Goldsworthy Iron Ore Mining Operations - Cundaline and Callawa Mining Operations Air Quality, Noise and Blasting Assessment

PREPARED BY:

Heggies Pty Ltd
212 Whatley Crescent Maylands WA 6051
Telephone 61 8 9370 0100 Facsimile 61 8 9370 0101
Email perth@heggies.com Web www.heggies.com

DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
75-1122	Revision 0	10 December 2008	Darlene Heuff	Darlene Heuff	Darlene Heuff
75-1122	Draft 3	2 October 2008	Darlene Heuff / Joe Carroll	Martin Doyle / Jerome Rivory	
75-1122	Draft 2	12 September 2008	Darlene Heuff / Joe Carroll	Martin Doyle / Jerome Rivory	
75-1122	Draft 1	8 September 2008	Darlene Heuff / Joe Carroll	Martin Doyle / Jerome Rivory	

EXECUTIVE SUMMARY

Heggies Pty Ltd has been commissioned by BHP Billiton Iron Ore Pty Ltd to conduct an air quality, noise and blasting assessment of the proposed expansion of the Goldsworthy Iron Ore Mining Operations (Goldsworthy operations) to include the mining of iron ore from the Cundaline and Callawa Deposits.

The operations are centred at Yarrie with existing operational deposits including Cattle Gorge, Yarrie, and Nimingarra. The opening of the planned Cundaline and Callawa mining operations will coincide with the phasing out of mining operations at the existing Yarrie and Cattle Gorge Deposits.

The planned Cundaline and Callawa mining operations would result in the production of up to approximately 2.5 million tonnes per annum (Mtpa) of iron ore. Mining at all Goldsworthy operations (including the Cundaline and Callawa Deposits) will continue to produce iron ore at up to approximately 8.5 Mtpa. Ore from the Callawa Deposit will be transported to the Yarrie facility for processing. Two options for the processing of ore extracted from the planned Cundaline mining operations have been considered:

- On-site processing using mobile plant and equipment; or
- Transportation of ore via road train to the Yarrie facility for processing.

Impacts on amenity at the Yarrie accommodation camp have been investigated. The Yarrie homestead was considered to be of sufficient distance from the sites not to be significantly affected by the impact of dust and noise emissions.

Air Quality

Results of the dispersion modelling have not highlighted any air quality issues in relation to emissions of particulate matter associated with:

- Overburden-related activities at the planned Cundaline and Callawa mining operations;
- Extraction of material from the planned Cundaline and Callawa mining operations;
- Processing, material handling, and train load-out at the Yarrie processing facility; and
- Stockpile erosion at the Yarrie processing facility during adverse wind conditions.

Results of the dispersion modelling highlight wheel-generated dust associated with transport as having the greatest potential to impact on air quality at the location of the accommodation camp, however modelling results indicated no exceedances of criteria were predicted from project-only emissions.

Greenhouse Gases

The total annual emissions of carbon dioxide-equivalent (CO_2-e) as a result of mining activities associated with the planned Cundaline and Callawa mining operations are likely to be in the order of 18,846 tonnes of CO_2-e per annum.

The Western Australian (WA) Environmental Protection Authority Guidance Statement for Minimising Greenhouse Gas Emissions reports total Australian 1990 emissions (i.e. comparison against 1990 levels recommended by the Kyoto Protocol) of 503.3 million tonnes (Mt) CO_2-e and WA's total 1990 emissions to be 42.5 Mt CO_2-e. A comparison of the predicted emissions from the planned Cundaline and Callawa mining operations against the 1990 levels demonstrates that the mining of the Cundaline and Callawa Deposits would represent approximately 0.004% of the total baseline Australian emissions and approximately 0.04% of the total baseline WA emissions.

More recent National emission estimates (i.e. 576 Mt in 2006) and WA emission estimates (i.e. 70.4 Mt in 2006) result in emissions from the planned Cundaline and Callawa mining operations comprising 0.003% of the total baseline Australian emissions and 0.03% of the total baseline WA emissions.

Noise and Blasting

The noise impacts associated with the following activities have been assessed using CONCAWE algorithms under "worst case" conditions:

- Typical mining plant in pits and on haul roads.
- Potential crushing and screening plant at the planned Cundaline mining operations.
- Potential rail load-out facility at the planned Cundaline mining operations.
- Existing crushing and screening plant at the Yarrie processing facility.
- Existing rail load-out facility at Yarrie.
- Possible road train movements between the planned Cundaline mining operations and the Yarrie processing facility.

Results were found to achieve less than the assigned noise levels.

The noise assessment identified that the highest noise impact associated with the planned Cundaline and Callawa mining operations was road trains travelling between the planned Cundaline mining operations and the Yarrie processing facility.

Airblast levels were found to achieve less than the criterion.

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

1 INTRODUCTION

BHP Billiton Iron Ore Pty Ltd (BHPBIO) is proposing to expand the Goldsworthy Iron Ore Mining Operations (Goldsworthy operations) to include the planned Cundaline and Callawa mining operations located in the Pilbara Region of Western Australia (WA).

Heggies Pty Ltd (Heggies) has been commissioned by BHPBIO to undertake an air quality, noise and blasting assessment of activities associated with the planned Cundaline and Callawa mining operations.

This assessment takes into account the impacts of ore processing from existing mining activities (i.e. ore processing at Yarrie) associated with the Goldsworthy operations and mining and processing operations associated with the Cundaline and Callawa Deposits.

1.1 Air Quality Assessment Objectives

The objectives of the air quality assessment were to:

- Identify the dominant dust-generating activities based on their potential for impacts on air quality at the location of the nearest sensitive receptor(s);
- Quantify worst-case incremental impacts of dust emissions from the dominate source(s) using dispersion modelling;
- Qualitatively assess the impacts of dust emission sources on air quality at sensitive receptor location(s);
- Qualitatively assess construction impacts; and
- Conduct a Greenhouse Gas Assessment.

1.2 Noise and Blasting Assessment Objectives

The objective of the noise and blasting assessment was to quantify the impact of noise and blasting generating activities on amenity at sensitive receptor location(s).

1.3 Relevant Documentation

In addition to the documents cited within this report, consideration of information contained in the following documents was considered in relation to this assessment;

- WA Environmental Protection Authority (EPA) Guidance Statement No. 8 – Environmental Noise (2007).
- *Environmental Protection (Noise) Regulations, 1997*.
- Kwinana Environmental Protection Policy (EPP) (EPA, 1999).
- The National Environment Protection (Ambient Air Quality) Measure (NEPM) (National Environment Protection Council [NEPC], 2003).
- *Environmental Protection (Controlled Waste) Regulations, 2004*.
- *Mine Safety and Inspection Regulations, 1995*.
- WA Department of Environment and Conservation (DEC) - Air Quality Modelling Guidance Notes (2006).
- Sinclair Knight Merz (SKM) (2005) Improvement of National Pollution Inventory (NPI) Fugitive Particulate Matter Emission Estimation Techniques. Prepared for the WA Department of Environment (DoE).
- Environment Australia – Best Practice Environmental Management in Mining, 1998.

- BHPBIO - Goldsworthy Extension Project Environmental Protection Statement, May 2005.
- EPA - Guidance Statement for Minimising Greenhouse Gas Emissions, 2002.
- Australian Government Department of Industry, Tourism and Resources - Best Practice Environmental Management in Mining - Energy Efficiency and Greenhouse Gas Reduction, 2002.
- BHPBIO - HSEC Guideline Energy and Greenhouse, 2002.
- EPA - Guidance for the assessment of Environmental Factors - Prevention of air quality impacts from land developments sites (2000).

1.4 Project-specific Limitations

The key limitations of the current study are associated with:

- The representativeness of emission rates applied in relation to proposed activities at the site for the purposes of predicting dust impacts at the receptor locations; and
- The limitations inherent to the use of numerical modelling tools such as TAPM, CALMET and CALPUFF. It is important to note that all numerical models that are based on approximating a governing set of equations will inherently be associated with some degree of error. The more complex the physical model, the greater the number of physical processes which must be parameterised. This frequently results in a large number of adjustable parameters within the model. There exists extensive in-house expertise in the use of TAPM, CALMET and CALPUFF within Heggies and our modellers make every reasonable attempt to ensure that model results are of the highest possible quality.

This study necessarily relies on the accuracy of the following data sets:

- Information including material properties, production volumes and operational practices provided by BHPBIO;
- Meteorological data obtained from the Yarrie on-site monitoring station;
- Meteorological data obtained from Bureau of Meteorology's monitoring sites at Marble Bar, Pardoo, Goldsworthy, and Mandora; and
- Terrain information provided by BHPBIO.

A number of assumptions have been applied within this assessment. These include:

- Dust emission rates derived from published emission factors are representative of sources on-site;
- Default values of parameters (in association with the development of emission factors) are representative of on-site conditions; and
- Simulated meteorology adequately represents local conditions.

2 PROJECT DESCRIPTION SUMMARY

2.1 Project Background Information

BHPBIO operates the Goldsworthy operations which are located approximately 200 km east of Port Hedland in the northern Pilbara region of WA.

The planned Cundaline and Callawa mining operations would result in the production of up to approximately 2.5 Million tonnes per annum (Mtpa) of iron ore. Mining at all Goldsworthy operations (including the Cundaline and Callawa Deposits) will continue to produce iron ore at up to approximately 8.5 Mtpa. The operations are centred at Yarrie with existing operational deposits including Cattle Gorge, Yarrie, and Nimingarra (**Figure 1**).

Table 1 shows the planned Cundaline and Callawa mining operations development schedule during the life of the mines.

Table 1 Planned Cundaline and Callawa Mining Operations Provisional Mining Schedule (2009-2016)

Year Ending June	Ore (kt)	Waste (kt)
2010	0	3,603
2011	877	4,822
2012	2,245	6,452
2013	1,994	6,210
2014	2,007	5,396
2015	1,337	1,838
2016	1,078	953

kt: kilotonnes

As indicated in Figure 1, with increasing distance from the Yarrie Deposit and processing area, the following deposits are located: Callawa Deposit (south), Cattle Gorge Deposit (north), followed by the Cundaline, Shay Gap, Sunrise Hill and Nimingarra Deposits (north-west).

2.1.1 Cundaline Deposit

The mining of approximately 5.5 Mt of ore from the Cundaline Deposit over a period of 5.5 years is scheduled to begin in 2011. It will be mined using progressive open pit mining techniques with the placement of overburden in mined-out voids (where practicable) and OSAs adjacent to the open pits (**Figure 2**).

In relation to the processing of iron ore from the Cundaline Deposit, two options are being considered:

- Option A: On-site processing (primary, secondary and tertiary crushing, and screening) and loading of ore directly to rail cars.
- Option B: Transport of Ore to Yarrie processing facilities for stockpiling, crushing (primary, secondary and tertiary) and screening and loading of ore onto rail cars.

2.1.2 Callawa Deposit

The mining of approximately 4.0 Mt of ore from the Callawa Deposit over a period of 6.5 years is scheduled to begin in 2009. It will be mined using progressive open pit mining techniques with the placement of overburden in mined-out voids (where practicable) and Overburden Storage Areas (OSAs) adjacent to the open pits (**Figure 3**).

In relation to the processing of material extracted from the Callawa Deposit, all ore will be transported to the Yarrie processing facilities for stockpiling, crushing, screening and loading of ore onto rail cars for transport.

2.2 Nearest Residences

The Cundaline and Callawa Deposits are located in a remote area (**Figure 1**), approximately 85 km north-east of Marble Bar (the nearest town). The nearest non-BHPBIO owned residences (i.e. Yarrie homestead and Warralong Aboriginal Community) are approximately 11 km south and 60 km west south-west of the Cundaline Deposit, respectively.

The scale and nature of the proposed development, combined with the distance from both the Yarrie homestead and the Warralong Aboriginal Community to the Cundaline and Callawa Deposits suggests that it is unlikely that ground-level concentrations of particulate matter at this location will differ significantly from current levels due to dust emissions associated with the planned Cundaline and Callawa mining operations. Similarly, associated noise emissions would not be significant at these locations.

Mine employees will be housed at the Yarrie accommodation camp (**Figure 4**). While this is not strictly considered a residence for assessment purposes, the potential impact of dust emissions on air quality at the accommodation camp has been assessed against health and nuisance-based criteria.

The location of the Yarrie homestead and the Yarrie Accommodation Camp are provided in **Table 2**.

Table 2 Location of Closest Receptors

Name	Easting (m)	Northing (m)
Yarrie Homestead	208781	7718119
Yarrie Accommodation Camp	217031	7719970

3 ASESSMENT CRITERIA – AIR QUALITY

3.1 Relevant Documentation

- The National Environmental Protection (Ambient Air Quality) Measure (NEPM) (NEPC, 2003);
- National Energy Research Development and Demonstration Council (NERDDC) – Air Pollution from Surface Coal Mining: Measurement, Modelling and Community Perception. Project No. 921, 1988;
- National Health and Medical Research Council (NHMRC) – Ambient Air Quality Goals Recommended by the NHMRC (1996);
- World Health Organisation (WHO) Air Quality Guidelines (2000); and
- WHO Air Quality Guidelines Global Update (2005).

3.2 Goals Applicable to Air Quality

The DEC (formerly the DoE) routinely adopts ambient air quality goals in the assessment of new proposals, and in the management of both local and regional ambient air quality.

As a matter of policy, the DEC has adopted the NEPM goals for ambient air quality. Adopting the NEPM goals is an interim approach while the DEC, in conjunction with the Department of Health, develops ambient air quality guidelines for WA.

The NEPM are broad framework-setting statutory instruments defined in the NEPC legislation. They outline agreed national objectives for protecting or managing particular aspects of the environment (NEPC, 2003).

In the absence of a NEPM standard, the WA DEC will adopt the WHO Air Quality Guidelines (2000), which was updated in 2005. In the absence of a NEPM standard or a WHO guideline, the WA DEC will adopt goals from another jurisdiction (once it has been assessed and determined to be applicable to the WA context).

3.3 National Environment Protection Measure

In June 1998, the NEPC of Environment Ministers agreed to set uniform standards for ambient air quality to apply to all States and Territories. These standards are contained in the NEPM for ambient air quality (NEPC, 2003).

These NEPM goals were developed by the NEPC in 1998 to be achieved within 10 years of commencement and set standards and goals for ambient levels of “criteria pollutants” (NEPC, 1998).

3.4 WHO Guidelines for Air Quality

WHO has published Air Quality Guidelines for Europe which address the effect of air pollution on human health and set an international standard for health based air quality guidelines (2000). The WHO air quality guidelines are also being used as a starting point for the derivation of legally binding limit values in the framework of the European Union Air Quality Directive.

3.5 Goals Applicable to Particulate Matter

In this report, the term *particulate matter* refers to a category of airborne particles typically less than 50 microns (µm) in diameter and ranging down to 0.1 µm in size. Particles less than 10 µm and 2.5 µm are referred to as PM_{10} and $PM_{2.5}$, respectively. These particulates are considered important pollutants because they have the potential to enter the respiratory system.

The NEPM ambient air quality goal for PM_{10} is (NEPC, 2003):

- A 24-hour maximum of 50 micrograms per cubic metre (µg/m^3) (with five exceedances allowable per annum)

The NEPM does not specify an annual average goal for PM_{10}, however the WHO have published an annual average guideline for 20 µg/m^3 and this has been adopted for this assessment.

In December 2000, the NEPC initiated a review to determine whether a new ambient air quality criterion for $PM_{2.5}$ was needed in Australia, and the feasibility of developing such a criterion. The review found that:

- there are health effects associated with fine particles;
- the health effects observed overseas are supported by Australian studies; and
- fine particle standards have been set in Canada and the USA, and an interim criterion proposed for New Zealand.

The review concluded that there is sufficient community concern regarding $PM_{2.5}$ to consider it an entity separate from PM_{10}.

As such, in July 2003 a variation to the Ambient Air Quality NEPM was made to extend its coverage to $PM_{2.5}$. This document references the following goals for $PM_{2.5}$ (NEPC, 2003):

- A 24-hour maximum of 25 µg/m^3.
- An annual average of 8 µg/m^3.

3.6 Goals Applicable to Total Suspended Particulate Matter

As recommended by the NHMRC at their 92^{nd} session in October 1981, the annual goal for Total Suspended Particulate Matter (or TSP) is given as 90 µg/m^3 (NHMRC, 1996).

It is noted that the PM_{10} sub-set is typically 50% of TSP mass in regions where road traffic is not the dominant particulate source (United Sates [US] EPA, 2001). This would be consistent with an annual average PM_{10} goal of approximately 45 µg/m^3 (derived from 50% of the annual NHMRC goal of 90 µg/m^3) (NHMRC, 1996). Thus, the historical NHMRC goal may be regarded as not as stringent as the newer PM_{10} goal of 20 µg/m^3 expressed as an annual average.

Therefore, the annual TSP goal is seen to be achieved if the annual PM_{10} goal is satisfied.

3.7 Nuisance Impacts of Fugitive Emissions

The DEC does not specify recommended levels for dust deposition. In New South Wales (NSW), the Department of Environment and Climate Change (NSW DECC) sets dust deposition limits in the *Approved Methods for the Modelling and Assessment of Air Pollutants* (DECC, 2005). In Victoria (VIC), the Draft Protocol for Environmental Management for Mining and Extractive Industry lists assessment criteria for Nuisance Dust (VIC EPA, 2006).

Table 3 presents the NSW DECC and VIC EPA impact assessment goals for nuisance dust, showing the allowable increase in dust deposition levels over the ambient (background) level which would be acceptable so that dust nuisance could be avoided.

Table 3 NSW DECC and VIC EPA goals for allowable dust deposition

Averaging Period	Maximum Increase in Deposited Dust Level	Maximum Total Deposited Dust Level
Annual	2 g/m^2/month	4 g/m^2/month

g/m^2/month: grams per square metre per month

In the absence of an ambient background dust deposition level, the maximum increase in deposited dust level will be the governing goal for the planned Cundaline and Callawa mining operations.

3.8 Project-specific Air Quality Goals

The proposed air quality standards for pollutants relevant to this assessment are summarised in **Table 4.**

Table 4 Proposed air quality assessment criteria

Pollutant	Averaging Period	Criteria	Source
Particulate Matter as PM_{10}	24-hour	50 $\mu g/m^3$	NEPM[1]/WHO
	Annual	20 $\mu g/m^3$	WHO
Particulate Matter as $PM_{2.5}$	24-hour	25 $\mu g/m^3$	NEPM/WHO
	Annual	8 $\mu g/m^3$	NEPM
TSP	Annual	90 $\mu g/m^3$	NHMRC[2]
Dust Deposition[3,4]	Annual	2 g/m^2/month	NERDDC

Note
1 Maximum of 5 exceedences per year is permitted (NEPC, 2003; WHO, 2000, 2005).
2 Currently under review by NHMRC, revised criteria due 2008 (NHMRC, 1996).
3 Dust is assessed as insoluble solids as defined by AS 3580.10.1-1991.
4 Note that 2 g/m^2/month relates to a Project-only contribution to dust deposition. Cumulative levels are not to exceed 4 g/m^2/month.

4 EXISTING AIR QUALITY AND METEOROLOGICAL ENVIRONMENT

4.1 Existing Ambient Air Quality

During dry conditions, the planned Cundaline and Callawa mining operations have the potential to generate dust and particulate matter. For the purposes of assessing the potential air quality impacts, an estimation of existing ambient air quality is required.

4.1.1 Mine Site

The existing air quality in the vicinity of the mine site is associated with that of a rural arid environment. Natural sources of particulate, such as windblown dust from exposed surfaces, would be the main contributor in the vicinity of the mine site.

No data exists in relation to existing air quality in the vicinity of Yarrie or the wider region. In the absence of site specific or site representative air quality data, it is difficult to assign an ambient background level for dust or particulate, particularly for short term averaging periods (i.e. 24 hour PM_{10} concentrations).

For the purposes of this assessment therefore, the incremental increase in dust levels and particulate concentrations is presented, showing the predicted incremental impact from the mine alone.

4.2 Meteorology and Climatology

4.2.1 Monitoring Sites

The sources of meteorological information relevant to this assessment are summarised in **Table 5**.

Table 5 Monitoring sites

Site	Latitude	Longitude	Opened	Status	Distance to Yarrie (km)
Marble Bar Comparison[1]	21.18 ºS	119.75 ºE	1895	Closed Sept 2006	85
Marble Bar[1]	21.18 ºS	119.75 ºE	Sept 2006	Open	85
Mandora[1]	19.74 ºS	120.84 ºE	1913	Open	100
Pardoo Station[1]	20.11 ºS	119.58 ºE	1904	Open	75
Goldsworthy[1]	20.34 ºS	119.52 ºE	1966	Closed May 1992	90
Yarrie Monitoring Site[2]	22.61 ºS	120.29 ºE	-	Open	-

Note 1 Bureau of Meteorology monitoring site.
2 BHPBIO monitoring site.

4.2.2 Climate

The Pilbara Region of WA is situated in the arid-tropical zone and is characterised in general by hot wet summers and dry winters.

Climate averages from the Bureau of Meteorology monitoring sites located at Marble Bar Comparison (1901 to 2006) and Goldsworthy (1966 to 1992) highlights the arid nature of the inland climate with the mean total annual rainfall in the range of 326 to 360 millimetres (mm) per year. Rainfall is recorded on an average of approximately 35 days per year. Rainfall over 1 mm is recorded on an average of 26 to 28 days year. Rainfall greater than 10 mm occurs on average 8 to 9 days per year, and rainfall greater than 25 mm on approximately 1 day per year.

4.2.3 Yarrie Monitoring Site

On-site meteorological data was made available for years 2006 and 2007 with 2006 displaying a greater percentage of data capture than 2007. The number of missing hours per month is summarised in **Table 6**.

Table 6 The number of missing hours of on-site wind data

Year	J	F	M	A	M	J	J	A	S	O	N	D	Total
2006	41	4	743	677	9	29	5	1	3	154	242	16	1924
2007	458	672	744	720	744	102	0	0	0	0	0	0	3440

Thus for 2006, 2.8% of the data is missing during the summer months, 64.72% during autumn, 1.6% during winter and 18.3% during spring. This equates to an annual percentage capture of 78.0%.

For 2007, 52.3% of the data is missing during the summer months, 100% during autumn, 4.6% during winter and 0% during spring. This equates to an annual percentage capture of only 61%, due mainly to wind damage and a significant period of electricity loss after Cyclone George in March 2007.

Thus the calendar year 2006 was chosen for modelling purposes.

