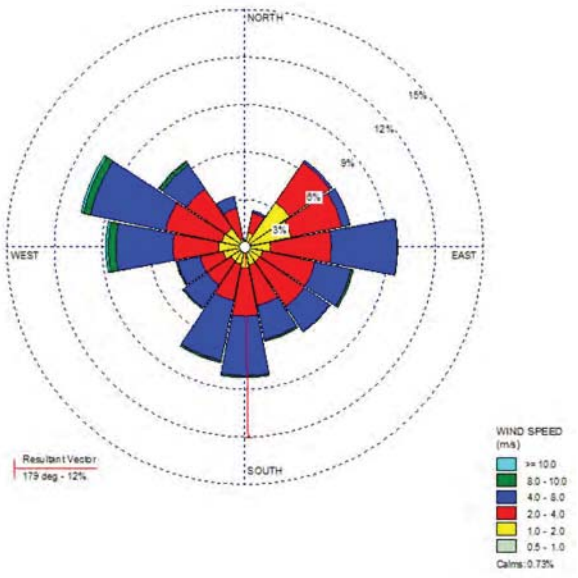
Wind roses show the frequency of occurrence of winds by direction and strength. Each wind rose arm represents a wind blowing from the direction it is projected i.e. arm pointing up represents northerly winds. The length of the bar represents the frequency of occurrence of winds from that direction, and wind speed categories are defined by different colours.

A comparison of the wind rose diagrams prepared for the BHP 1995 monitoring data against the Stockton Monitoring Station data for October 2012 to August 2013 (available data at http://www.stocktonairqualitymonitoring.com/) are shown below. The data are presented for the annual average, 9am average and 3pm average.

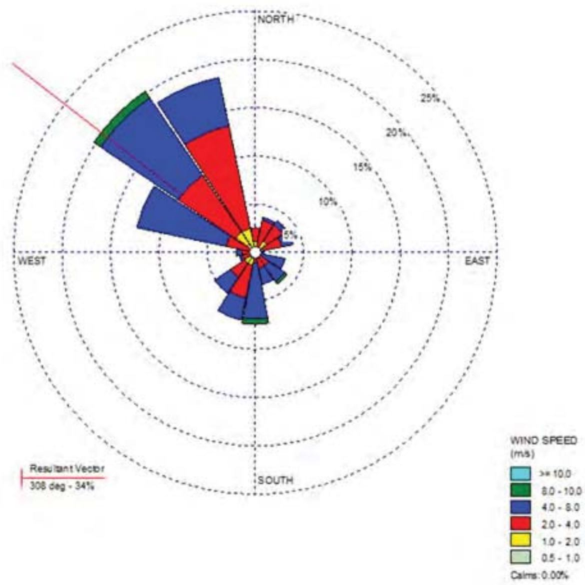
The data shows that a good correlation exists between the BHP data set used in the assessment and the Stockton monitoring Station data. Both sets of data show annual winds from most directions, with higher tendencies towards the north west and east north-east. Both sets of data also show 9am wind distribution dominated from the north west and 3pm wind distribution dominated from the north north-east to south east winds. This aligns with the common wind patterns seen in the lower hunter.