Presented in **Figure 5** is the annual wind rose based on data from the Yarrie monitoring site for 2006. Winds at this location are dominated by light north-east through south-easterlies, and are infrequently observed to occur from the western sectors.

The seasonal wind roses for the Yarrie monitoring site are presented in **Appendix A**.

The seasonal wind roses derived from the on-site data indicate that:

- In summer the winds are light and variable, though seldom from the north-west sector;
- In autumn the frequency of moderate to strong winds is greater than during any of the other seasons with winds from the east-northeast and east-southeast dominating. (Note that data for the months of March and April are missing and therefore the Autumn seasonal wind rose may not be a true representation of the seasonal characteristics, but only representative of the conditions during May, 2006. Data from this same period was also missing during 2007. Thus a accurate representation of autumn seasonal wind characteristics is not able to be presented.);
- In winter, the winds show similar characteristics as during autumn with the dominant wind directions from the east-northeast and east-southeast dominating; and
- In spring the dominant wind direction is from the north-east and north-northeast.

Rainfall data obtained during 2006 indicates a total of 49 days for which rainfall over 0.25 mm was recorded. A daily maximum total rainfall of 64.4 mm was recorded on 28 February 2006. The total annual rainfall was 496.6 mm which is approximately 40% higher than the climate average for Goldsworthy and Marble Bar Comparison monitoring sites.

For comparison, rainfall data obtained the following year (i.e. 2007) at Pardoo indicates a daily maximum total rainfall of 285 mm, recorded on 27 March 2007 during Cyclone George. The total annual rainfall was 815.7 mm, which is approximately 150% higher than the climate average for Goldsworthy and Marble Bar.

5 DUST EMISSIONS INVENTORY

5.1 Dust Emission Sources

Activities that are likely to generate dust emissions include:

- Topsoil stripping;
- Drilling and blasting;
- Primary, secondary and tertiary crushing;
- Loading operations;
- Ore and overburden hauling;
- Truck unloading;
- Product/ore stockpiles;
- Conveyor transfer points;
- Rail load out; and
- Wind erosion of exposed areas.

5.2 Relevant Documentation

Emission factors relevant to dust-generating activities were developed in accordance with and/or in consideration of the following:

- NPI Emission Estimation Technique Manual for Mining, Version 2.3 (NPI EETM), Environment Australia, 2001;
- US EPA AP-42 Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, USEPA 1995 and updates (US EPA, 1985, 1988, 1992, 1995, 2002, 2006a, 2006b, 2006c). In particular:
  - Section 11.24 Metallic Minerals Processing;
  - Section 13.2.2 Unpaved Roads;
  - Section 13.2.4 Aggregate Handling and Storage Piles;
  - Section 13.2.5 Industrial Wind Erosion;
- SKM (2005) Improvement of NPI Fugitive Particulate Matter Emission Estimation Techniques. Prepared for the DoE.

5.3 Project Information and Assumptions

Information relevant to the Cundaline and Callawa deposits is summarised in **Table 7**. Information relating to material properties and operational practices are summarised in **Table 8**.

Table 7 Summary of deposit-specific information

Parameter	Units	Deposit	
		Cundaline	Callawa
Deposit[1]	Mt	5.5	4.0
Waste[1]	Mt	11.1	17.6
Pit footprint[2]	ha	127	16.6
OSA footprint[2]	ha	113	46
Stockpiles	ha	5	-
Infrastructure	ha	7	-
Roads Footprint	ha	51	40
Haul road: pit to processing[2]	km	13.6	9.3
Haul road: pit to OSA[2]	km	1.6	1.5
Number of bulldozers[2]	-	1	1
Primary Crushing (location)	-	Cundaline or Yarrie	Yarrie
Secondary Crushing (location)	-	Cundaline or Yarrie	Yarrie
Tertiary Crushing (location)	-	Cundaline or Yarrie	Yarrie

Note [1] Information provided by BHPBIO
[2] Estimated from diagrams supplied by BHPBIO

Table 8 Information and assumptions applied for the purposes of developing emission factors

Parameter	Units	Value	Source
Material properties			
Ore density	tonnes/m^3	2.5	BHPBIO
Ore moisture content (lump)	%	2.07	BHPBIO
Ore moisture content (fine)	%	4.32	BHPBIO
Ore silt content	%	9.5	US EPA AP42 Section 13.2.4
Overburden moisture content	%	3.1	BHPBIO
Haul road moisture content	%	0.2	SKM OB24
Haul road silt content	%	8.4	SKM OB24
Operational Practices			
Annual production rate[1]	Mtpa	8.5	BHPBIO
Grader speed	km/hr	5	BHPBIO
Haul road grading frequency	per month	3	BHPBIO
Dozers	hours/day	21	BHPBIO
Stockpile height	m	10	Assumed
Blasting			
Typical Blast Area	m^2	8,000	BHPBIO
Number of holes	holes/blast	135	BHPBIO
Depth of holes	m	6	BHPBIO

Note [1] Total annual production rate from the Goldsworthy region BHPBIO mines.
km/hr: kilometres per hour
m: metres
m^2: square metres

5.4 Dust Emission Factors

5.4.1 Emission Factors Associated with Operational Activities

The emission factors for all loading, unloading and handling are estimated using the NPI EETM emission factor equation for loading (and miscellaneous transfer points). The equation is dependent on mean wind speed and material moisture content as follows:

$$E = k \times 0.0016 \times (U/2.2)^{1.3} / (M/2)^{1.4} \quad \text{kilograms per tonne (kg/t)}$$

where,

- E = emission factor
- k = 0.74 for TSP, 0.35 for PM_{10}
- U = Mean wind speed (metres per second [m/s])
- M = Moisture content (%)

The emission factor for blasting is estimated from the US EPA TSP emission factor for blasting and is dependent on blast area, moisture content and blast hole depth, as follows:

$$EF = 344 \times A^{0.8} \times M^{-1.9} \times D^{-1.8} \quad \text{kilograms per hectare per year (kg/ha/year)}$$

where,

- EF = emission factor
- A = Blast Area
- M = Moisture content (%)
- D = Blast Hole Depth

The PM_{10} emissions factor is $EF_{TSP} \times 0.52$

The emission factor for the grader is estimated from the NPI EETM TSP emission factor for Graders and is dependent on mean vehicle speed, as follows:

$$EF_{TSP} = 0.0034 \times S^{2.5}$$

$$EF_{PM10} = 0.0034 \times S^{2}$$

where,

- S = mean vehicle speed in km/hr

The emission factor for dozers on ore is estimated from the NPI EETM TSP emission factor for bulldozers on material other than coal and is dependent on silt content and moisture content, as follows:

$$EF_{TSP} = 2.6 \times s^{1.2} \times M^{-1.3}$$

$$EF_{PM10} = 0.34 \times s^{1.5} \times M^{-1.4}$$

where,

- s = Silt Content (%)
- M = Moisture content (%)

The emission factor for wheel generated dust is estimated from the US EPA emission equation for Wheel Generated Dust from Unpaved Roads (2006a) as follows:

$$E = K \times (s/12)^{A} \times (W/3)^{B} \quad \text{lb/VMT}$$

where,

- K = 4.9 for TSP and 1.5 for PM_{10}
- s = Silt Content (%)
- W = vehicle gross mass, tons
- A = 0.9 for PM_{10} and 0.7 for TSP
- B = 0.45 for PM_{10} and TSP

Default emission factors for crushing, and screening were derived in accordance with Table 2 *Default Emission Factors for Various Operations at Metalliferous Mines* of the NPI EETMM.

5.4.2 Emission Factors Associated with Wind Erosion

The current Australian NPI equation used in the NPI EETM is based on the US EPA procedure for estimating dust emission generated by wind erosion from open aggregate storage piles and exposed areas within industrial facilities (USEPA AP42 Chapter 13, Section 13.2.5 Industrial Wind Erosion). Historically the US EPA wind erosion equation was given as:

$$EF_{TSP} = 1.9 \times (s/1.5) \times 365 \times (365 - p/235) \times (f/15) \quad \text{and}$$

$$EF_{PM10} = 0.95 \times (s/1.5) \times 365 \times (365 - p/235) \times (f/15) \qquad \text{(units: kg/ha/year)} \qquad (1)$$

where,

- s is the silt content (%);
- p is the number of days where rainfall exceeds 0.25 mm; and
- f is the percentage of time wind speeds exceed 5.4 m/s at the mean height of the stockpile.

The latest edition of the US EPA AP42 Fifth Edition provides a more detailed procedure for wind erosion in Chapter 13 Industrial Wind Erosion (November 2006). It is noted, however, that the equations apply only to exposed materials with limited erosion potential that are not frequently disturbed. The equations relate to periods in between disturbances and therefore represent intermittent events that should not be input directly into dispersion models that assume steady-state conditions.

The current US EPA method calculates the erosion potential from exposed surfaces as follows:

$$P = 58 (U^* - Ut^*)^2 + 25 (U^* - Ut^*) \quad (P = 0 \text{ for } U^* \le Ut^*) \qquad (2)$$

where,

- U^* is the friction velocity (m/s)
- Ut^* is the threshold friction velocity (m/s) (wind speed at which erosion is initiated).

The friction velocity is a measure of the wind shear stress on the erodible surface and is best estimated from a measure of the fastest mile of wind for the period in between stockpile disturbances. When the actual friction velocity at the site is greater than the threshold friction velocity, wind erosion can be expected; however, when the threshold friction velocity is equal to or greater than the actual friction velocity at the site, wind erosion will not occur.

Although this approach is more robust than previous wind erosion equations, certain limitations exist in the estimation of input parameters, many of which are highly sensitive to the results obtained.

SKM (2005) recommendations relating to the estimation of wind erosion are that the current NPI equation (Equation 1) should continued to be used (although considered indicative only) with the US EPA equation (Equation 2) considered to be based on little data for non-coal mines and difficult to implement. However it is accepted that the NPI emission equation (Equation 1) is best suited to determining annual emissions of wind erosion.

Based on a study referred to in SKM (2005) with data specific to iron ore stockpiles, results from the study were fitted to a modified particulate matter flux equation proposed by Shao *et al.*, (1996):

$$EF= k\,[U^3 \times (1- (U_t^2)/ U^2)] \text{ for } U > U_t \qquad \text{(units: } g/m^2/s) \qquad (3a)$$

$$EF= 0 \text{ for } U < U_t \qquad \text{(units: } g/m^2/s) \qquad (3b)$$

where:

- U is the wind velocity (m/s);
- U_t is the threshold velocity for particulate matter lift off (m/s); and
- k is a constant.

Noting both the limitations and representativeness of the US EPA approach (Equation 1) and the wind dependent approach outlined in SKM (2005) (Equation 3), for the purposes of the modelling of wind-generated fugitive emissions, a combination of these two methodologies has been used. By equating the emission factor given as Equation 1 which is considered representative of annual average values, and the annual average of Equation 3, a value for the constant k (Equation 3) can be determined. This methodology for the development of hourly-varying emission factors will lead to an annual average emission rate which is consistent with that recommended by the NPI EETM while maintaining a wind speed dependence that is more representative of time-varying impacts.

5.4.3 Dust Suppressant Measures and Control Factors

Based on information contained in the *Goldsworthy Extension Project Environmental Protection Statement* (BHPBIO, 2005), dust levels are controlled by the implementation of the following measures:

- Watering of haul roads and other operational areas with significant potential to generate dust including unsealed roads and construction areas;
- Use of chemical suppressants on roads where practicable;
- Dust extraction via collectors installed at the crushing plants
- Use of water sprays on ore stackers and crushers;
- Use of dust curtain around hoppers;
- Moisture conditioning of ore prior to transport;
- Enclosing ore transfer points and/or fitting them with water sprays where practicable;
- Minimising areas of exposed soil where practicable; and
- Progressive rehabilitation.

Based on information contained in Table 3 of the NPI EETM for Mining, control factors that apply to mining activities are summarised in **Table 9** .

Table 9 Control factors for various activities

Activity	Control Method	Control factor
Drilling	fabric filters	0.99
	water sprays	0.7
Haul roads	level 1 (2 litres/m^2/hour)	0.5
	level 2 (> 2 litres/m^2/hour)	0.7
Unloading trucks	water spray	0.7
Loading stockpiles	water sprays	0.5
	variable height stacker	0.25
	telescopic chute with water spray	0.75
	total enclosure	0.99
Unloading from stockpiles	water sprays	0.5
Wind erosion from stockpiles	water sprays	0.5
	wind breaks	0.3
	revegetation (overburden or complete enclosure)	0.99
Processing, conveying, reclaimers	windbreaks	0.3
	water sprays	0.5
	hooding with cyclones	0.65
	hooding with scrubbers	0.75
	fabric filters	0.83
	enclosed or underground	1
Misc transfer point and conveying	water spray	0.9
	enclosure	0.7
	enclosure and use of fabric filters	0.99
	TSP	0.5
Pit retention	PM_{10}	0.05

5.4.4 TSP and PM_{10} Emission Factors

The emissions factors relevant to activities at the Cundaline and Callawa deposits are summarized in **Table 10**.

Table 10 Emission Factors for TSP and PM_{10}

Emission Factors	Units	TSP Emission Factor	Control Efficiency	PM_{10} to TSP Ratio	% of Material Handled
Overburden					
Front-End Loaders/Excavators	kg/t	0.0015	0.00	0.5	100%
Bulldozers	kg/hr	17	0.00	0.2	100%
Truck Unloading at OSA	kg/t	0.012	0.50	0.4	100%
Wheel Dust- Pit to OSA	kg/VKT	8.9	0.70	0.3	
Wheel Dust - OSA to Pit	kg/VKT	6.0	0.70	0.3	
Extraction					
Drilling	kg/hole	0.59	0.70	0.5	
Blasting	kg/blast	4550	0.00	0.5	
Front-End Loaders/Excavators on Ore	kg/t	0.0015	0.50	0.5	100%
Transport of Ore (Option A)					
Wheel Dust - Pit to Processing	kg/VKT	8.8	0.70	0.5	
Wheel Dust - Processing to Pit	kg/VKT	6.0	0.70	0.5	
Transport of Ore (Option B)					
Wheel Dust - Pit to Transfer Area	kg/VKT	8.9	0.70	0.3	
Wheel Dust - Transfer Area to Pit	kg/VKT	6.0	0.70	0.3	
Unloading of trucks	kg/t	0.0015	0.50	0.0	100%
Bulldozers on Stockpiles	kg/hr	14.0	0.50	0.3	100%
Loading of Road Trains	kg/t	0.0015	0.50	0.5	100%
Wheel Dust - Transfer Area to Processing	kg/VKT	12.2	0.70	0.3	
Wheel Dust - Processing to Transfer Area	kg/VKT	8.9	0.70	0.3	
Processing					
Unloading of Trucks to Hopper	kg/t	0.0015	0.75	0.5	85%
Unloading of Trucks at ROM	kg/t	0.0015	0.50	0.5	15%
Rehandling of Ore	kg/t	0.0015	0.50	0.5	15%
Primary Crushing	kg/t	0.2	0.88	0.1	100%
Secondary Crushing	kg/t	0.6	0.88	0.1	35%
Tertiary Crushing	kg/t	1.4	0.88	0.1	25%
Screening	kg/t	0.08	0.88	0.8	160%
Stockpile Loading	kg/t	0.0015	0.50	0.5	15%
Blending	kg/t	0.0015	0.50	0.5	25%
Bulldozers on Stockpiles	kg/hr	14.0	0.50	0.0	100%
Loading of Trains	kg/t	0.0015	0.50	0.5	100%
Wind Erosion					
Stockpiles	kg/ha/year	2,803	0.50	0.5	

kg/hr kilograms per hour

kg/VKT kilograms per Vehicle Kilometres Travelled

Presented in **Figure 6** is the wind speed dependent hourly time series of emission factors based on the methodology outlined in **Section 5.4.2**. The annual emission factor is 2,803 kg/ha/year based on site-specific meteorological data.

5.4.5 $PM_{2.5}$ Emission Factors

The NPI EETMM contains emission factors for TSP and PM_{10}. The US EPA AP-42 documentation provides $PM_{2.5}/PM_{10}$ ratios for a variety of fugitive dust source categories. These ratios range from 0.15 for unpaved roads to 0.4 for industrial wind erosion.

The US Midwest Research Institute (MRI) conducted a study to examine these ratios in light of a number of fugitive dust studies conducted in the US. The findings indicated that $PM_{2.5}$ emission estimates from the US EPA AP-42 were biased high and should be in the range 0.1 to 0.15 for all fugitive sources. Although these updated ratios are proposed at the current time, much of the size distribution data has been incorporated into the latest AP-42 documentation, for example for unpaved roads (Section 13.2.2). The proposed particle size ratios are presented in **Table 11**.

Table 11 Proposed Particle Size Ratios for AP-42

Fugitive Dust Source Category	**AP-42 Section**	**$PM_{2.5}/PM_{10}$ ratio**	
		Current	**Proposed**
Paved Roads	13.2.1	0.25	0.15
Unpaved Roads (Public and Industrial)	13.2.2	0.15	0.1
Construction and Demolition	-	0.208	0.1
Aggregate Handling and Storage Piles	13.2.4	0.314	0.1 (traffic) 0.15 (transfer)
Industrial Wind Erosion	13.2.5	0.4	0.15
Agricultural Tilling	-	0.222	0.2 (no change)
Open Area Wind Erosion	-	-	0.15

For the purposes of this assessment a qualitative approach has been adopted in relation to estimating $PM_{2.5}$ impacts from key dust emission sources based on dispersion modelling results for PM_{10}. A conservative $PM_{2.5}$ to PM_{10} ratio of 0.15 will be applied.

5.4.6 Emission Inventories

Presented in **Appendix B** are the detailed PM_{10} (and implied TSP) emission inventories for the planned Cundaline and Callawa mining operations (Option A and Option B), and the Yarrie Processing Facility (Option A and Option B). The PM_{10} emission inventories are summarised in the following tables. Emissions from activities listed in **Table 10** have been grouped into categories (as indicated in the table). Both the annual total mine-related emission of PM_{10} and the percentage that each grouping contributes to the annual total are presented.

The PM_{10} emission inventory summary for the planned Callawa mining operations presented in **Table 12** suggests that emissions of PM_{10} resulting from activities associated with mining of the Callawa Deposit will be greatest in 2016 (224.2 tonnes) followed by 2011 (233.6 tonnes)[1]. During the lifespan of the planned Callawa mining operations, a total of 1,244 tonnes of PM_{10} is predicted to be released into the local airshed as a result of operational activities.

[1] Note that emissions relating to the extraction of ore in 2016 are likely to be conservative. Information provided by BHPBIO suggests that two Project-related blasting events will occur per week. With the completion of mining at the Cundaline deposit in 2015, two blasts per week are assumed to occur at the Callawa mine during 2016.

A summary of PM_{10} emissions for the planned Cundaline mining operations based on the processing of material on-site (Option A) are presented in **Table 13**. Results suggest that emissions of PM_{10} will be greatest in 2013 (303.1 tonnes) followed by 2012 (285.8 tonnes). If this operational scenario is adopted, results suggest that during the lifespan of the planned Cundaline mining operations, a total of 1,022 tonnes of PM_{10} will be released into the local airshed as a result of operational activities and stockpile erosion.

The planned Cundaline mining operations (Option B) involves the transport of ore via road train from the Cundaline Deposit to the Yarrie processing facility, a distance of approximately 13.6 km. In general, wheel-generated dust has the potential to be a significant source of particulate emissions (**Table 14**). Based on this operational scenario, the contribution of emissions associated with the transport of ore to the processing facility to the overall emissions for 2013, increases from 8.7% (Option A) to 67.8%. The total annual emission of PM_{10} into the airshed in year 2013 is estimated to increase by 122% to 672.7 tonnes when compared to PM_{10} emissions associated with Option A.

Mining of the Cundaline and Callawa deposits will not contribute to an increase in the production of ore within the region, with annual production rates of up to approximately 8.5 Mtpa anticipated throughout the life of continuing Goldsworthy operations. Presented in **Table 15** and **Table 16** are summaries of the estimated annual PM_{10} emissions at the Yarrie processing facility associated with the processing of ore from all deposits including Callawa (if Cundaline Option A is implemented, **Table 15**), and Cundaline and Callawa (if Option B is implemented, **Table 16**). Results suggest that for 2013, emissions associated with processing of ore at Cundaline (Option A) will result in a decrease of emissions from the Yarrie facility by approximately 68%, (i.e. from 40.6 tonnes to 12.9 tonnes).

Table 12 Summary of PM_{10} emissions inventory – Callawa Mine

Emissions Inventory	**YEJ* 2010**		**YEJ 2011**		**YEJ 2012**		**YEJ 2013**		**YEJ 2014**		**YEJ 2015**		**YEJ 2016**	
	tpa	%	tpa	%	tpa	%	tpa	%	tpa	%	tpa	%	tpa	%
Ore (Mtpa)	0.0		0.6		0.6		0.6		0.6		0.6		1.1	
Waste (Mtpa)	3.6		4.5		2.7		1.0		4.0		0.9		1.0	
Total	**3.6**		**5.1**		**3.3**		**1.6**		**4.6**		**1.5**		**2.1**	
Overburden	49.4	29.7	79.3	33.9	54.7	36.9	31.4	28.1	72.1	37.3	29.4	20.1	30.6	12.5
Extraction	116.7	70.3	104.0	44.5	44.0	29.7	23.7	21.2	71.8	37.1	63.3	43.3	117.1	48.0
Transport of Ore	0.0	0.0	38.9	16.6	38.3	25.8	43.8	39.2	38.2	19.8	41.2	28.2	74.6	30.5
Processing	0.0	0.0	11.4	4.9	11.3	7.6	12.9	11.5	11.2	5.8	12.1	8.3	21.9	9.0
Total	166.1		233.6		148.3		111.8		193.3		146.0		244.2	

*Year Ending June (YEJ)

Table 13 Summary of PM_{10} emissions inventory – Cundaline Mine Option A (On-site processing)

Emissions Inventory	**YEJ 2011**		**YEJ 2012**		**YEJ 2013**		**YEJ 2014**		**YEJ 2015**	
	Tpa	%	tpa	%	tpa	%	tpa	%	tpa	%
Ore (Mtpa)	0.3		1.7		1.4		1.5		0.7	
Waste (Mtpa)	0.3		3.7		5.2		1.4		0.5	
Total	**0.6**		**5.4**		**6.6**		**2.9**		**1.2**	
Overburden	22.1	29.1	71.6	25.0	92.6	30.5	37.9	18.3	24.8	16.5
Extraction	13.0	17.1	73.5	25.7	93.8	30.9	45.7	22.1	53.9	35.8
Transport of Ore	6.1	8.0	32.7	11.4	26.3	8.7	28.2	13.6	14.3	9.5
Processing	31.3	41.2	104.5	36.6	86.9	28.7	91.9	44.4	53.9	35.8
Stockpile Erosion	3.5	4.6	3.5	1.2	3.5	1.2	3.5	1.7	3.5	2.3
Total	75.8		285.8		303.1		207.2		150.4	

Table 14 Summary of PM_{10} emissions inventory – Cundaline Mine Option B (Processing at Yarrie)

Emissions Inventory	YEJ 2011		YEJ 2012		YEJ 2013		YEJ 2014		YEJ 2015	
	Tpa	%	tpa	%	tpa	%	tpa	%	tpa	%
Ore (Mtpa)	0.3		1.7		1.4		1.5		0.7	
Waste (Mtpa)	0.3		3.7		5.2		1.4		0.5	
Total	**0.6**		**5.4**		**6.6**		**2.9**		**1.2**	
Overburden	22.1	4.4	71.6	11.2	92.6	13.8	37.9	6.6	24.8	4.5
Extraction	12.9	2.6	72.7	11.4	92.8	13.8	45.2	7.9	53.3	9.7
Transport of Ore	455.8	91.0	456.2	71.5	456.1	67.8	456.2	79.7	455.9	82.5
Processing	6.4	1.3	34.4	5.4	27.7	4.1	29.6	5.2	15.1	2.7
Stockpile Erosion	3.5	0.7	3.5	0.5	3.5	0.5	3.5	0.6	3.5	0.6
Total	**500.7**		**638.4**		**672.7**		**572.4**		**552.6**	

Table 15 Summary of PM_{10} emissions inventory – Yarrie Processing (Processing conducted at Cundaline)

Emissions Inventory	YEJ 2010		YEJ 2011		YEJ 2012		YEJ 2013		YEJ 2014		YEJ 2015		YEJ 2016	
	tpa	%	tpa	%	tpa	%	tpa	%	tpa	%	tpa	%	tpa	%
Ore (Mtpa)	2.0		1.6		0.6		0.6		0.6		1.3		2.0	
Waste (Mtpa)	6.3		6.0		2.7		1.0		4.6		5.6		6.1	
Total	**8.3**		**7.6**		**3.3**		**1.6**		**5.2**		**6.9**		**8.1**	
Processing	40.7	89.2	33.4	87.2	11.3	69.7	12.9	72.4	11.3	69.7	27.1	84.7	40.5	89.2
Stockpile Erosion	4.9	10.8	4.9	12.8	4.9	30.3	4.9	27.6	4.9	30.3	4.9	15.3	4.9	10.8
Total	**45.6**		**38.3**		**16.2**		**17.8**		**16.2**		**32.0**		**45.4**	

Table 16 Summary of PM_{10} emissions inventory – Yarrie Processing (All processing conducted at Yarrie facility)

Emissions Inventory	**YEJ 2010**		**YEJ 2011**		**YEJ 2012**		**YEJ 2013**		**YEJ 2014**		**YEJ 2015**		**YEJ 2016**	
	tpa	%	tpa	%	tpa	%	tpa	%	tpa	%	tpa	%	tpa	%
Ore (Mtpa)	2.0		2.0		2.2		2.0		2.0		2.1		2.0	
Waste (Mtpa)	6.3		6.3		6.5		6.2		6.0		6.1		6.1	
Total	**8.3**		**8.3**		**8.7**		**8.2**		**8.0**		**8.2**		**8.1**	
Processing	40.7	89.2	39.8	89.0	45.7	90.3	40.6	89.2	40.9	89.3	42.2	89.6	40.5	89.2
Stockpile Erosion	4.9	10.8	4.9	11.0	4.9	9.7	4.9	10.8	4.9	10.7	4.9	10.4	4.9	10.8
Total	**45.6**		**44.7**		**50.6**		**45.5**		**45.8**		**47.1**		**45.4**	

6 ATMOSPHERIC DISPERSION MODELLING

6.1 Methodology

6.1.1 Dispersion Model Selection

The atmospheric dispersion modelling carried out for this assessment utilises the CALPUFF software (Version 6.112) developed by the US EPA. Default options have been used unless otherwise specified.

The dispersion model CALPUFF was chosen in conjunction with the CALMET meteorological modelling tool to quantify the potential impact of emissions of dust on air quality at the accommodation camp.

It is noted in the *Air Quality Modelling Guidance Notes* (DEC, 2006) that the US EPA approved dispersion model CALPUFF has significantly improved scientific formulation when compared with AUSPLUME developed by the VIC EPA. It is further noted that CALPUFF has the ability to handle light winds, long-range transport and the effect of topography. In relation to the modelling of low-level emission sources with zero buoyancy, the DEC (2006) document states that it will not accept either the direct or indirect use of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) developed (The) Air Pollution Model (TAPM).

6.1.2 Development of Meteorological File for Input into CALPUFF

The CALMET meteorological model requires that for each hour simulated at least one surface station contains non-missing wind fields. Unfortunately, as noted in **Section 4.2** the Yarrie on-site monitoring data has gaps in both the wind direction and wind speed data and is therefore not able to be utilised exclusively as input (as an initial guess field) into CALMET.

Therefore, for the purposes of the current assessment, a multi-staged approach was used to develop a site-representative, three-dimensional wind field as follows:

- One year (2006) of meteorological modelling using TAPM was conducted using data assimilation of wind speed and wind direction information obtained from the following monitoring sites:
  - Yarrie on-site (hourly with some gaps);
  - Marble Bar (3 hourly data);
  - Marble Bar (hourly data);
  - Mandora (3-4 readings daily); and
  - Pardoo (3-4 readings daily).
- A TAPM generated meteorological file was extracted at the location of the Yarrie monitoring site. A comparison of the wind speed and wind direction output by TAPM and Yarrie on-site data was conducted. However, it was concluded that there was insufficient agreement between the predicted and observed wind fields to use the TAPM generated wind speed and wind directions to fill in the gaps of missing Yarrie on-site data.
- As an alternative approach, a TAPM generated meteorological file was extracted at a location (E 220.045, N 7720.119) approximately 3.6 km to the north-east of the Yarrie monitoring site. Both surface and upper air meteorological fields were extracted at this location. This location was chosen as it is situated near the boundary of the CALMET modelling domain.
- A one year simulation (2006) using CALMET was conducted which included two surface stations: the Yarrie on-site meteorological fields (including missing data) and the TAPM generated surface station to the north-east.

- CALMET was configured to include TAPM-generated upper air data at heights above 1250 m only. This height was selected in order to limit the influence of TAPM upper data within the boundary layer where terrain effects may have a significant impact on flow development. Above the boundary layer where the flow may be approximated by the gradient wind, it is anticipated that TAPM may adequately represent flow conditions.
- A time series of parameters including wind speed, wind direction and mixing height have been extracted from the three-dimensional CALMET-generated meteorological fields at the location of the on-site monitoring sites.

6.2 Terrain and Landuse

Topography plays an important role in atmospheric dispersion of pollutants by allowing or obstructing the free movement of air and mechanically forcing the circulation of air masses.

Air pollutants emitted into the lowest layers of the atmosphere can show complex behaviour as a result of the influence of local and regional scale terrain features such as night-time katabatic drainage flows from elevated terrain or channelling effects in valleys or gullies.

Figure 7 shows the contours of the gridded terrain data that was used as input into CALMET. The grid was developed using US National Aeronautics and Space Agency (NASA) satellite terrain data. A total of 93 by 75 nodes were used on a grid spacing of 90 m, representing an area of 8.28 km by 6.66 km.

Land use categories associated with barren land (70) and a small number of urban (10) cells (associated with the camp) were used.

6.3 Dispersion Meteorology

The CALMET generated annual wind rose extracted at the location of the Yarrie monitoring site is presented in **Figure 8**. The annual wind rose indicates that winds are primarily from the northeast through southeast with winds from the west occurring infrequently. In general winds are predominantly light with an annual average wind speed predicted of 2.7 m/s. Winds are predicted to exceed 5.4 m/s approximately 7.1% of the time. (Recall that the frequency that the wind speed exceeds 5.4 m/s is used in the development of the emission factor for wind-generated erosion, **Section 5.4.2**.)

The CALMET generated seasonal wind roses for the Yarrie monitoring site are presented in **Appendix C**.

A comparison of the seasonal wind roses produced by CALMET and those constructed from on-site data (**Figure 5** and **Appendix A**) suggests that:

- The summer, winter and spring wind fields show good agreement in general with those from the on-site data; and
- In autumn, wind fields predicted by the model show a bias towards east-southeast winds which are stronger than observed, with fewer winds predicted to occur from the east-northeast. This discrepancy is attributed to the 65% of missing on-site data during this period, and thus the influence of TAPM generated wind fields for March and April.

6.3.1 Atmospheric Stability

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Gifford assignment scheme identifies six Stability Classes, “A” to “F”, to categorise the degree of atmospheric stability. These classes indicate the characteristics of the prevailing meteorological conditions.

Stability Class "A" represents highly unstable conditions that are typically found during summer, categorised by strong winds and convective conditions. Conversely, Stability Class "F" relates to highly stable conditions, typically associated with clear skies, light winds and the presence of a temperature inversion. Classes "B" through to "E" represent conditions intermediate to these extremes.

The frequency of occurrence of each stability class for the year 2006 at the location of the Yarrie monitoring site, as predicted by CALMET, is presented in **Figure 9**.

The results indicate a high frequency of conditions typical to Stability Class "F". Stability Class "F" is indicative of stable conditions, which will impede atmospheric pollutant dispersion. Under stable atmospheric conditions, pollutant plumes can extend for long distances downwind of the source with poor dilution.

Appendix D illustrates the seasonal variation in atmospheric stability class.

6.3.2 Mixing Height

The mixing height refers to the vertical extent of mixing in the atmosphere. The air within this layer is usually well-mixed through turbulent motion, resulting in better atmospheric dispersion.

Research has shown an inverse relationship between pollutant concentrations and mixing height, so mixing height is a critical guide to pollution potential in an area (Oke, 1987). Diffusion of atmospheric contaminants into a larger volume of air will necessarily reduce the ambient concentration of pollutants. Dispersion model predictions can be highly sensitive to changes in mixing heights. However this is typically most relevant to elevated sources with buoyant plumes.

A frequency distribution of the mixing heights representative of the Yarrie monitoring site (2006) is given in **Figure 9**. The results indicate high occurrences of mixing heights to 100 m at this location.

6.4 Dispersion Modelling

Due to the remoteness of the mine sites, the relatively minor scale of the planned Cundaline and Callawa mining operations in comparison with other iron ore mining in the wider region and the distance between receptors and dust-generating activities, limited dispersion modelling using CALPUFF has been undertaken.

A simplified approach has been adopted which assumes that all particulate matter emissions are released simultaneously from a single point as a volume source centred at the activity (activities) of interest.

In the case of modelling of the haul road from the planned Cundaline mining operations to the Yarrie processing facility, a series of volume sources placed at regular intervals along the route was used following the VIC EPA recommended modelling methodology for the simulation of line sources using AUSPLUME. Multiple simulations were conducted to verify that ground-level concentrations predicted at the Yarrie accommodation camp were independent of the spacing between volume sources.

Based on the PM_{10} emission inventories presented in **Table 12** through **Table 16**, the grouped dust emissions sources were ranked in accordance with their likely potential to impact on air quality at the location of the Yarrie accommodation camp. The sources (or group of sources) in order of highest to lowest estimated impact potential are:

- Wheel-generated dust associated with the transport of ore from the planned Cundaline mining operations to the Yarrie processing facility (Option B);
- Overburden and extraction related activities at the planned Callawa mining operations;
- Processing and stockpile erosion at the Yarrie Processing Facility;

- Stockpile erosion, overburden and extraction related activities at the planned Cundaline mining operations (Option A); and
- Overburden and extraction related activities at the planned Cundaline mining operations (Option B).

For screening purposes, not all of these sources were explicitly modelled. Sources that were modelled were done so separately in order to quantify the contribution of different activities to ground-level concentrations of particulate matter at the Yarrie accommodation camp. In particular the following sources were explicitly modelled:

- The haul road joining the planned Cundaline mining operations to the Yarrie processing facility;
- The planned Callawa mining operations – overburden and excavation activities;
- Yarrie processing facility – processing-related activities assuming that there is processing of ore at the planned Cundaline mining operations; and
- Yarrie processing facility – processing-related activities assuming that there is no processing of ore at the Cundaline mine.

7 INTERPRETATION OF AIR QUALITY IMPACTS - CONSTRUCTION

Construction and site establishment activities are expected to commence following mine approval and planning. Construction at the mine sites includes vegetation clearing and site establishment, construction of haulage routes, construction of processing plant (at the planned Cundaline mining operations if required), and other site infrastructure.

During dry conditions, on-site construction activities have the potential to generate dust. In addition, diesel emissions from construction vehicles including excavators, graders, scrapers and trucks are expected during construction.

However, given the isolated nature of the mine sites (closest non-BHPBIO owned residence is over 10 km away) construction phase air quality impacts are not considered likely to be significant. The scale and duration of the operational phase of the development would result in significantly greater impacts than during construction. As such, construction impacts were not explicitly modelled.

However, localised air quality impacts associated with construction should be controlled as much as possible, through good site management, vehicle maintenance and applying appropriate dust mitigation measures as detailed in **Section** Error! Reference source not found..

Vehicle exhaust emissions of oxides of nitrogen (NO_X), sulphur dioxide (SO_2) and hydrocarbons from construction vehicles are not expected to be significant given the relatively small scale nature of the construction activities. These emissions are expected to be easily assimilated into the local airshed and unlikely to cause exceedances of air quality goals at residences surrounding the mine site. Additionally, the low sulphur content of Australian diesel is expected to ensure air quality goals for sulphur dioxide (SO_2) would not be exceeded.

7.1 Dust Management for Construction

As part of this assessment, consideration was given to mitigation measures found in the *Goldsworthy Environmental Management Plan* (EMP), and currently used at the existing Goldsworthy operations for potential air quality impacts during the construction phase:

- Water tankers are used to apply water to sites within areas of operation which have the potential to generate dust, including unsealed roads, haul roads and construction areas.
- Areas of exposed soil (land disturbance) are minimised.
- Dust suppression equipment is maintained in efficient operating condition.
- Disturbed areas are rehabilitated as they become available.
- Routine maintenance and housekeeping practices are employed to ensure that waste materials in or around the premises do not accumulate and lead to the generation of unacceptable airborne dust.
- Routine maintenance of dust collection and dust control systems to ensure dust emissions are minimised.
- All employees and contractors are informed of the importance of minimising ambient dust levels.

By incorporating these measures into the assessment for the planned Cundaline and Callawa mining operations, the impacts during construction were not considered likely to be significant.

8 INTERPRETATION OF AIR QUALITY IMPACTS - OPERATIONAL

The interpretation of air quality impacts presented in the following sections focus on health-related impacts associated with ground level concentrations of PM_{10}.

A combination of dispersion modelling and qualitative analysis has been used to assess operational phase air quality impacts associated with the planned Cundaline and Callawa mining operations.

As indicated in **Section 2.2,** the planned Cundaline and Callawa mining operations are situated in an isolated area with the closest non-BHPBIO owned residence over 10 km away. Given this separation distance, adverse air quality impacts at non-BHPBIO owned residences due to site-based activities are not expected.

For the purposes of dispersion modelling, a worst-case approach was adopted (i.e. sources were combined and assumed to be emitted simultaneously from a single location centred on the mine of interest). In the case of the haul road between the planned Cundaline mining operations and the Yarrie processing facility, a series of volume sources were used to simulate potential impacts from wheel-generated dust.

8.1 Callawa Mine – Extraction and Overburden-related Activities

Results of the dispersion modelling suggest that the impact of dust emissions from the planned Callawa mining operations associated with overburden-related activities and excavation on air quality at the Yarrie accommodation camp will be negligible with a maximum increase in the 24-hour average ground-level concentration of PM_{10} of 1.8 µg/m^3 predicted. The NEPM standard for the 24-hour average ground-level concentration of PM_{10} is 50 µg/m^3 (NEPC, 2003).

The contribution of emissions from these activities to the annual average ground-level concentration of PM_{10} at the location of the Yarrie accommodation camp is predicted to be 0.1 µg/m^3. The NEPM goal for the annual average ground-level concentration of PM_{10} is 20 µg/m^3 (NEPC, 2003).

Thus, overburden-related and excavation activities (including blasting, loading of trucks, etc.) at the planned Callawa mining operations are not predicted to have a measurable impact on air quality at the location of the Yarrie accommodation camp.

8.2 Cundaline Mine Option A – On-site Processing of Ore

8.2.1 Cundaline Mine Site-based Activities

Based on information presented in **Table 12** and **Table 13**, the estimated worst-case annual input of PM_{10} emissions into the air shed associated with extraction and overburden activities at the planned Callawa mining operations (year 2011, 183.3 tonnes) is comparable to worst-case annual dust emissions for these same activities at the planned Cundaline mining operations (year 2013, 186.4 tonnes). With the addition of emissions associated with transport, processing and stockpile erosion at the planned Cundaline mining operations, the estimated total annual emission of PM_{10} from mine-site based activities is 303.1 tonnes (2013).

A separation distance of over 10 km between the extraction and processing activities at Cundaline to the accommodation camp, combined with results from the planned Callawa mining operations simulation, suggests that adverse impacts on air quality at the location of the accommodation camp will be negligible.

8.2.2 Yarrie Processing Facility

Results from numerical simulations of the impact of emissions of dust from activities including processing and stockpile erosion at the Yarrie facility suggest that an increase in the maximum 24--hour average ground-level concentration of PM_{10} of 2.2 µg/m^3 may occur at the location of the accommodation camp. The NEPM standard for the 24-hour average ground-level concentration of PM_{10} is 50 µg/m^3 (NEPC, 2003).

The contribution of emissions from these activities to the annual average ground-level concentration of PM_{10} at the location of the Yarrie accommodation camp is predicted to be 0.2 µg/m^3. The NEPM goal for the annual average ground-level concentration of PM_{10} is 20 µg/m^3 (NEPC, 2003).

Thus, fugitive emissions of dust from processing and stockpile erosion at the Yarrie processing facility is predicted to have a negligible impact on air quality at the location of the Yarrie accommodation camp.

8.3 Cundaline Mine Option B – Processing of Ore at the Yarrie Facility

8.3.1 Wheel-Generated Dust

Simulations of dust emissions from the haul road joining the planned Cundaline mining operations to the Yarrie processing facility were conducted. Results suggest that in terms of potential impacts to air quality at the Yarrie accommodation camp, wheel-generated dust from the proposed haul route from the planned Cundaline mining operations to Yarrie is the only significant dust emission source.

Particulate matter as PM_{10}

Dispersion modelling results suggest that the maximum incremental contribution of wheel-generated dust emissions to the 24-hour average ground-level concentration at the location of the Yarrie accommodation camp is 39.7 µg/m^3. The NEPM standard is 50 µg/m^3 (NEPC, 2003). The five highest 24-hour concentrations of PM_{10} predicted at the Yarrie accommodation camp are presented in **Table 17**.

Table 17 Five highest incremental contributions of wheel-generated dust to the 24-hour average ground level concentration of PM_{10} at the Yarrie accommodation camp (µg/m^3)

Location	**1**	**2**	**3**	**4**	**5**
Yarrie accommodation camp	39.7	36.9	32.8	31.2	30.7

It is noted that the NEPM allows for 5 exceedences of the 24-hour average ground level concentration of PM_{10} per year (NEPC, 2003), however, it is anticipated that naturally occurring dust events in this arid region may contribute to significantly elevated dust levels at times throughout the year.

It is further noted that estimates of background levels of particulate matter has not been conducted due to the limitations noted in **Section 4.1**.

Experience acquired by Heggies modellers in relation to predicted impacts from low level emission sources using CALPUFF suggests that model results may lead to ultra-conservative estimates of ground level impacts. The high percentage of “F” class stability combined with shallow mixing heights of 50 m (default minimum height recommended by CALPUFF) may lead to elevated concentrations of pollutants during the evening and night-time.

The incremental contribution of wheel-generated dust emissions from the planned Cundaline mining operations to Yarrie haul route to the annual average ground-level concentration of PM_{10} at the location of the accommodation camp is predicted to be 5.6 µg/m^3. The NEPM goal is 20 µg/m^3 (NEPC, 2003).

Particulate Matter as $PM_{2.5}$

Based on the $PM_{2.5}$ to PM_{10} ratio of 0.15 (as discussed in **Section 5.4.5**), results for the predicted ground-level concentration of PM_{10} presented in the previous section, suggest that wheel-generated dust from the planned Cundaline mining operations to Yarrie haul route may contribute 6.0 µg/m^3 to the maximum 24-hour average ground-level concentration of $PM_{2.5}$ at the accommodation camp. The NEPM and WHO goal is 25 µg/m^3 for the 24-hour average concentration of $PM_{2.5}$ (NEPC, 2003; WHO, 2000, 2005).

An incremental contribution of 0.8 µg/m^3 is estimated in relation to the annual average ground-level concentration of $PM_{2.5}$. The NEPM goal is 8 µg/m^3 (NEPC, 2003).

Particulate Matter as TSP

As noted in **Section 3.6**, the NHMRC annual average goal for TSP of 90 µg/m^3 is less strict than the NEPM goal of 20 µg/m^3 for the annual average concentration of PM_{10} based on an average PM_{10} to TSP ratio of 0.5 (**Table 10**). Thus compliance of the NEPM goal for PM_{10} will ensure compliance with the NHMRC goal for TSP.

Dust Deposition

The predicted incremental contribution of wheel-generated dust to dust-deposition at the location of the accommodation camp is not predicted to exceed 0.1 g/m^2/month. The goal relating to the incremental contribution to dust deposition associated with the planned Cundaline and Callawa mining operations is 2 g/m^2/month (**Table 4**).

8.3.2 Yarrie Processing Facility

Results from numerical simulations of the impact of emissions of dust from processing activities at the Yarrie facility suggest that an increase in the maximum 24-hour average ground-level concentration of PM_{10} of 2.7 µg/m^3 may occur at the location of the accommodation camp. This represents an increase of 1.8 µg/m^3 compared with results for Cundaline Option A which involves the processing of ore at the planned Cundaline mining operations.