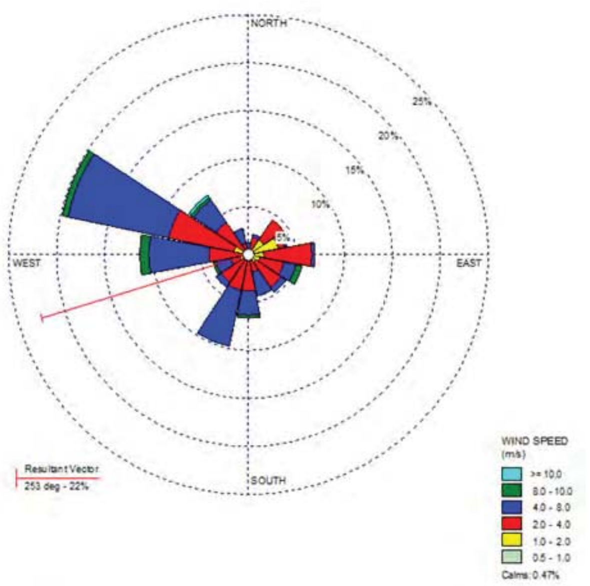
BHP 1995 Data Set – Annual



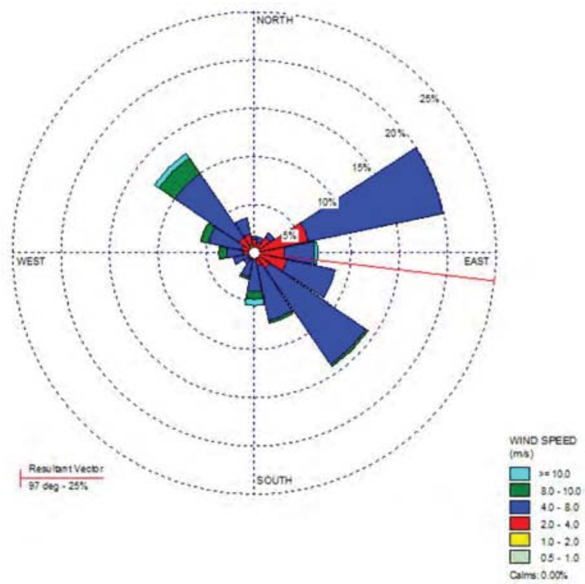
Stockton Monitoring Station October 2012 to August 2013 – Annual



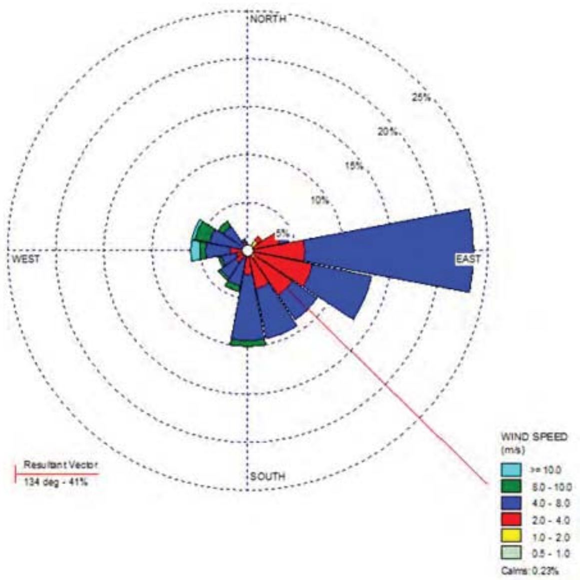
BHP 1995 Data Set – 9am



Stockton Monitoring Station October 2012 to August 2013 – 9am



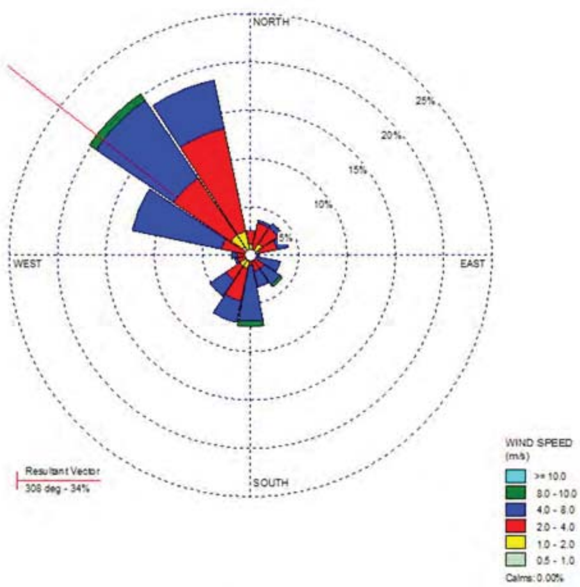
BHP 1995 Data Set – 3pm



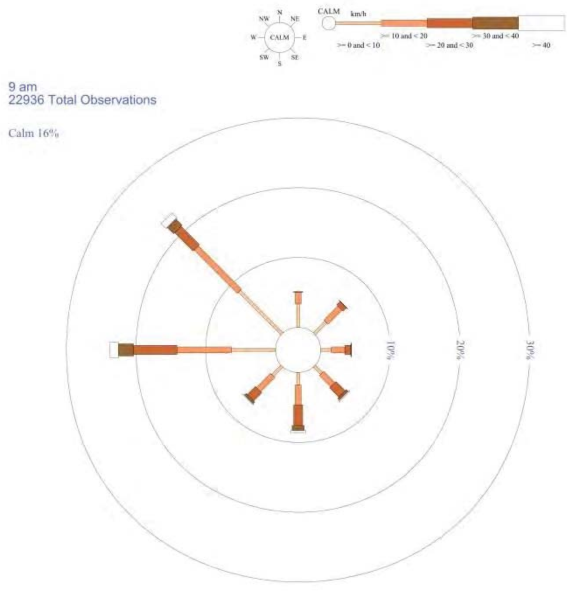
Stockton Monitoring Station October 2012 to August 2013 – 3pm

A comparison of the wind rose diagrams prepared for the BHP 1995 monitoring data against the Bureau of Meteorology (BoM) Williamtown monitoring station long-term data for 1942 to 2010 are shown below. The data presented is the 9am average and 3pm average.

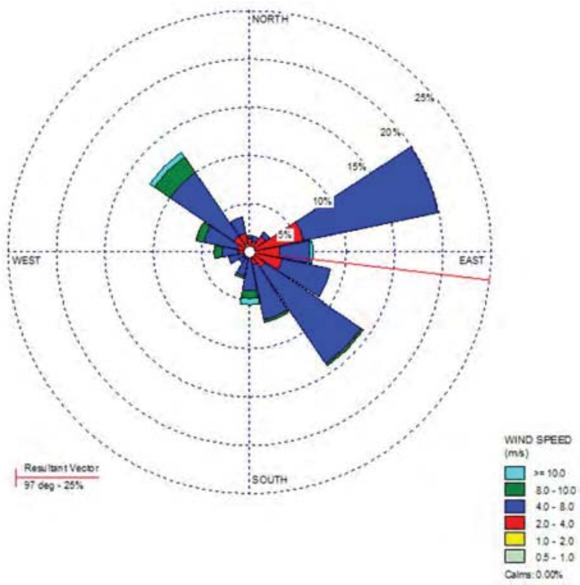
The data shows that a good correlation exists between the BHP data set used in the assessment and the BoM Williamtown long-term data. Both sets of data show 9am wind distribution dominated from the north west and 3pm wind distribution dominated from the north north-east to south east winds. This aligns with the common wind patterns seen in the lower hunter.