The contribution of emissions from processing activities at the Yarrie facility to the annual average ground-level concentration of PM_{10} at the location of the Yarrie accommodation camp is predicted to increase from 0.1 µg/m^3 (processing at Cundaline) to 0.4 µg/m^3. The NEPM goal for the annual average ground-level concentration of PM_{10} is 20 µg/m^3 (NEPC, 2003).

Wind-erosion of stockpiles at the Yarrie processing facility are predicted to contribute an additional 1.8 µg/m^3 to the 24-hour average ground-level concentration of PM_{10} and negligible contribution to the annual average ground-level concentration of PM_{10} at the location of the accommodation camp.

9 OPERATIONAL DUST MANAGEMENT

9.1 Existing Measures Incorporated into the Model

As part of this assessment, consideration was given to mitigation measures currently used at the existing Goldsworthy operations for potential air quality impacts during the operations phase. These measures can be found in the Goldsworthy EMP, and were incorporated into the assessment to take dust amelioration activities into account:

- Transfer points are enclosed and fitted with water sprays.
- Water tankers are used to apply water to sites within areas of operation which have the potential to generate dust, including unsealed roads, haul roads and construction areas.
- Areas of exposed soil (land disturbance) are minimised.
- Dust suppression equipment is maintained in efficient operating condition.
- Disturbed areas are rehabilitated as they become available.
- Routine maintenance and housekeeping practices are employed to ensure that waste materials in or around the premises do not accumulate and lead to the generation of unacceptable airborne dust.
- Routine maintenance of dust collection and dust control systems to ensure dust emissions are minimised.
- All employees and contractors are informed of the importance of minimising ambient dust levels.
- A Low Frequency Microwave Moisture Analyser (LFMMA) is used to monitor the moisture content of material on the conveyor system. In the event that moisture content is outside the accepted ore moisture range, the water supply will be adjusted to ensure adequate dust suppression.
- Dust extraction via collectors.

By incorporating these measures into the assessment for the planned Cundaline and Callawa mining operations, the impacts due to operational Project-only emissions did not reach criteria described in **Section 3**.

10 GREENHOUSE GAS ASSESSMENT

Operations at the planned Cundaline and Callawa mining operations have the potential to generate greenhouse gas emissions from a number of sources. These sources include the following.

- The combustion of fuel by diesel-powered generators, equipment and vehicles.
- Use of explosives during blasting operations.
- Use of purchased electricity.

This assessment of greenhouse gas emissions from the mining of the Cundaline and Callawa deposits reports direct emissions (scope 1) produced within the boundary of the site, and indirect emissions (scopes 2 and 3) from electricity consumed, transmission and distribution losses and emissions attributable to the extraction, production and transport of fuels (DCC, 2008).

Carbon dioxide (CO_2) is produced during fuel combustion as a result of the oxidation of the fuel carbon content. CO_2 is likely to make the largest contribution to greenhouse gas emissions from fuel combustion as approximately 99% of automotive diesel oil (ADO) fuel is oxidised during the combustion process (Australian Greenhouse Office [AGO], 2002).

Other greenhouse gases emitted as a result of excavation operations may include carbon monoxide (CO), methane (CH_4), oxides of nitrogen (NO_X) and non-methane volatile organic compounds (NMVOCs). These are produced by incomplete fuel combustion, reactions between air and fuel constituents during fuel combustion, and post-combustion reactions. Fugitive emissions of NMVOCs may also be expected due to fuel evaporation.

For comparative purposes, non-CO_2 greenhouse gases are awarded a "CO_2-equivalence" based on their contribution to the enhancement of the greenhouse effect. The CO_2-equivalence (CO_2-e) of a gas is calculated using an index called the Global Warming Potential (GWP). The GWPs for a variety of non-CO_2 greenhouse gases are contained within the Intergovernmental Panel on Climate Change (IPCC) document *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*. The GWPs of relevance to this assessment are:

- **Methane (CH_4)**: GWP of 21 (21 times more effective as a greenhouse gas than CO_2); and
- **Nitrous Oxide (N_2O)**: GWP of 310 (310 times more effective as a greenhouse gas than CO_2).

The short-lived gases such as CO, NO_2, and NMVOCs vary spatially and it is consequently difficult to quantify their global radiative forcing impacts. For this reason, GWP values are generally not attributed to these gases nor have they been considered further as part of this assessment.

An assessment of the predicted greenhouse gas emissions from the planned Cundaline and Callawa mining operations has been undertaken for each of the aforementioned sources and is outlined below.

10.1 Diesel Combustion

The primary fuel source for mining equipment and vehicles would be Automotive Diesel Oil (ADO). Based on information supplied by the Proponent, the expected diesel consumption rate associated with mining and transport activities is approximately 3,850 kL per annum.

The annual emissions of CO_2 and other greenhouse gases from this source have been estimated using National Greenhouse Accounts (NGA) Factors (2008) produced by the DCC.

Presented in **Table 18** are the greenhouse gas emission factors that relate to the consumption of diesel fuel by mobile sources as outlined in Table 3 of the Australian Government's *National Greenhouse Accounts (NGA) Factors* document.

Table 18 National Greenhouse Accounts Factors for Diesel Fuel Consumption

Activity	Units	Scope 1	Scope 2	Scope 3	Total
Diesel Consumption	t CO_2-e/kL	2.7	-	0.2	2.9

Note (1) t CO2-e = tonnes of CO_2 equivalent

Presented in **Table 19** is the amount of CO_2-e associated with diesel fuel consumption.

Table 19 GHG emitted from the consumption of Diesel (ADO) per annum

Diesel per annum KL	Units	Scope 1	Scope 2	Scope 3	Total
3850	t CO_2-e	10,395	-	770	11,165

Based on these assumptions, it is predicted that the combustion of diesel fuel will result in the emission of approximately 11,165 tonnes of CO_2-equivalent per annum.

10.2 Explosives

Information provided by BHPBIO suggests that at Cundaline and Callawa, there will be on average:

- Two blasts per week;
- A total of 135 holes per blast; and
- 170 kg of ANFO explosive used per hole.

An estimate of the CO_2 emissions resulting from blasting activities has been derived using information contained in Table 4 of the AGO document NGA Factors.

Presented in **Table 20** is the emission factor and corresponding amount of CO_2-e associated with blasting.

Table 20 CO_2 equivalent levels emitted from blasting from 2009 to 2016

Explosive type	Tonne of product per annum	Emission Factor for scope 1 t CO2-e/t product	t CO2-e
ANFO	2386.8	0.17	405.8

Based on this information, it is predicted that blasting at the planned Cundaline and Callawa mining operations would emit approximately 406 tonnes of CO_2-e per annum.

10.3 Electricity

Power will be supplied by electricity transmission lines reticulated from Yarrie operations. Anticipated electricity consumption at the mine site is of the order of 7,500 megawatt hours (MWh) per year.

The annual consumption of electricity per year has been estimated using the assumption that the operations will continue 24 hours per day, 365 days per year.

Presented in **Table 21** is the emission factor and corresponding CO_2-e associated with the use of purchased electricity.

Table 21 National Greenhouse Accounts Factors for electricity end users in Western Australia in 2007

Activity	Units	Scope 1	Scope 2	Scope 3	Total
Electricity Consumption	kg CO2-e/kWh	-	0.87	0.17	1.06

Presented in **Table 22** is the amount of CO_2-equivalent in tonnes per year resulting from electricity consumption.

Table 22 CO_2-e levels emitted from electricity consumption

Electricity Consumption MWh	Units	Scope 1	Scope 2	Scope 3	Total
7,500	t CO2-e	-	6,525	750	7,275

Based on these assumptions, it is predicted that the use of electricity consumption will result in the emission of approximately 7,275 tonnes of CO_2-e per annum.

10.4 Total Greenhouse Gas Emissions

A summary of the predicted greenhouse gas emissions per year associated with the planned Cundaline and Callawa mining operations is presented in **Table 23**.

As indicated in the table, the total annual emissions of CO_2-e as a result of operational activities are likely to be in the order of 18,846 tonnes of CO_2-e per annum.

Greenhouse gas estimates are assessed relative to 1990 baseline levels for reporting purposes. The *1990 National Greenhouse Gas Inventory* (AGO, 1990) provides estimates of greenhouse emissions in Australia.

The WA EPA in its *Guidance Statement for Minimising Greenhouse Gas Emissions* (WA EPA, 2002) report total Australian 1990 emissions to be of the order of 503.3 Mt CO_2-e and WA's total 1990 emissions to be 42.5 Mt CO_2-e.

A comparison of the predicted emissions from the planned Cundaline and Callawa mining operations against the 1990 estimate demonstrates that the mining of the Cundaline and Callawa deposits would represent approximately 0.004% of the total baseline Australian emissions and approximately 0.04% of the total baseline WA emissions.

More recent National emission estimates (i.e. 576 Mt in 2006) and WA emission estimates (i.e. 70.4 Mt in 2006) result in emissions from the planned Cundaline and Callawa mining operations comprising 0.003% of the total baseline Australian emissions and 0.03% of the total baseline WA emissions (DCC, 2006).

Table 23 Estimated annual greenhouse gas emissions

Years	Source	Predicted Emissions (tpa CO_2-e) per year			Total (tpa CO_2-e) per year
		Scope 1	**Scope 2**	**Scope 3**	
2009 – 2016	Diesel	10,395	-	770	11,165
	Electricity	-	6,525	750	7,275
	Blasting	405.8	-	-	405.8
	Total	**10,800.8**	**6,525.0**	**1,520.0**	**18,845.8**

10.5 Greenhouse Gas Management

As part of this assessment, consideration was given to mitigation measures currently used at the existing Goldsworthy operations for greenhouse gas emissions. These measures were considered in the assessment of greenhouse gas emissions and are described below:

- restricting land clearing to the practicable minimum;
- using efficient plant equipment and conducting regular maintenance; and
- rehabilitating disturbed areas as soon as they become available.

In July 2007 BHP Billiton finalised and adopted a new Climate Change Policy to replace its existing policy, which had been in place since 2002. The Climate Change Policy commits to a series of actions including new greenhouse gas and energy targets and measures, a major investment in research and development of low carbon emissions technologies, and participation in the design of effective national and international climate change policies.

11 CONCLUSIONS – AIR QUALITY ASSESSMENT

An air quality assessment has been conducted to assess the potential impacts of dust resulting from activities associated with the mining of the Cundaline and Callawa Deposits on air quality at the nearest receptor location (i.e. the Yarrie accommodation camp). The Yarrie homestead was considered to be of sufficient distance from the sites not to be significantly affected by impacts from dust emissions.

Based on an analysis of the PM_{10} emission inventories, grouped dust emissions sources were ranked in accordance with their potential to impact on air quality at the location of the Yarrie accommodation camp. The sources (or group of sources) in order of highest to lowest estimated impact potential were identified as:

- Wheel-generated dust associated with the transport of ore from the planned Cundaline mining operations to the Yarrie processing facility (Option B);
- Overburden and extraction related activities at the planned Callawa mining operations;
- Processing and stockpile erosion at the Yarrie Processing Facility;
- Stockpile erosion, overburden and extraction-related activities at the planned Cundaline mining operations (Option A); and
- Overburden and extraction related activities at the planned Cundaline mining operations (Option B).

For screening purposes, not all sources were modelled explicitly. Sources that were modelled were done so separately in order to quantify the contribution of different activities to ground-level concentrations of particulate matter at the Yarrie accommodation camp.

Limited availability of site-specific air quality background data has lead to the consideration of the incremental contribution of Project-only dust emissions to the ground-level concentration of particulate matter at the Yarrie accommodation camp.

Two options for the processing of ore from the planned Cundaline mining operations were considered:

- On-site processing of ore; and
- Transport of ore via road trains to the Yarrie facility for processing.

Air Quality

Results of the dispersion modelling have not highlighted any air quality issues in relation to emissions of particulate matter associated with:

- Overburden-related activities at the planned Cundaline and Callawa mining operations;
- Extraction of material from the planned Cundaline and Callawa mining operations;
- Processing, material handling, and train load-out at the Yarrie processing facility; and
- Stockpile erosion at the Yarrie processing facility.

Results of the dispersion modelling highlight wheel-generated dust associated with the transport as having the greatest potential to impact on air quality at the location of the accommodation camp, however modelling results indicated no exceedances of criteria were predicted from project-only emissions.

The maximum incremental contribution of wheel-generated dust emissions to the 24-hour average ground-level concentration at the location of the Yarrie accommodation camp is predicted to be 39.7 µg/m^3. The NEPM standard is 50 µg/m^3. The incremental contribution of wheel-generated dust emissions from the planned Cundaline mining operations to Yarrie haul route to the annual average ground-level concentration of PM_{10} at the location of the Yarrie accommodation camp is predicted to be 5.6 µg/m^3. The NEPM goal is 20 µg/m^3 (NEPC, 2003).

Greenhouse Gases

The total annual emissions of CO_2-e as a result of the operational activities associated with the planned Cundaline and Callawa mining operations are likely to be in the order of 18,846 tonnes of CO_2-e per annum.

The EPA *Guidance Statement for Minimising Greenhouse Gas Emissions* reports total Australian 1990 emissions (i.e. comparison against 1990 levels recommended by the Kyoto Protocol) of 503.3 Mt CO_2-e and WA's total 1990 emissions to be 42.5 Mt CO_2-e. A comparison of the predicted emissions from planned Cundaline and Callawa mining operations against 1990 levels demonstrates that the mining of the Cundaline and Callawa deposits would represent approximately 0.004% of the total baseline Australian emissions and approximately 0.04% of the total baseline WA emissions.

More recent National emission estimates (i.e. 576 Mt in 2006) and WA emission estimates (i.e. 70.4 Mt in 2006) result in emissions from the planned Cundaline and Callawa mining operations comprising 0.003% of the total baseline Australian emissions and 0.03% of the total baseline WA emissions (DCC, 2006).

12 NOISE AND BLASTING ASSESSMENT

This Noise Impact Assessment report addresses potential operational noise impacts on the existing Yarrie accommodation camp as a result of development of the planned Cundaline and Callawa mining operations. This report also addresses over-pressure resulting from blasting. The Yarrie homestead and the Warralong Aboriginal Community are also considered to be noise sensitive receivers. However, the distance (i.e. greater than 10 km) from the homestead to the planned Cundaline and Callawa mining operations is such that amenity at the Yarrie homestead and the Warralong Aboriginal Community is unlikely to be impacted upon from noise emissions associated with the planned Cundaline and Callawa mining operations.

Figure 11 shows the topography in the area. It can be seen that the line-of-sight to the proposed mines from the accommodation camp will be obscured by intervening topography. The planned Cundaline and Callawa mining operations are approximately 9 km and 5 km from the accommodation camp, respectively.

Details of the proposed mining operations including plant and equipment are provided in **Appendix E**.

13 NOISE ASSESSMENT CRITERIA

13.1 Assigned Noise Levels

Assigned noise levels from the *Environmental Protection (Noise) Regulations 1997* are shown in **Table 24**.

Table 24 Assigned Noise Levels

Type of premises receiving noise	Time of day	Assigned level (dB)		
		LA10	LA1	LAmax
Noise sensitive premises at locations within 15 metres of a building directly associated with a noise sensitive use	0700 to 1900 hours Monday to Saturday	45 + influencing factor	55 + influencing factor	65 + influencing factor
	0900 to 1900 hours Sunday and public holidays	40 + influencing factor	50 + influencing factor	65 + influencing factor
	1900 to 2200 hours all days	40 + influencing factor	50 + influencing factor	55 + influencing factor
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	35 + influencing factor	45 + influencing factor	55 + influencing factor
Noise sensitive premises at locations further than 15 metres of a building directly associated with a noise sensitive use	All hours	60	75	80
Commercial premises	All hours	60	75	80
Industrial and utility premises	All hours	65	80	90

dB = decibels.

LA10 = A-weighted sound pressure level exceeded for 10% of a given measurement period.

LA1 = A-weighted sound pressure level exceeded for 1% of a given measurement period.

LAmax = Maximum A-weighted noise level.

It is considered that since the majority of the proposed operations will run continuously, the LA10 is the appropriate parameter to assess.

13.2 Influencing Factor

The “influencing factor” is calculated for each noise-sensitive premises receiving noise. It takes into account land on which a mining operation is carried on and the presence of roads within a 450 m radius around the noise receiver.

Because the Yarrie accommodation camp is located wholly within an operating mining lease, the influencing factor determined for the Yarrie accommodation camp in accordance with Schedule 3 of the *Environmental Protection (Noise) Regulations 1997* is 20. This calculation is shown in **Appendix F**.

The assigned noise levels (inclusive of influencing factor) are shown in **Table 25**.

Table 25 Site-Specific Assigned Noise Levels

Type of premises receiving noise	Time of day	Assigned level (dB)		
		LA10	LA1	LAmax
Noise sensitive premises at locations within 15 metres of a building directly associated with a noise sensitive use	0700 to 1900 hours Monday to Saturday	65 (45 + 20)	75 (55 + 20)	85 (65 + 20)
	0900 to 1900 hours Sunday and public holidays	60	70	85
	1900 to 2200 hours all days	60	70	85
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	55	65	75

13.3 Compliance with Assigned Noise Levels

Regulation 7 of the *Environmental Protection (Noise) Regulations 1997* requires that "noise emitted from any premises when received at other premises must not cause, or significantly contribute to, a level of noise which exceeds the assigned level in respect of noise received at premises of that kind". A noise emission is taken to "significantly contribute to" a level of noise if the noise emission exceeds a value which is 5dB below the assigned level at the point of reception.

13.4 Screening Procedure

The *Environmental Noise Guidance Statement* provides a mechanism to conduct a "screening" exercise in order to determine whether a detailed noise assessment is required for a proposal.

The screening exercise was conducted for the planned Cundaline and Callawa mining operations. However, it was determined that a detailed noise assessment would be required. The working of the screening procedure for the proposals is provided in **Appendix G**.

13.5 Airblast

The *Environmental Protection (Noise) Regulations 1997* provide the following criteria for airblast:

13.5.1 Daytime Blasting

For blasting carried out between 7am and 6pm on any day which is not a Sunday or public holiday, the airblast level received on any other premises must not exceed -

125 dB Llinear, peak for any blast; and

120 dB Llinear, peak for nine in any 10 consecutive blasts, regardless of the interval between blasts.

13.5.2 Blasting on Sundays and Public Holidays

For blasting carried out between 7am and 6pm on a Sunday or public holiday, the airblast level received on any other premises must not exceed -

120 dB Llinear, peak for any blast; and

115 dB Llinear, peak for nine in any 10 consecutive blasts, regardless of the interval between blasts.

14 NOISE EMISSIONS INVENTORY

Sound power levels for noise sources are shown as linear levels in 1/1 octave bands and as overall "A" frequency weighted levels (dBA) in **Appendix H**. The sound power levels are typical maximum noise levels from Heggies internal database.

15 NOISE MODELLING

15.1 Noise

Noise impact levels were calculated using the CONCAWE algorithms, which are the algorithms incorporated into the SoundPlan noise modelling software package. **Appendix I** shows the results of the calculations. The input parameters are summarized as follows:

- Source locations were taken to be the point on the designated area for that source which was nearest to the Yarrie accommodation camp. In particular, noise from road trains was modelled as two road trains simultaneously travelling along the haul route between Cundaline Ridge and the Yarrie processing facility, passing the accommodation camp at its nearest point to the road.
- The heights of the sources were estimated above ground level. Ground levels for sources, receivers and intervening topography were derived from BHPBIO data.
- Results are presented for both acoustically "hard" and "soft" ground as incorporated by the CONCAWE algorithms. "Hard" ground provides minimal or nil additional absorption of sound as it propagates over the surface (e.g. water, concrete and other impervious surfaces such as solid rock). However, "soft" or porous ground provides additional absorption which can be significant depending on the specific properties of the ground e.g. grass, coarse sand and snow. The reality is that the ground in the area would have acoustic properties somewhere between these two extremes. For the purposes of this assessment a conservative approach has been adopted. Results will be presented for the "hard" ground model input option.
- Results were calculated using "worst case" meteorological conditions in accordance with *Guidance Statement No. 8 – Environmental Noise* published by the EPA (2007). Specifically, the meteorological conditions are:
  - Wind speed $\leq$ 3 m/s;
  - Pasquill Stability Class "F";
  - Temperature 15ºC; and
  - Relative Humidity 50%.

It should be noted that while the calculations were all conducted assuming "worst case" meteorological conditions, the locations of the sources with respect to the accommodation camp is such that the wind could only be blowing from one of the mines toward the camp at any one time.

Adjustments for tonality and impulsiveness have been incorporated into the results as presented. It is considered that these penalties would apply only to noise from the rail facilities as a result of shunting and wheel squeal, for which the maximum penalty of +15 dBA has been applied. There are no sources considered to have modulation.

15.2 Airblast

Airblast has been estimated at the Yarrie accommodation camp using proprietary calculation spreadsheets, incorporating the ICI air blast calculation methodology (ICI Explosives Blasting Technical Services - ICI explosives, Oct 1995) and the following parameters:

- Free-face average rock.
- Assessment distance (worst case) 4,500 m.
- Maximum Instantaneous Charge (MIC) 855 kg ANFO.

16 INTERPRETATION OF IMPACTS

16.1 Noise

Noise emissions were modelled during the years of highest production, therefore producing the highest noise-related emissions (i.e. years 2011 and 2013). The results of the noise modelling are shown below in **Table 26** and **Table 27**.

Table 26 Noise Modelling Results Presented as L_{A10} - Year 2011

			L_{A10} **Sound Pressure Level (dB)**
2011	Cundaline	Crushing and Screening Plant	3
		Mine (pit) plant	0
		Rail loadout facilities	15
		Road trains	43
	Callawa	Crushing and Screening Plant	25
		Mine (pit) plant	22
		Rail loadout facilities	27

Table 27 Noise Modelling Results Presented as L_{A10} - Year 2013

			L_{A10} **Sound Pressure Level (dB)**
2013	Cundaline	Crushing and Screening Plant	3
		Mine (pit) plant	3
		Rail loadout facilities	15
		Road trains	43
	Callawa	Crushing and Screening Plant	25
		Mine (pit) plant	21
		Rail loadout facilities	27

Cumulative “worst case” noise impacts of the possible operational scenarios are shown in **Table 28**.

Table 28 shows that higher noise levels are expected if ore is transported by road train to the Yarrie processing facilities. However, the cumulative noise impact levels for all scenarios are less than the assigned noise levels in **Table 26**.

Table 28 Cumulative Noise Impacts for Possible Operational Scenarios

Operational Scenario	Cumulative L_{A10} Noise Impact Level
2011 Crushing and screening at Cundaline, rail loadout facility at Cundaline	30 dBA
2011 Ore transport to Yarrie processing facilities by road train	43 dBA
2013 Crushing and screening at Cundaline, rail loadout facility at Cundaline	30 dBA
2013 Ore transport to Yarrie processing facilities by road train	43 dBA

The potential for sleep disturbance (awakening) is sometimes used to assess noise amenity. The criterion of 45 dBA L_{Amax} internal has been adopted through common use from WHO guidelines. It can be seen that an external noise level of 43 dBA will result in an internal noise level conservatively estimated to be less than 28 dBA (i.e. at least a 15 dBA reduction through closed windows).

16.2 Blasting

Airblast results indicated that the maximum blasting noise at the accommodation camp would be 100 dB. Blasting noise levels are therefore expected to achieve the most stringent criterion of 115 dB.

17 DISCUSSION – NOISE ASSESSMENT

Table 26 and **Table 27** show that noise from the majority of the operations is unlikely to cause a decrease in noise amenity. The most significant noise source is road trains travelling between Cundaline Ridge and the Yarrie processing facilities. While the noise levels produced by the road trains are higher than other sources associated with the proposed operations, they are still below the assigned noise levels for the accommodation camp.

Airblast levels are expected to achieve the most stringent criterion of 115 dB.

Heggies has conducted a Noise Impact Assessment for the planned Cundaline and Callawa mining operations. The CONCAWE noise calculation algorithms were used, with noise impacts assessed under “worst case” conditions as required by the *WA Environmental Noise Guidance Statement No. 8*.

It was determined that noise impacts at the Yarrie accommodation camp as a result of the proposed mines will achieve the nominated criteria (assigned noise levels).

18 REFERENCES

- Australian Government Department of Climate Change (2008): National Greenhouse Accounts Factors, January 2008.
- Australian Government Department of Industry, Tourism and Resources (2002): Best Practice Environmental Management in Mining. Energy Efficiency and Greenhouse Gas Reduction.
- Australian Government Intergovernmental Panel on Climate Change (IPCC) (1996): Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.
- Australian Greenhouse Office (1990): 1990 National Greenhouse Gas Inventory.
- Australian Greenhouse Office (2002): Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2002 – Energy (Stationary Sources).
- BHP Billiton Iron Ore Pty Ltd (2002): HSEC Guideline Energy and Greenhouse.
- BHP Billiton Iron Ore Pty Ltd (2005): Goldsworthy Extension Project. Environmental Protection Statement.
- Department of Climate Change (2006): State & Territory Greenhouse Gas Inventories, 2006.
- Department of Environment and Climate Change (2005): Approved Methods for the Modelling and Assessment of Air Pollutants.
- Department of Environment and Conservation (1995): Mine Safety and Inspection Regulations.
- Department of Environment and Conservation (2004): Environmental Protection (Controlled Waste) Regulations, 2004.
- Department of Environment and Conservation (2006): Air Quality Modelling Guidance Notes.
- Environment Australia (1998): Best Practice Environmental Management in Mining.
- Environment Australia (2001) NPI Emission Estimation Technique Manual for Mining, Version 2.3 (NPI EETM).
- Environmental Protection Authority (1999): Revised Draft Environmental Protection Policy (Kwinana) (Atmospheric Wastes) Policy 1999
- Environmental Protection Authority (2000): Guidance for the assessment of Environmental Factors. Prevention of air quality impacts from land developments sites.
- Environmental Protection Authority (2002): Guidance for the Assessment of Environmental Factors. Guidance Statement for Minimising Greenhouse Gas Emissions No. 12.
- Environmental Protection Authority (2007): Guidance for the Assessment of Environmental Factors Environmental Noise Statement No. 8.
- Government of Western Australia (1997): Environmental Protection (Noise) Regulations, 1997.
- Imperial Chemical Industries (1995): ICI Explosives Blasting Technical Services, ICI explosives, Oct 1995.
- National Energy Research Development and Demonstration Council (1988): Air Pollution from Surface Coal Mining: Measurement, Modelling and Community Perception. Project No. 921.
- National Environment Protection Council (1998): National Environment Protection (National Pollutant Inventory) Measure.
- National Environment Protection Council (2003): National Environment Protection (Ambient Air Quality) Measure.

- National Health and Medical Research Council (1996): Ambient Air Quality Goals Recommended by the National Health and Medical Research Council.
- OKE (1987) in New Zealand Ministry for the Environment (NZ MFE) (2004): Good practice guide for Atmospheric Dispersion Modelling.
- Shao, Y., Raupach, M.R., and Leys J.F. (1996): A Model for predicting aeolian sand drift and dust entrainment on scales from paddock to region. Aust. J. Soils Res., 34, 309-342.
- Sinclair Knight Merz (2005) Improvement of NPI Fugitive Particulate Matter Emission Estimation Techniques. Prepared for the WA Department of Environment.
- United States Environmental Protection Authority (1985): Compilation of Air Pollutant Emission Factors AP-42. Fourth Edition United States Environmental Protection Authority.
- United States Environmental Protection Authority (1988): Compilation of Air Pollutant Emission Factors AP-42 Fourth Edition United States Environmental Protection Authority.
- United States Environmental Protection Authority (1992): AP42 Section 11.24 Metallic Minerals Processing.
- United States Environmental Protection Authority (1995): Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources.
- United States S Environmental Protection Authority (2001): AP42 Compilation of Air Pollutant Emission Factors, Fifth Edition.
- United States Environmental Protection Authority (2006a): AP42 Section 13.2.2 Unpaved Roads.
- United States Environmental Protection Authority (2006b): AP42 Section 13.2.4 Aggregate Handling and Storage Piles.
- United States Environmental Protection Authority (2006c): AP42 Section 13.2.5 Industrial Wind Erosion.
- Victoria Environmental Protection Authority (2006): Draft Protocol for Environmental Management for Mining and Extractive Industry lists assessment criteria for Nuisance Dust.
- World Health Organisation (2000): Air Quality Guidelines for Europe 2nd Edition. WHO Regional Publications, European Series, No.91.
- World Health Organisation (2005): Air Quality Guidelines Global Update, October 2005.

FIGURES

Figure 1 Goldsworthy Iron Ore Mining Operations

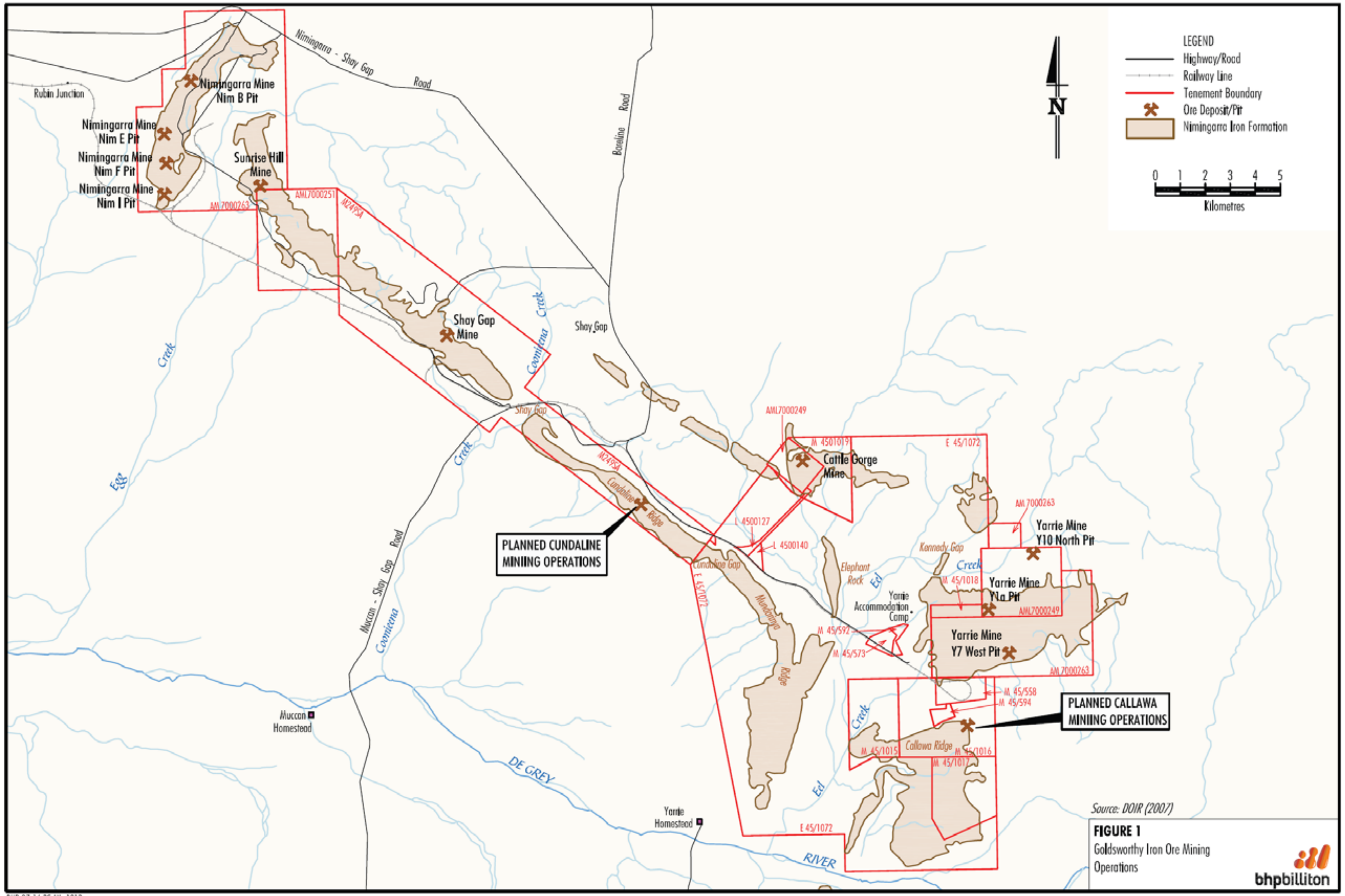
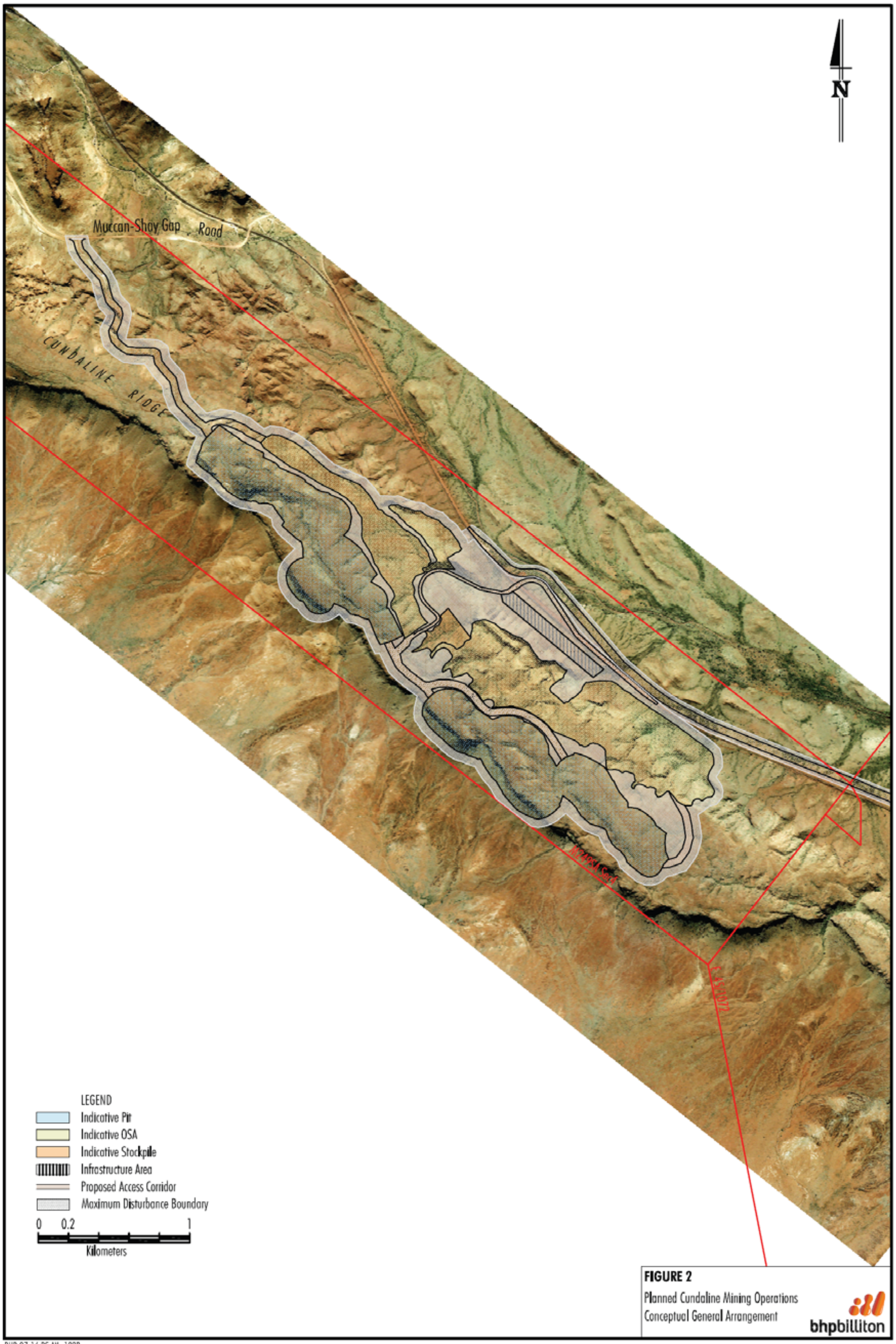
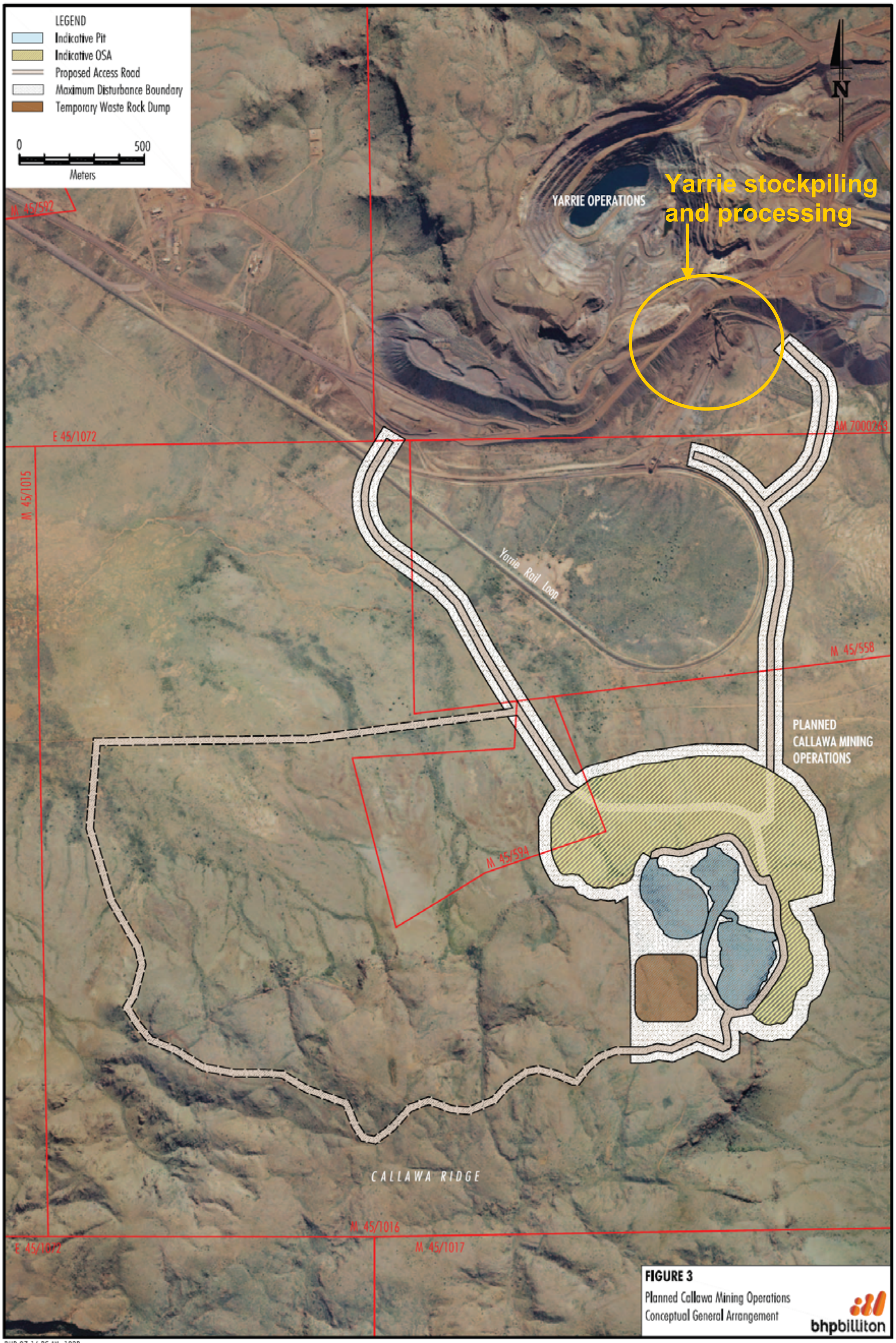