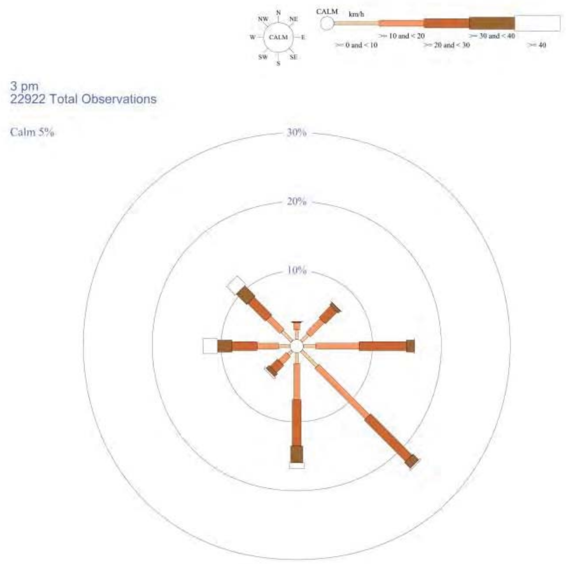
BHP 1995 Data Set – 9am



BoM Williamtown 1942 to 2010 – 9am



BHP 1995 Data Set – 3pm



BoM Williamtown 1942 to 2010 – 3pm

The distribution of wind speeds was also reviewed for the assessment. The below tables present the data for the BHP data set and the Stockton Monitoring Station data in that order. The two data sets show an excellent correlation in wind speed distribution. The dominate wind range was 2-4 m/s for both sites, with both showing a 41% contribution. The next dominate ranges, in order, were 4-8, 1-2, ≤1 and >8 m/s for both data sets. The BHP data set showed a higher percentage of low wind speeds less than 1 m/s (8% verse 5% for the Stockton data).