Figure 2 Cundaline Deposit: Pits, Stockpiles, OSAs and Infrastructure Layout



BHP-07-16 BS AN_102B

Figure 3 Callawa Deposit: Pits, OSAs and infrastructure layout



BHP-07-16 BS AV_103B

Figure 4 Location of the Yarrie Accommodation Camp

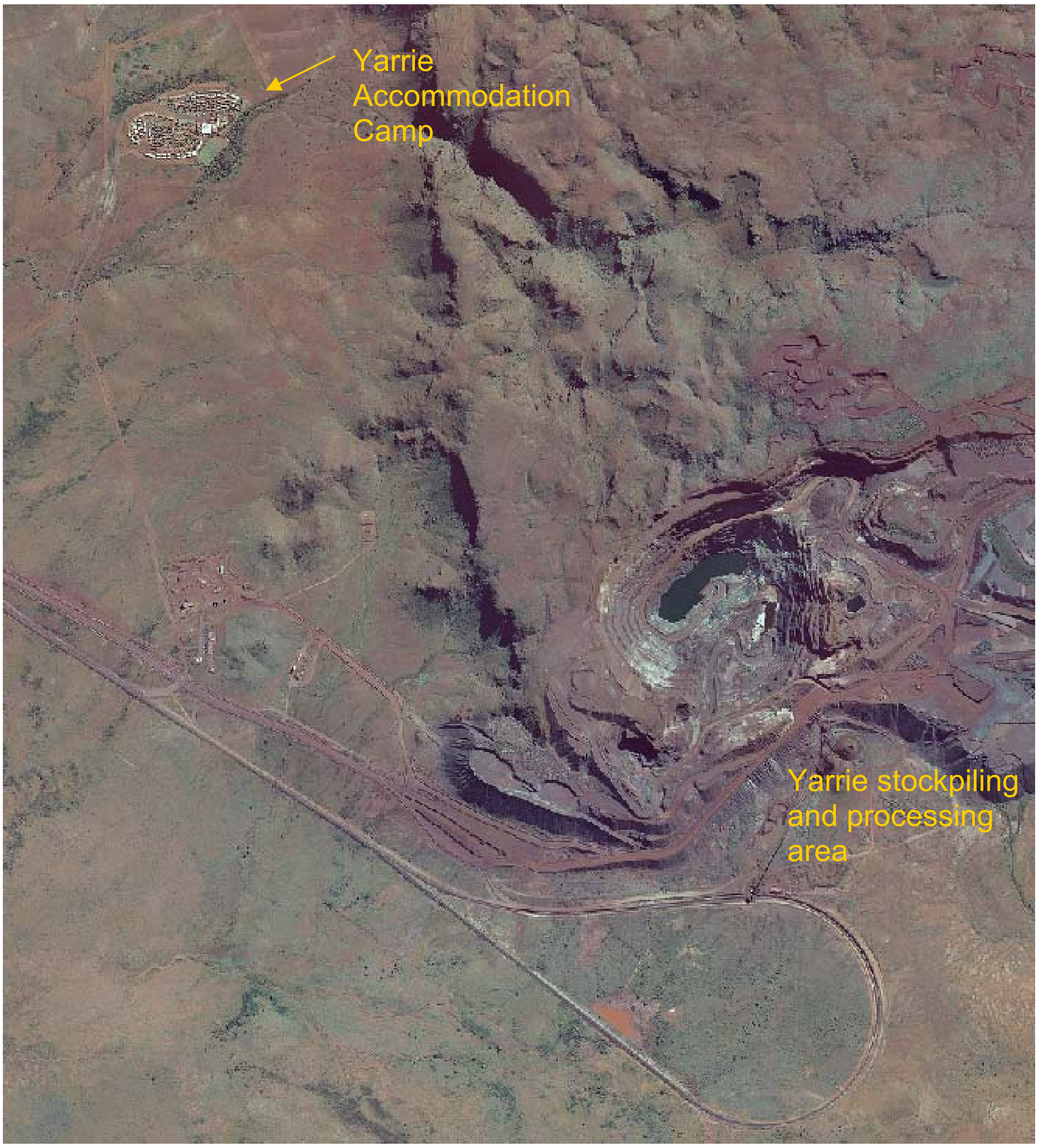


Figure 5 Annual wind rose from Yarrie Monitoring Site Data, 2006

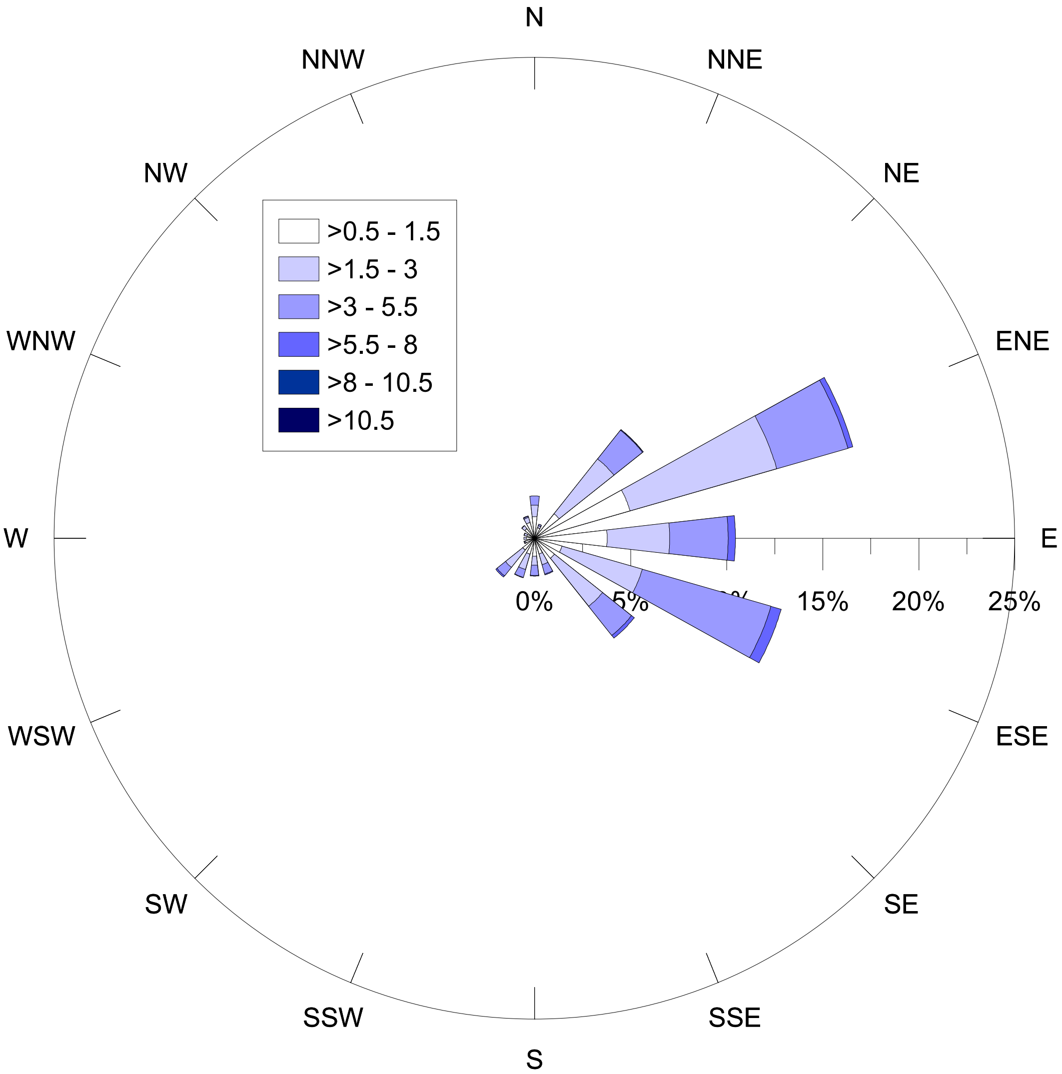


Figure 6 Wind Speed Dependent Hourly Emission Factors for Wind Erosion

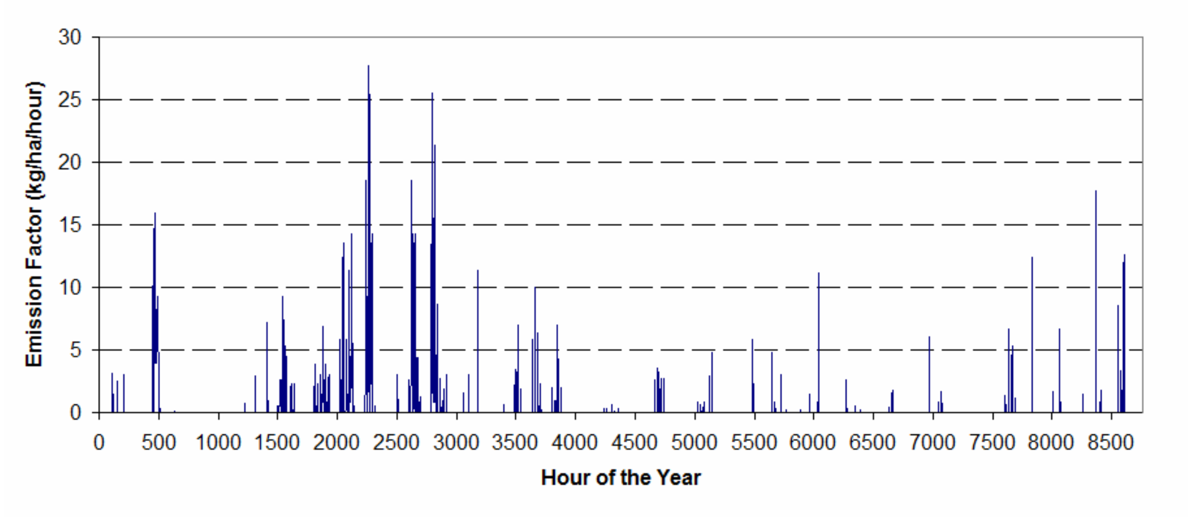


Figure 7 Location of TAPM meteorological files used as input into CALMET

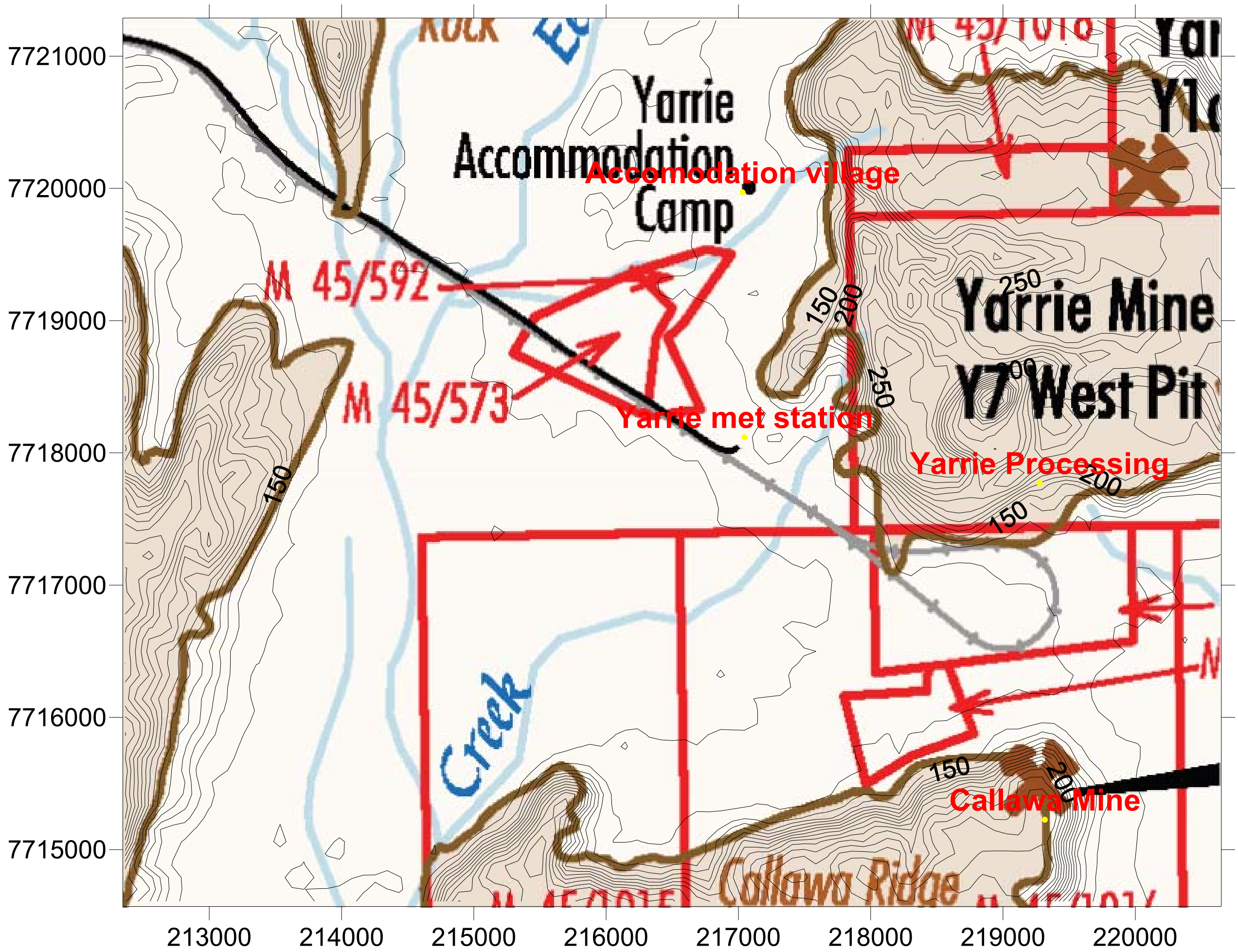


Figure 8 Annual wind rose for the Yarrie monitoring site generated by CALMET, 2006

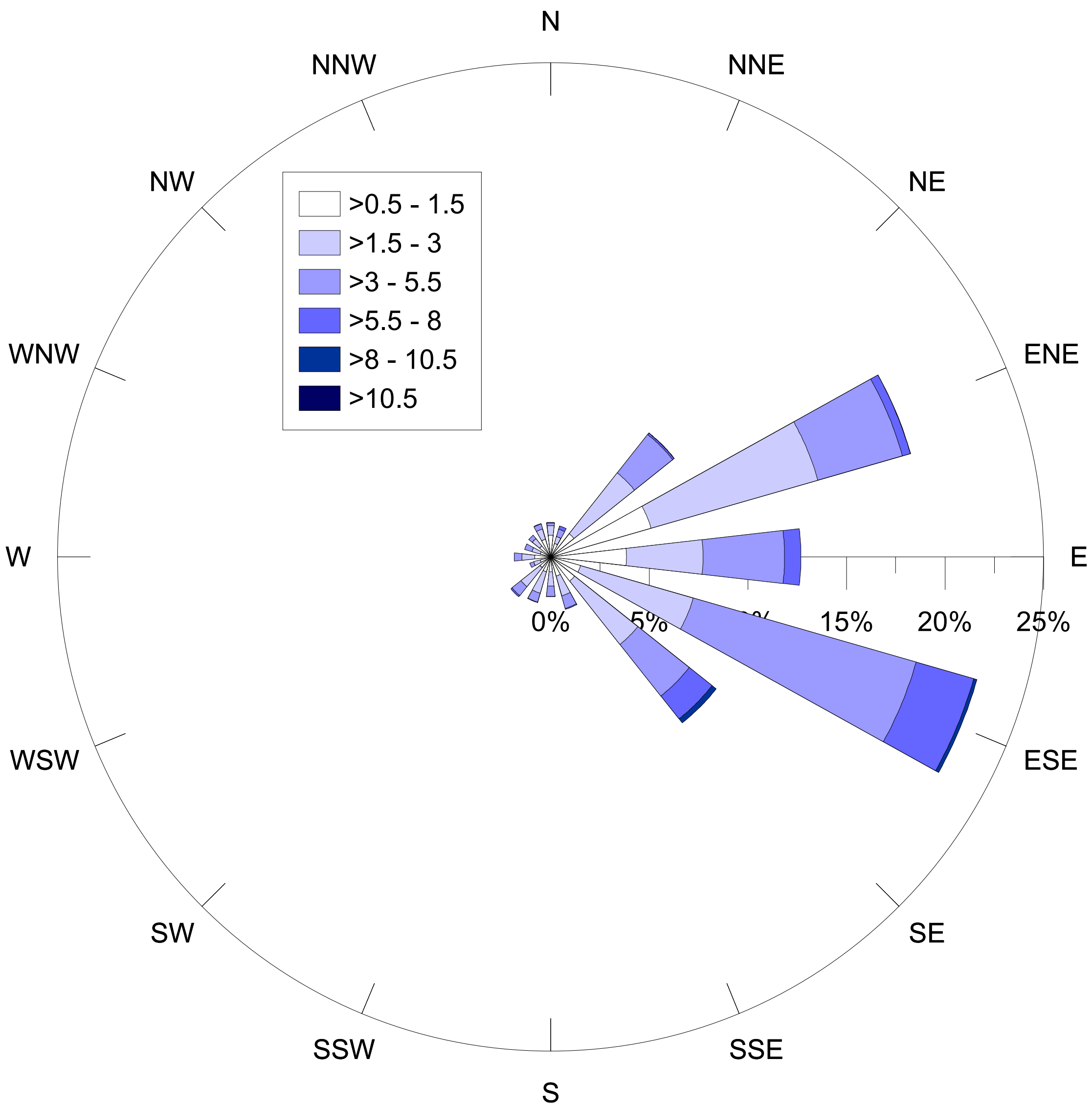


Figure 9 Annual Stability Class Distribution for the Yarrie monitoring site – CALMET, 2006

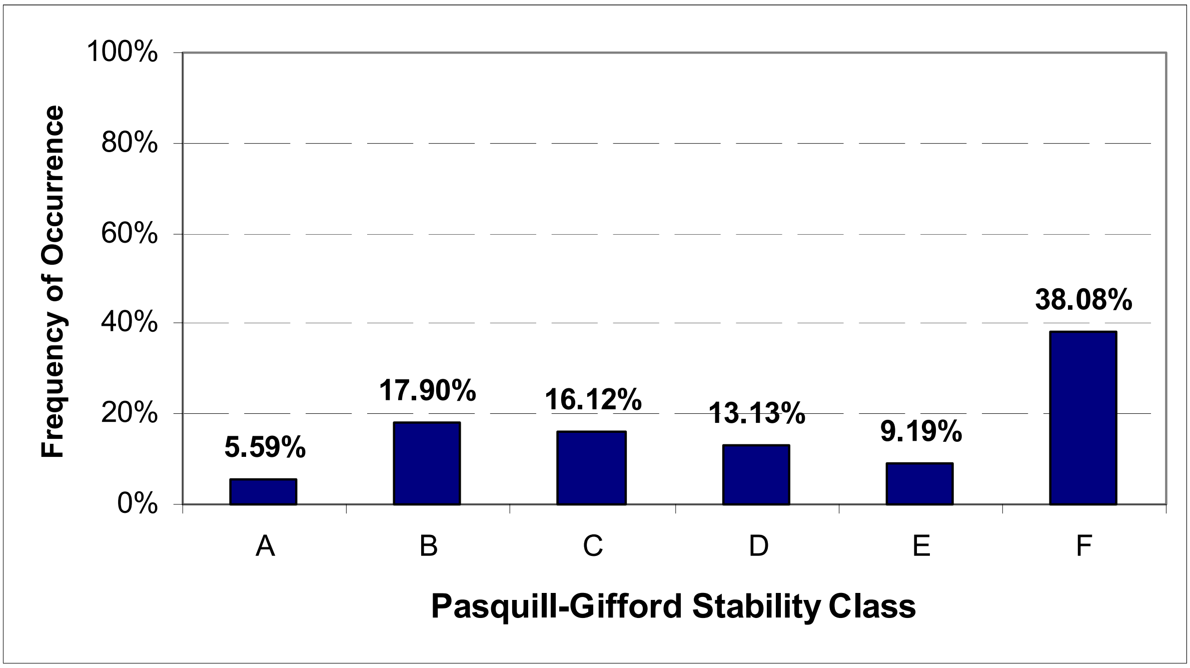


Figure 10 Frequency Distribution of Mixing Height at the Yarrie monitoring site – CALMET, 2006

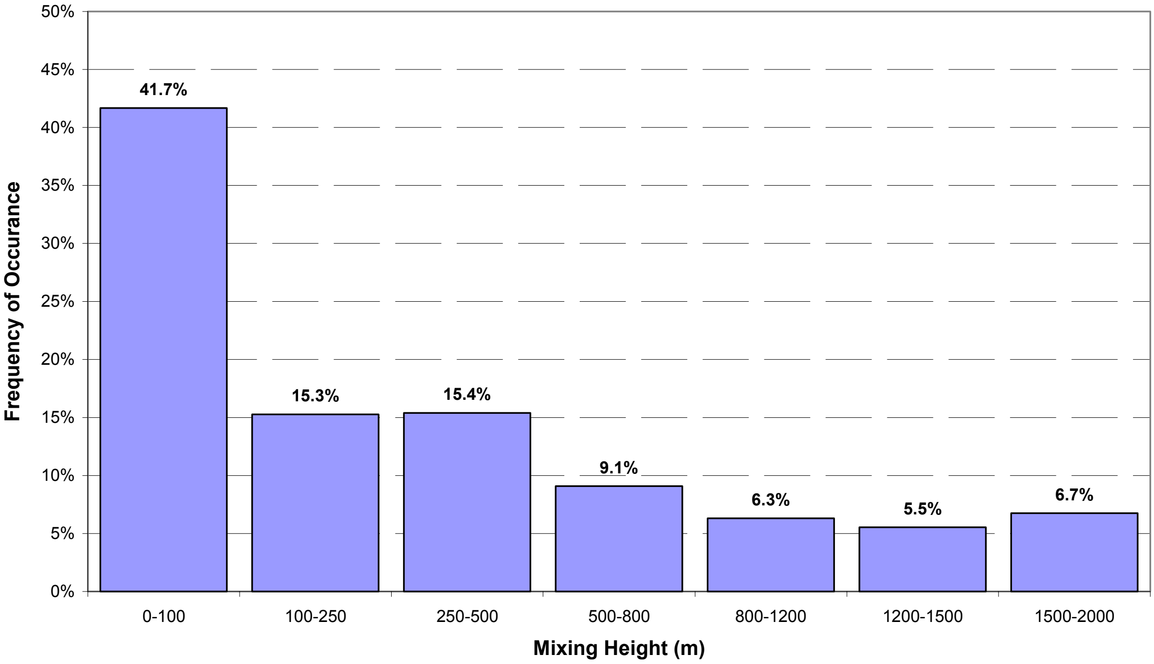
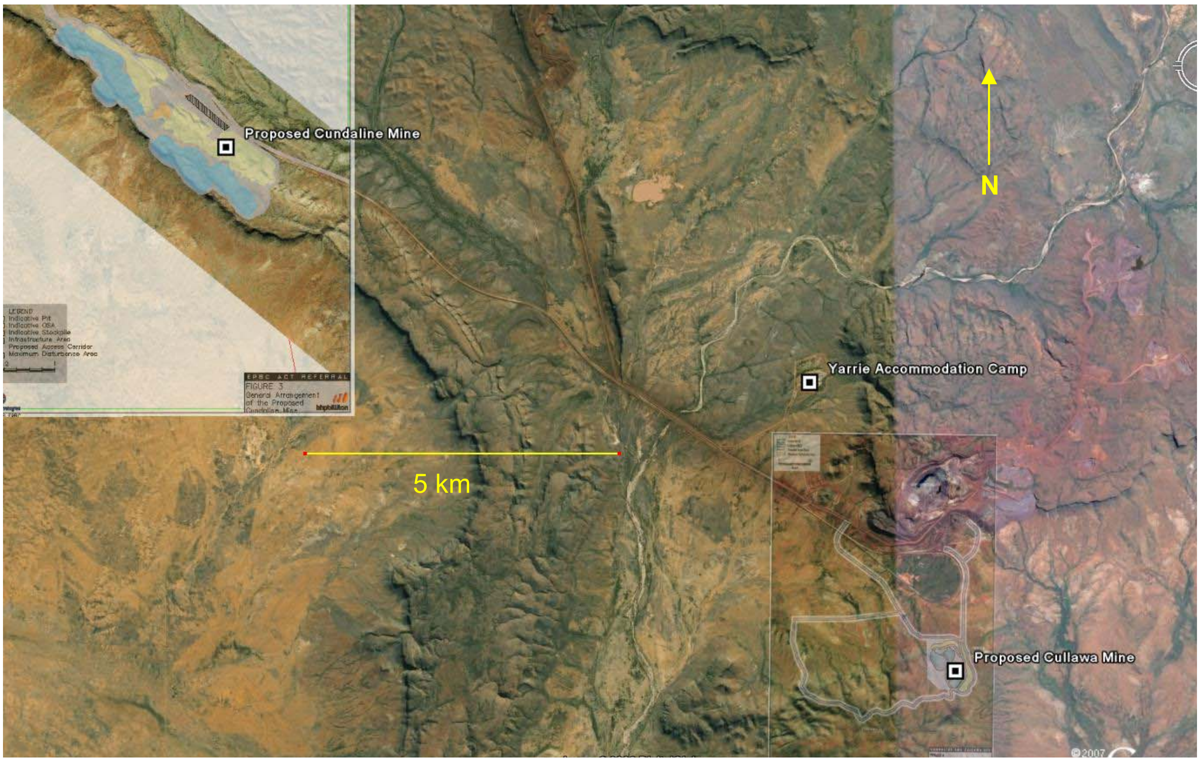
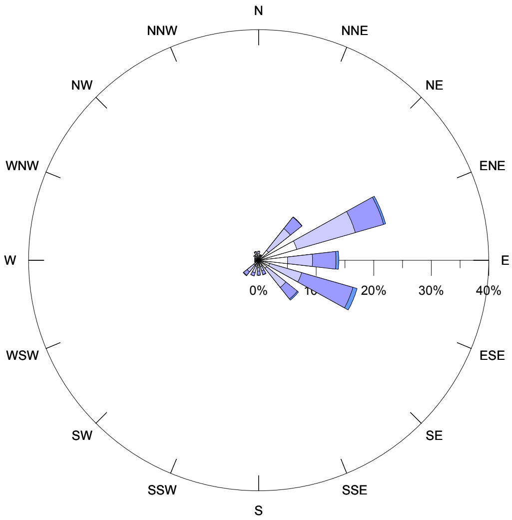


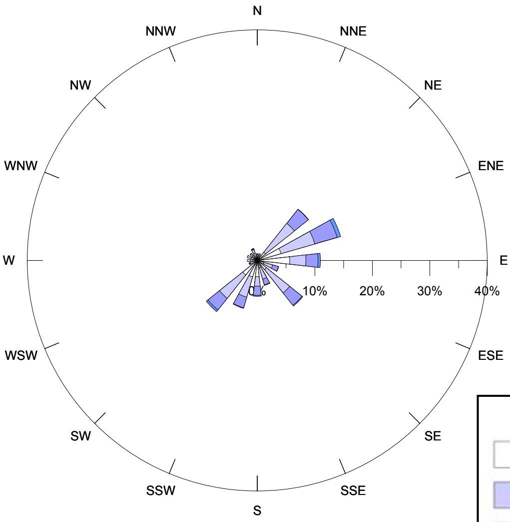
Figure 11 Project Area Showing Topography



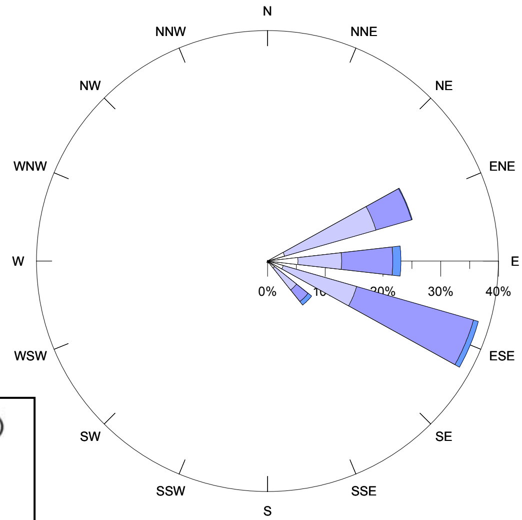
ANNUAL

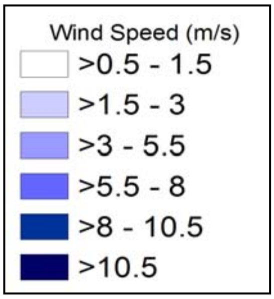


SUMMER

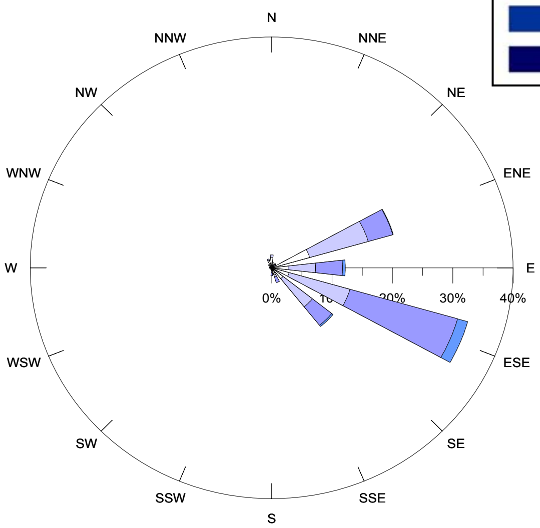


AUTUMN

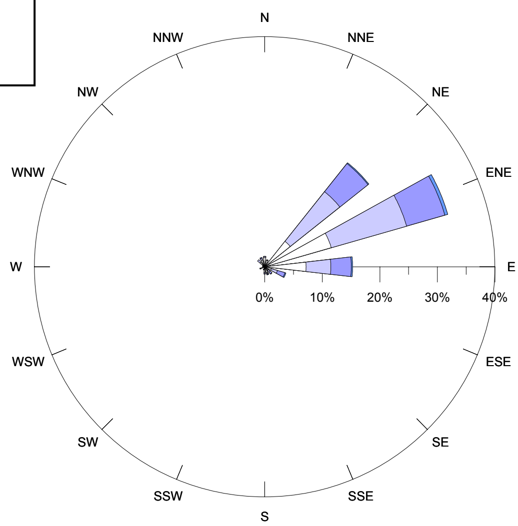




WINTER



SPRING



Heggies Australia Pty Ltd	Designed by	Checked by	Approved by - date	Filename	Dated
Consulting Engineers 212 Whatley Cresent Maylands WA 6051 Australia Telephone +618 9370 0100 Facsimile +618 9370 0101 Email perth@heggies.com.au	BB	DNH	DNH	75-1122	08-09-08
	Appendix A: Seasonal Windroses – Yarrie, 2006				

Quality System
Quality Endorsed Company
ISO 9001 Lic 3236
Standards Australia

Table 1 PM_{10} Emissions Inventory - Cundaline Deposit Option A (tonnes/annum)

Parameter	**PM_{10}/TSP Ratio**	**2011**	**2012**	**2013**	**2014**	**2015**
Ore (Mta)		0.3	1.7	1.4	1.5	0.7
Waste (Mta)		0.3	3.7	5.2	1.4	0.5
TOTAL		**0.6**	**5.4**	**6.6**	**2.9**	**1.2**
Overburden						
Front-End Loaders/Excavators	0.5	0.1	1.5	2.0	0.5	0.2
Bulldozers	0.2	17.5	17.5	17.5	17.5	17.5
Truck Unloading at OSA	0.4	0.7	8.0	11.2	3.0	1.1
Wheel Dust- Pit to OSA	0.3	2.2	26.5	36.9	10.0	3.6
Wheel Dust - OSA to Pit	0.3	1.5	18.0	25.0	6.8	2.4
SUB-TOTAL		**22.1**	**71.6**	**92.6**	**37.9**	**24.8**
% of Total		29.1%	25.0%	30.5%	18.3%	16.5%
Extraction						
Drilling	0.5	0.1	0.8	1.0	0.5	0.6
Blasting	0.5	12.8	72.1	92.2	44.7	53.0
Front-End Loaders/Excavators on Ore	0.5	0.1	0.6	0.5	0.6	0.3
SUB-TOTAL		**13.0**	**73.5**	**93.8**	**45.7**	**53.9**
% of Total		17.1%	25.7%	30.9%	22.1%	35.8%
Transport of Ore (Option A)						
Wheel Dust - Pit to Processing	0.3	3.6	19.5	15.7	16.8	8.5
Wheel Dust - Processing to Pit	0.3	2.5	13.2	10.6	11.4	5.8
SUB-TOTAL		**6.1**	**32.7**	**26.3**	**28.2**	**14.3**
% of Total		8.0%	11.4%	8.7%	13.6%	9.5%
Processing, Storage, Train Loading						
Unloading of Trucks to Hopper	0.5	0.0	0.2	0.2	0.2	0.1
Unloading of Trucks at ROM	0.5	0.0	0.1	0.1	0.1	0.0
Rehandling of Ore	0.5	0.0	0.1	0.1	0.1	0.0
Primary Crushing	0.1	3.7	20.0	16.1	17.2	8.8
Secondary Crushing	0.1	3.9	21.0	16.9	18.1	9.2
Tertiary Crushing	0.1	6.5	35.0	28.2	30.1	15.3
Screening	0.8	2.4	12.8	10.3	11.0	5.6
Stockpile Loading	0.5	0.0	0.1	0.1	0.1	0.0
Blending	0.5	0.0	0.1	0.1	0.1	0.1
Bulldozers on Stockpiles	0.0	14.5	14.5	14.5	14.5	14.5
Loading of Trains	0.5	0.1	0.6	0.5	0.5	0.3
SUB-TOTAL		**31.3**	**104.5**	**86.9**	**91.9**	**53.9**
% of Total		41.2%	36.6%	28.7%	44.4%	35.8%
Wind Erosion						
Stockpiles	0.5	3.5	3.5	3.5	3.5	3.5
SUB-TOTAL		**3.5**	**3.5**	**3.5**	**3.5**	**3.5**
% of Total		4.6%	1.2%	1.2%	1.7%	2.3%
TOTAL		**76.0**	**285.8**	**303.1**	**207.2**	**150.5**

Table 2 PM_{10} Emissions Inventory - Cundaline Deposit Option B (tonnes/annum)

Parameter	PM_{10}/TSP Ratio	2011	2012	2013	2014	2015
Ore (Mta)		0.3	1.7	1.4	1.5	0.7
Waste (Mta)		0.3	3.7	5.2	1.4	0.5
TOTAL		**0.6**	**5.4**	**6.6**	**2.9**	**1.2**
Overburden						
Front-End Loaders/Excavators	0.5	0.1	1.5	2.0	0.5	0.2
Bulldozers	0.2	17.5	17.5	17.5	17.5	17.5
Truck Unloading at OSA	0.4	0.7	8.0	11.2	3.0	1.1
Wheel Dust- Pit to OSA	0.3	2.2	26.5	36.9	10.0	3.6
Wheel Dust - OSA to Pit	0.3	1.5	18.0	25.0	6.8	2.4
SUB-TOTAL		**22.1**	**71.6**	**92.6**	**37.9**	**24.8**
% of Total		4.4%	11.2%	13.8%	6.6%	4.5%
Extraction						
Drilling	0.5	0.1	0.8	1.0	0.5	0.6
Blasting	0.5	12.6	71.3	91.3	44.2	52.5
Front-End Loaders/Excavators on Ore	0.5	0.1	0.6	0.5	0.5	0.3
SUB-TOTAL		**12.9**	**72.7**	**92.8**	**45.2**	**53.3**
% of Total		2.6%	11.4%	13.8%	7.9%	9.7%
Transport of Ore (Option B)						
Wheel Dust - Pit to Transfer Area	0.3	31.6	31.6	31.6	31.6	31.6
Wheel Dust - Transfer Area to Pit	0.3	21.4	21.4	21.4	21.4	21.4
Unloading of trucks	0.0	0.0	0.0	0.0	0.0	0.0
Bulldozers on Stockpiles	0.3	7.9	7.9	7.9	7.9	7.9
Loading of Road Trains	0.5	0.1	0.6	0.5	0.5	0.3
Wheel Dust - Transfer Area to Processing	0.3	227.9	227.9	227.9	227.9	227.9
Wheel Dust - Processing to Transfer Area	0.3	166.8	166.8	166.8	166.8	166.8
SUB-TOTAL		**455.8**	**456.2**	**456.1**	**456.2**	**455.9**
% of Total		91.0%	71.5%	67.8%	79.7%	82.5%
Processing						
Unloading of Trucks to Hopper	0.5	0.0	0.2	0.2	0.2	0.1
Unloading of Trucks at ROM	0.5	0.0	0.1	0.1	0.1	0.0
Rehandling of Ore	0.5	0.0	0.1	0.1	0.1	0.0
Primary Crushing	0.1	0.8	4.2	3.4	3.6	1.9
Secondary Crushing	0.1	0.8	4.4	3.6	3.8	1.9
Tertiary Crushing	0.1	0.8	4.2	3.4	3.6	1.9
Screening	0.8	3.8	20.3	16.3	17.5	8.9
Stockpile Loading	0.5	0.0	0.1	0.1	0.1	0.0
Blending	0.5	0.0	0.1	0.1	0.1	0.1
Bulldozers on Stockpiles	0.0	0.0	0.0	0.0	0.0	0.0
Loading of Trains	0.5	0.1	0.6	0.5	0.5	0.3
SUB-TOTAL		**6.4**	**34.4**	**27.7**	**29.6**	**15.1**
% of Total		1.3%	5.4%	4.1%	5.2%	2.7%
Wind Erosion						
Stockpiles	0.5	3.5	3.5	3.5	3.5	3.5
SUB-TOTAL		**3.5**	**3.5**	**3.5**	**3.5**	**3.5**
% of Total		0.7%	0.5%	0.5%	0.6%	0.6%
TOTAL		**500.6**	**638.4**	**672.7**	**572.4**	**552.6**

Table 3 PM_{10} Emissions Inventory - Callawa Deposit (tonnes/annum)

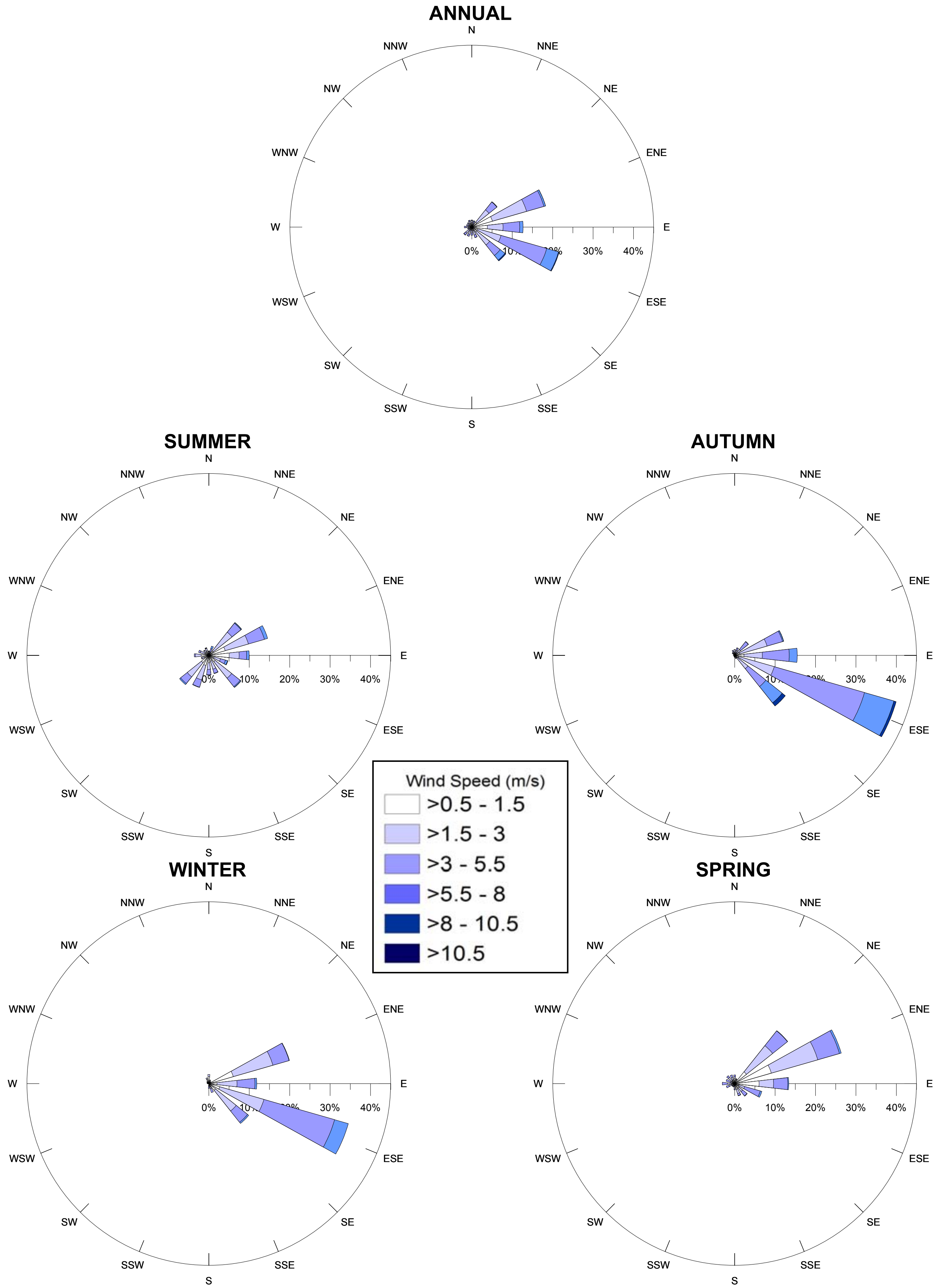
Parameter	PM_{10}/TSP Ratio	2010	2011	2012	2013	2014	2015	2016
Ore (Mta)		0.0	0.6	0.6	0.6	0.6	0.6	1.1
Waste (Mta)		3.6	4.5	2.7	1.0	4.0	0.9	1.0
TOTAL		**3.6**	**5.1**	**3.3**	**1.6**	**4.5**	**1.5**	**2.0**
Overburden								
Front-End Loaders/Excavators	0.5	1.4	1.8	1.1	0.4	1.6	0.3	0.4
Bulldozers	0.2	0.0	17.5	17.5	17.5	17.5	17.5	17.5
Truck Unloading at OSA	0.4	7.7	9.7	5.8	2.2	8.6	1.9	2.0
Wheel Dust- Pit to OSA	0.3	24.0	30.0	18.0	6.8	26.5	5.8	6.3
Wheel Dust - OSA to Pit	0.3	16.2	20.3	12.2	4.6	18.0	3.9	4.3
SUB-TOTAL		**49.4**	**79.3**	**54.7**	**31.4**	**72.1**	**29.4**	**30.6**
% of Total		29.7%	33.9%	36.9%	28.1%	37.3%	20.1%	12.5%
Extraction								
Drilling	0.5	1.3	1.2	0.5	0.3	0.8	0.7	1.3
Blasting	0.5	115.4	102.7	43.3	23.2	70.8	62.4	115.4
Front-End Loaders/Excavators on Ore	0.5	0.0	0.2	0.2	0.2	0.2	0.2	0.4
SUB-TOTAL		**116.7**	**104.0**	**44.0**	**23.7**	**71.8**	**63.3**	**117.1**
% of Total		70.3%	44.5%	29.7%	21.2%	37.1%	43.3%	48.0%
Transport of Ore								
Wheel Dust - Pit to Processing	0.3	0.0	23.2	22.9	26.1	22.8	24.6	44.5
Wheel Dust - Processing to Pit	0.3	0.0	15.7	15.5	17.7	15.4	16.7	30.1
SUB-TOTAL		**0.0**	**38.9**	**38.3**	**43.8**	**38.2**	**41.2**	**74.6**
% of Total		0.0%	16.6%	25.8%	39.2%	19.8%	28.2%	30.5%
Processing, Storage, Train Loading								
Unloading of Trucks to Hopper	0.5	0.0	0.1	0.1	0.1	0.1	0.1	0.2
Unloading of Trucks at ROM	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Rehandling of Ore	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Primary Crushing	0.1	0.0	1.4	1.4	1.6	1.4	1.5	2.7
Secondary Crushing	0.1	0.0	1.5	1.5	1.7	1.4	1.6	2.8
Tertiary Crushing	0.1	0.0	1.4	1.4	1.6	1.4	1.5	2.7
Screening	0.8	0.0	6.7	6.6	7.6	6.6	7.2	12.9
Stockpile Loading	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Blending	0.5	0.0	0.0	0.0	0.1	0.0	0.1	0.1
Bulldozers on Stockpiles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Loading of Trains	0.5	0.0	0.2	0.2	0.2	0.2	0.2	0.4
SUB-TOTAL		**0.0**	**11.4**	**11.3**	**12.9**	**11.2**	**12.1**	**21.9**
% of Total		0.0%	4.9%	7.6%	11.5%	5.8%	8.3%	9.0%
TOTAL		**166.1**	**233.7**	**148.3**	**111.8**	**193.3**	**146.1**	**244.3**

Table 4 PM_{10} Emission Inventory – Yarrie Processing (tonnes/annum)

Parameter	PM_{10}/TSP Ratio	2010	2011	2012	2013	2014	2015	2016
Ore (Mta)		2.0	2.0	2.2	2.0	2.0	2.1	2.0
Waste (Mta)		6.3	6.3	6.5	6.2	6.0	6.1	6.1
TOTAL		**8.3**	**8.2**	**8.7**	**8.2**	**8.0**	**8.1**	**8.1**
Processing								
Unloading of Trucks to Hopper	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Unloading of Trucks at ROM	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Rehandling of Ore	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Primary Crushing	0.1	5.0	4.9	5.6	5.0	5.0	5.2	5.0
Secondary Crushing	0.1	5.3	5.1	5.9	5.2	5.3	5.4	5.2
Tertiary Crushing	0.1	5.0	4.9	5.6	5.0	5.0	5.2	5.0
Screening	0.8	24.0	23.5	26.9	23.9	24.1	24.9	23.9
Stockpile Loading	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Blending	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Bulldozers on Stockpiles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Loading of Trains	0.5	0.7	0.7	0.8	0.7	0.7	0.7	0.7
SUB-TOTAL		**40.7**	**39.8**	**45.7**	**40.6**	**40.9**	**42.2**	**40.5**
% of Total		89.2%	89.0%	90.3%	89.2%	89.3%	89.6%	89.2%
Wind Erosion								
Stockpiles	0.5	4.9	4.9	4.9	4.9	4.9	4.9	4.9
SUB-TOTAL		**4.9**	**4.9**	**4.9**	**4.9**	**4.9**	**4.9**	**4.9**
% of Total		10.8%	11.0%	9.7%	10.8%	10.7%	10.4%	10.8%
TOTAL		**45.6**	**44.7**	**50.6**	**45.5**	**45.8**	**47.1**	**45.4**

Table 5 PM_{10} Emission Inventory – Yarrie Processing (tonnes/annum)

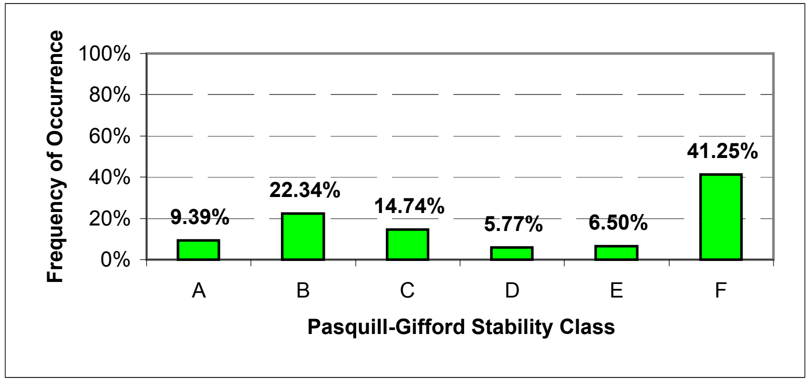
Parameter	PM_{10}/TSP Ratio	2010	2011	2012	2013	2014	2015	2016
Ore (Mta)		2.0	1.6	0.6	0.6	0.6	1.3	2.0
Waste (Mta)		6.3	6.0	2.7	1.0	4.6	5.6	6.1
TOTAL		**8.3**	**7.6**	**3.3**	**1.6**	**5.2**	**6.9**	**8.1**
Processing								
Unloading of Trucks to Hopper	0.5	0.3	0.2	0.1	0.1	0.1	0.2	0.3
Unloading of Trucks at ROM	0.5	0.1	0.1	0.0	0.0	0.0	0.1	0.1
Rehandling of Ore	0.5	0.1	0.1	0.0	0.0	0.0	0.1	0.1
Primary Crushing	0.1	5.0	4.1	1.4	1.6	1.4	3.3	5.0
Secondary Crushing	0.1	5.3	4.3	1.5	1.7	1.5	3.5	5.2
Tertiary Crushing	0.1	5.0	4.1	1.4	1.6	1.4	3.3	5.0
Screening	0.8	24.0	19.7	6.6	7.6	6.6	16.0	23.9
Stockpile Loading	0.5	0.1	0.1	0.0	0.0	0.0	0.1	0.1
Blending	0.5	0.2	0.1	0.0	0.1	0.0	0.1	0.2
Bulldozers on Stockpiles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Loading of Trains	0.5	0.7	0.6	0.2	0.2	0.2	0.5	0.7
SUB-TOTAL		**40.7**	**33.4**	**11.3**	**12.9**	**11.3**	**27.1**	**40.5**
% of Total		89.2%	87.2%	69.7%	72.4%	69.7%	84.7%	89.2%
Wind Erosion								
Stockpiles	0.5	4.9	4.9	4.9	4.9	4.9	4.9	4.9
SUB-TOTAL		**4.9**	**4.9**	**4.9**	**4.9**	**4.9**	**4.9**	**4.9**
% of Total		10.8%	12.8%	30.3%	27.6%	30.3%	15.3%	10.8%
TOTAL		**45.6**	**38.3**	**16.2**	**17.8**	**16.2**	**32.0**	**45.4**