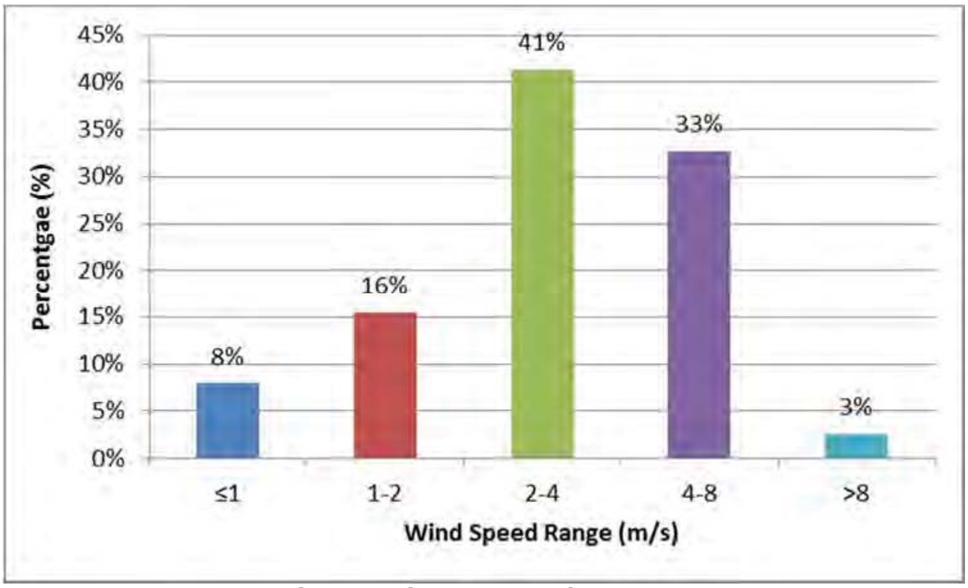


Figure BHP 1995 Data Set Wind Speed Range Contribution

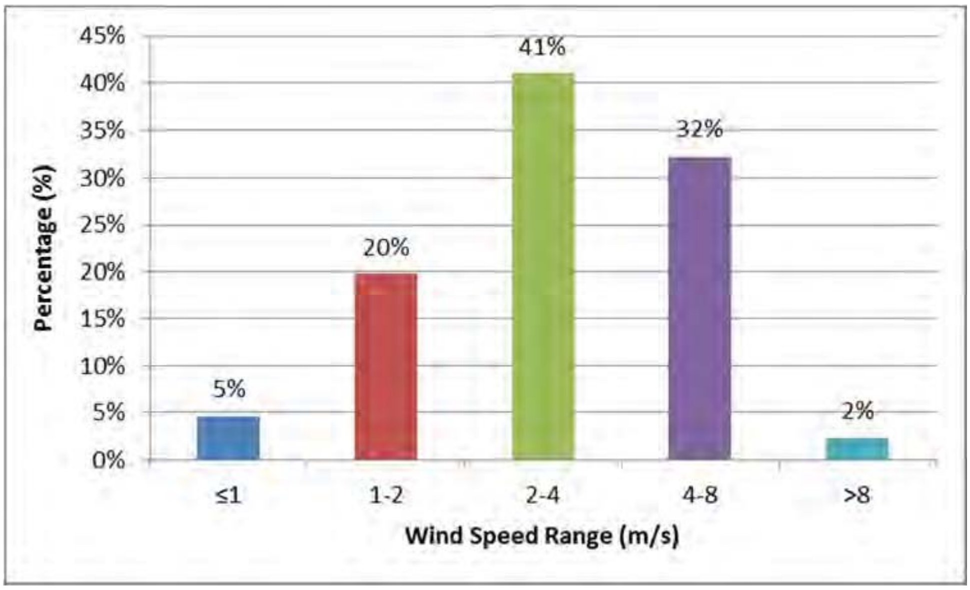


Figure Stockton Monitoring Station October 2012 to August 2013 Wind Speed Range Contribution

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Appendix C

Sensitive Receptor Locations

Appendix C Sensitive Receptor Locations

A summary of the approximate sensitive receptor locations is presented below in **Table 17**. The receptors have been defined as residential, industrial or sporting to help identify the sensitivity of the receptor.

Table 17 Sensitive Receptor Locations

Sensitive Receptor No.	Sensitive Receptor Description	Type
1	Corner of Meredith Ave & Fullerton Streets, Stockton	Residential
2	Corner of Griffith Ave. & Fullerton Streets, Stockton	Residential
3	Corner of Stone & Fullerton Streets, Stockton	Residential
4	Corner of Flint & Fullerton Streets, Stockton	Residential
5	Corner of Cardigan & Fullerton Streets, Stockton	Residential
6	Corner of Pembroke & Fullerton Streets, Stockton	Residential
7	Corner of Hereford & Fullerton Streets, Stockton	Residential
8	Corner of Monmouth & Fullerton Streets, Stockton	Residential
9	Corner of Griffith Ave. & Dunbar Streets, Stockton	Residential
10	Corner of Stone & Dunbar Streets, Stockton	Residential
11	Corner of Cardigan & Dunbar Streets, Stockton	Residential
12	Corner of Pembroke & Douglas Streets, Stockton	Residential
13	Corner of Roxburgh and Hereford Streets, Stockton	Residential
14	Corner of Forfar & Monmouth Streets, Stockton	Residential
15	Corner of Mitchell & Pembroke Streets, Stockton	Residential
16	Corner of Dunbar & Hereford Streets, Stockton	Residential
17	Corner of Dunbar & Monmouth Streets, Stockton	Residential
18	Corner of Scott & Elizabeth Streets, Carrington	Residential
19	Corner of Scott & Hargrave Streets, Carrington	Residential
20	Corner of Robertson & Scott Streets, Carrington	Residential
21	Corner of Coe and Bourke Streets, Carrington	Residential
22	Corner of Gipps & Hargrave Streets, Carrington	Residential
23	Corner of Young & Robertson Streets, Carrington	Residential
24	Corner of Young & Victoria Streets, Carrington	Residential
25	Corner of Denison & Cowper Streets, Carrington	Residential
26	Corner of Fitzroy & Tully Streets, Carrington	Residential
27	Corner of Harrison & Hannell Streets, Maryville	Residential
28	Corner of William Streets, & Industrial Dr. Maryville	Residential
29	Corner of Elizabeth Streets, & William Streets, Maryville	Residential
30	Corner of Graham Bridge & Lewis Streets, Maryville	Residential
31	Corner of Harrison & Lewis Streets, Maryville	Residential
32	Corner of Downie & Estell Streets, Maryville	Residential

Sensitive Receptor No.	Sensitive Receptor Description	Type
33	Corner of The Avenue & Lewis Streets, Maryville	Residential
34	Port Hunter Commodities Administration Building	Industrial
35	Port Waratah Coal Service Administration Building	Industrial
36	No. 3 Kooragang Berth	Industrial
37	No.2 Kooragang Berth	Industrial
38	Greenleaf Rd. Kooragang Island	Industrial
39	Corner of Oval Dr. & Riverview Rd. Stockton	Sporting
40	Oval Dr. opposite Stockton Cemetery	Sporting

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