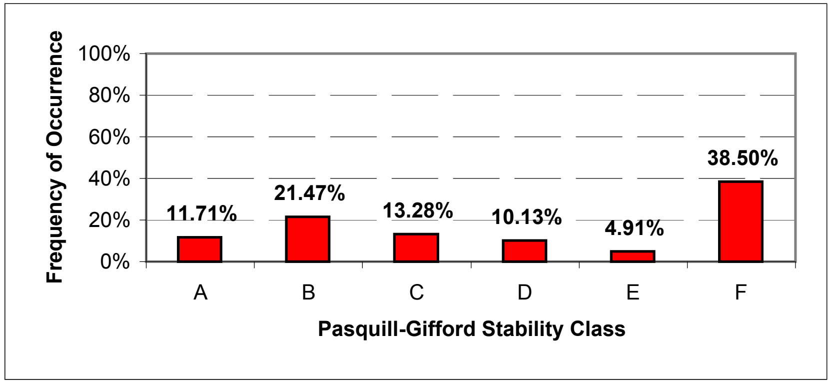
Heggies Australia Pty Ltd
Consulting Engineers
212 Whatley Crescent
Maylands WA 6051 Australia
Telephone +618 9370 0100 Facsimile +618 9370 0101
Email perth@heggies.com.au

Designed by	Checked by	Approved by - date	Filename	Dated
BB	DNH	DNH	75-1122	08-09-08

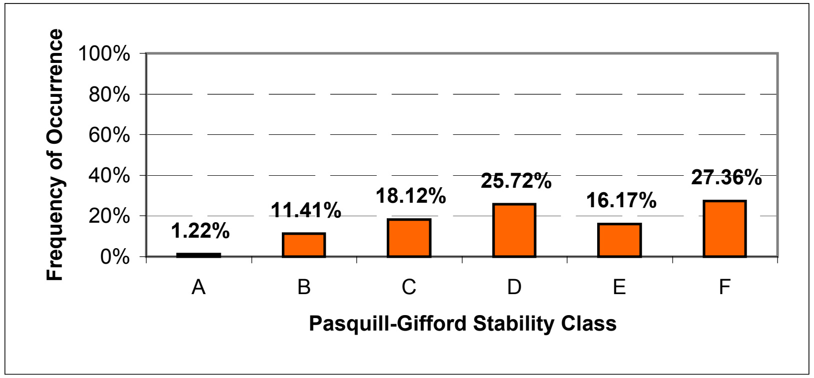
Appendix C: Seasonal Windroses – Calmet, 2006



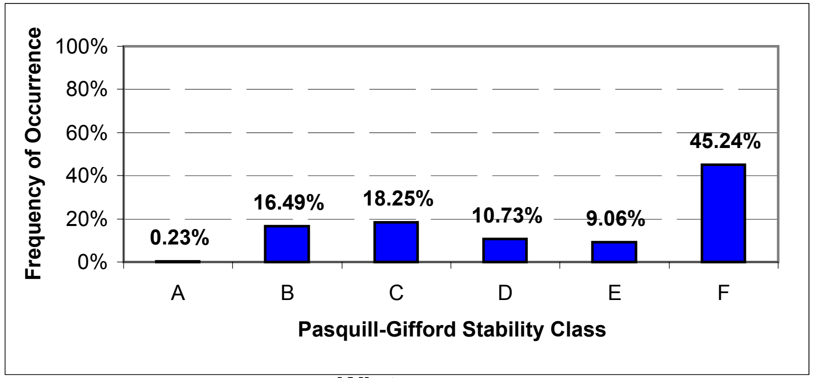
Spring



Summer



Autumn



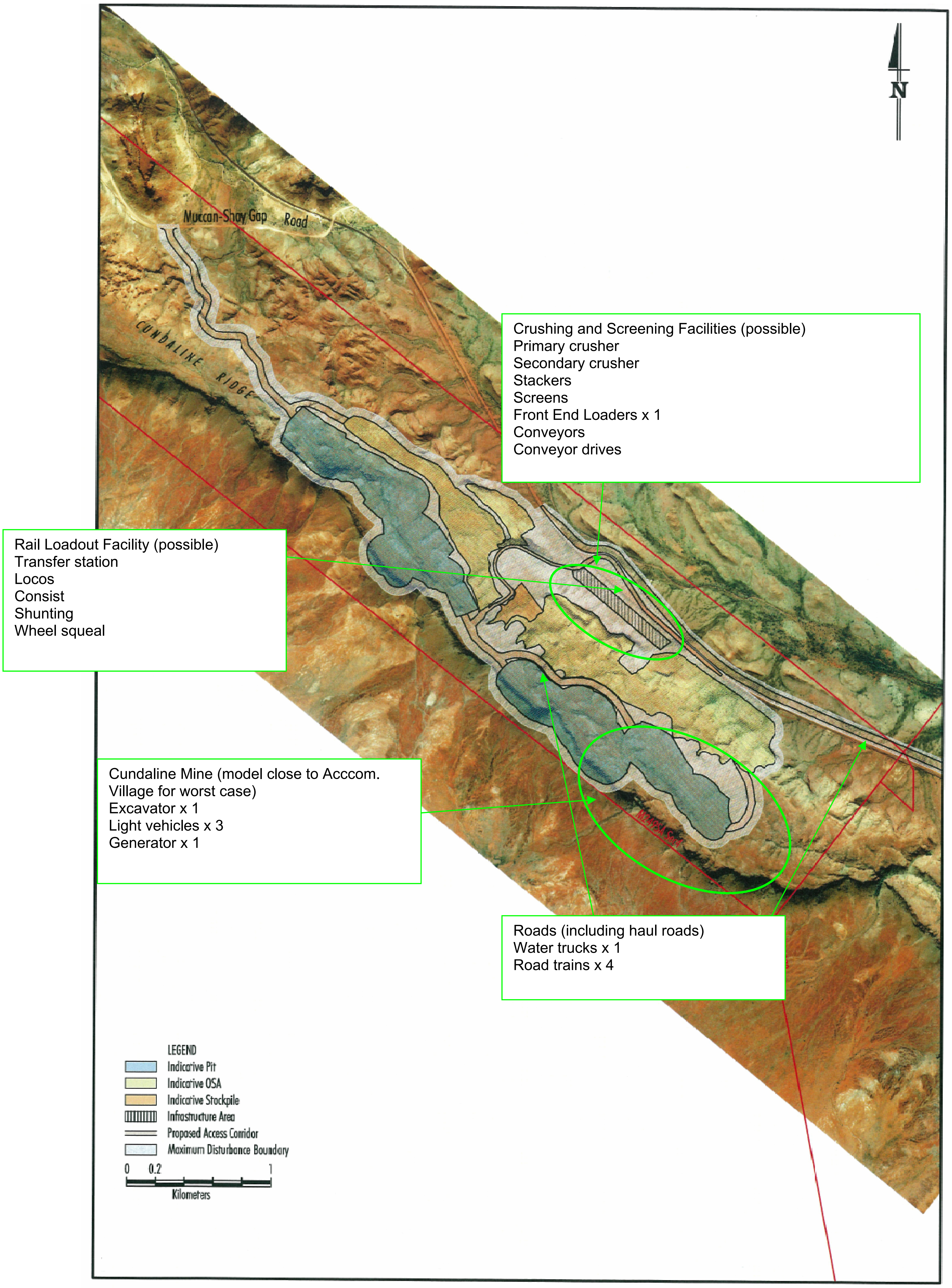
Winter

Heggies Pty Ltd
Consulting Engineers and Scientists
212 Whatley Cresent
Maylands WA 6051
Telephone 61 8 9370 0100 Facsimile 61 8 9370 0101
Email Perth@heggies.com Website www.heggies.coı

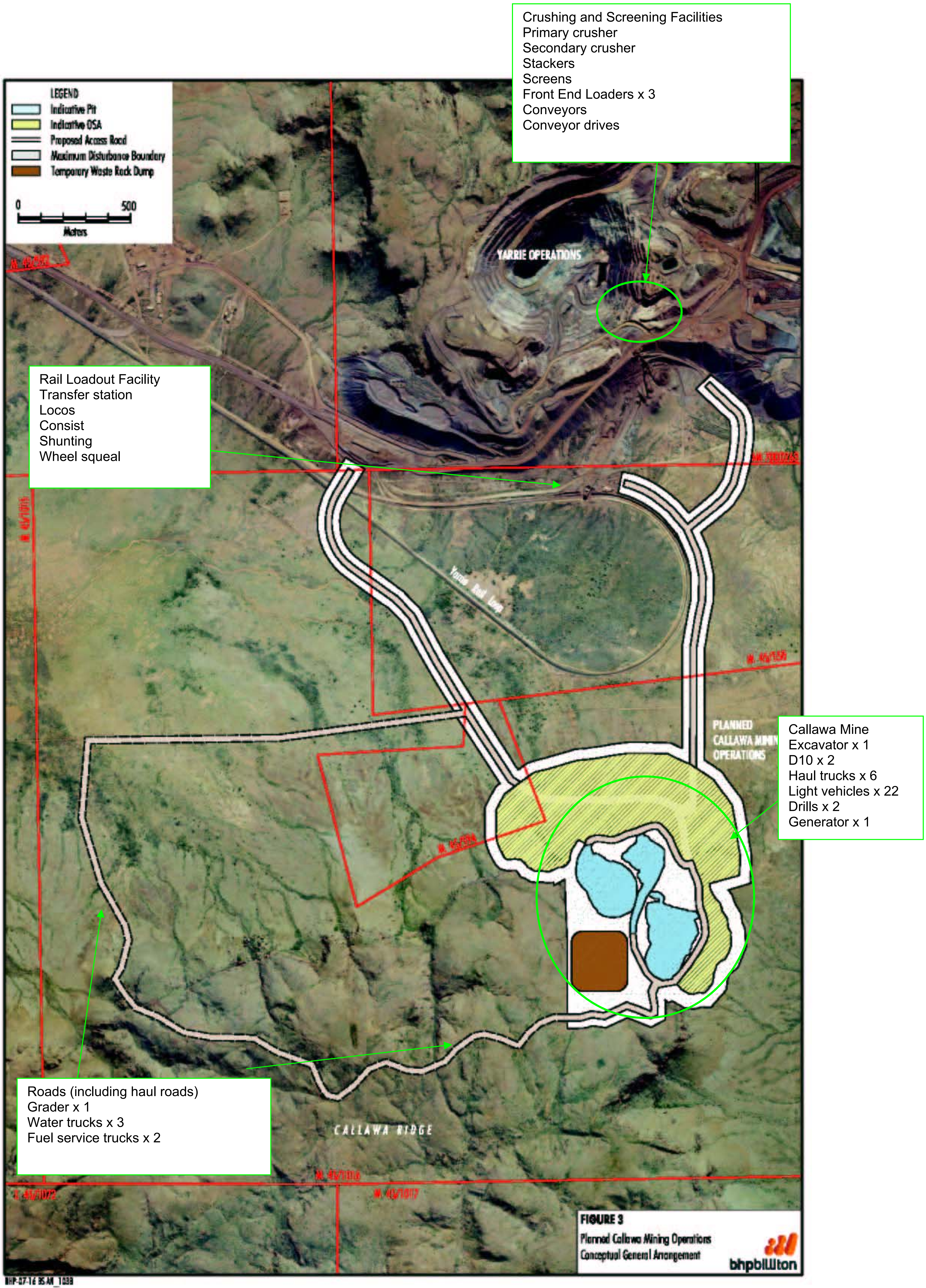
Designed by	Checked by	Approved by - date	Filename	Dated
BB	DH		75-1122	5/09/2008

Appendix D: Seasonal Stability Class Frequency Distribution: Yarrie Monitoring Site (2006)

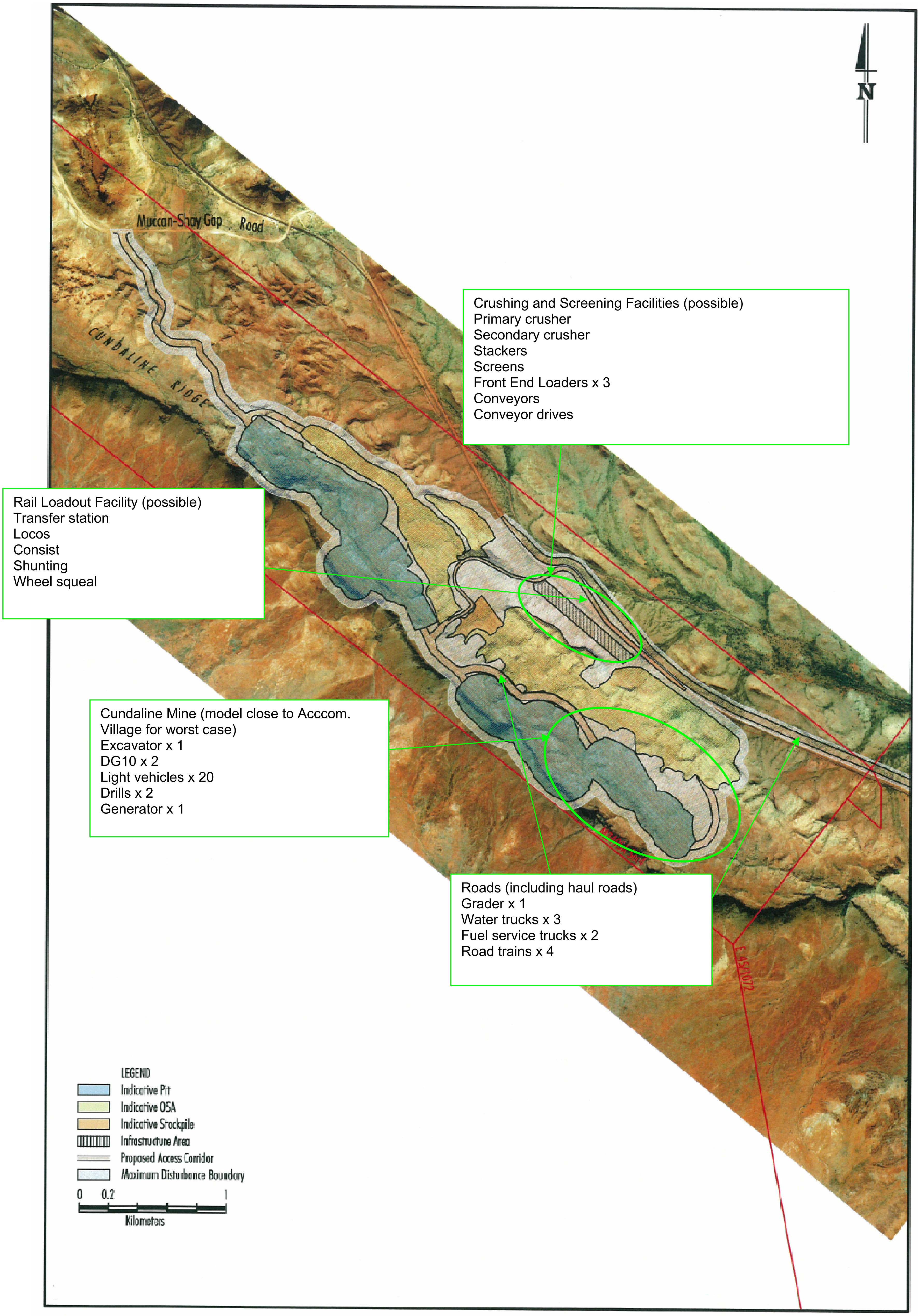
OPERATIONAL SCENARIO – CUNDALINE 2011



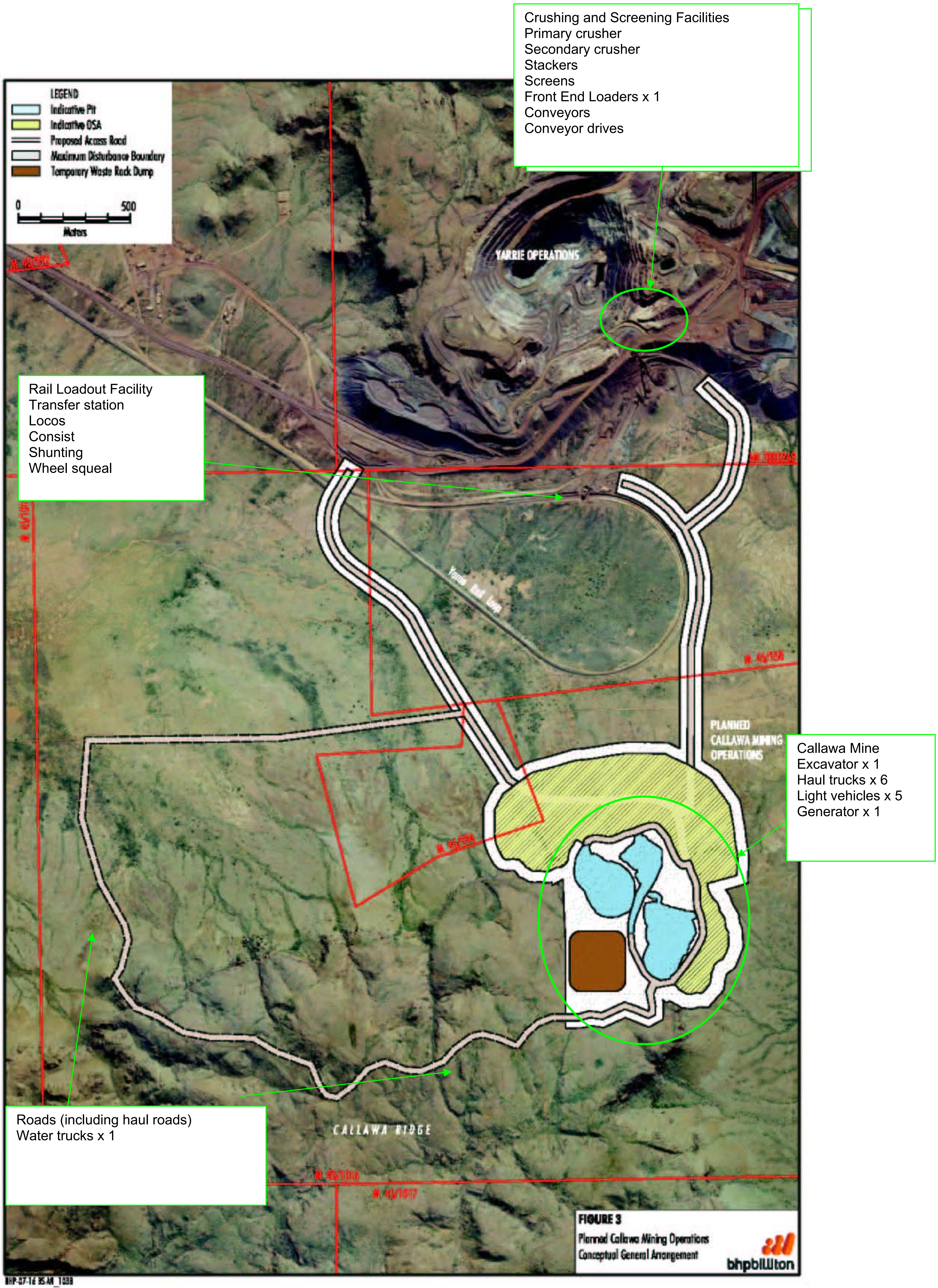
OPERATIONAL SCENARIO – CALLAWA 2011



OPERATIONAL SCENARIO – CUNDALINE 2013



OPERATIONAL SCENARIO – CALLAWA 2013



% of industrial in small circle = 100 % (accommodation village is within mining tenement)

% of industrial in large circle = 100 % (accommodation village is within mining tenement)

0 % commercial in small or large circles.

Industrial Factor

I = (% industrial in small circle + % industrial in large circle) x 1/10

= (100 % + 100 %) x 1/10

= 20

Transport Factor

[1]No major (more than 15,000 vehicles per day) or secondary (6,000-15,000 vehicles per day) roads in small or large circle

TF = 0

Influencing Factor

IF = I + TF

= 20 + 0

= 20

[1] As defined in the *Environmental Protection (Noise) Regulations 1997.*

Sheet 1

Screening Procedure for Noise - Worksheet

*Detailed assessment should be done on any of the questions in **bold type** for which the ansv is "Yes".*

1. Community Concern

Is the proposal particularly sensitive within the community? NO..........

2. Buffer distances

(a) Buffer distance for this type of operation (from Guidance No. 3) 1500 - 3000......m

(b) Distance to nearest residence 4500...m

Is distance (a) greater than distance (b)? NO..........

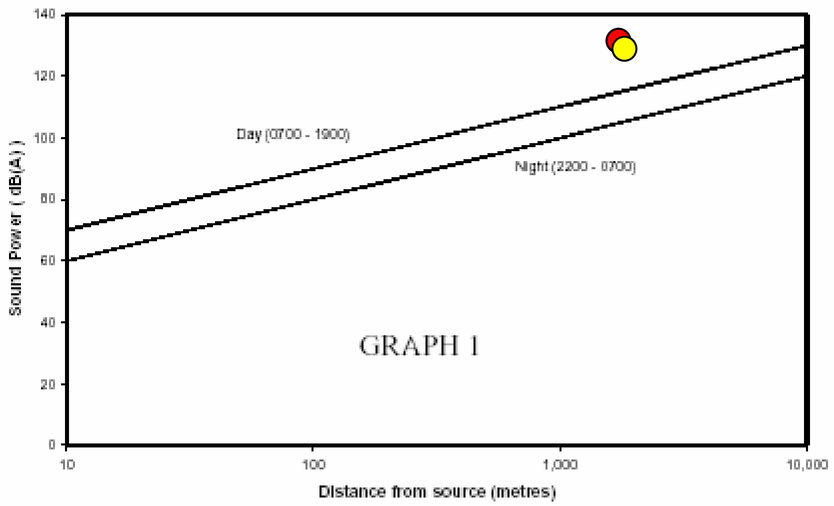
3. Operational noise

(a) Estimated total sound power for all sources on site

- daytime 130..dB(A)
- nighttime 130..dB(A)

(b) Distance to nearest residence 4500......m

(c) Plot the two points (a) against (b) on Graph 1 below –



(d) ***Is operational noise above the relevant line in Graph 1?*** YES..............

Appendix 1

Sheet 2

4. Construction activities on site

4.1 Where construction activity is likely to take place within the hours 7.00 am to 7.00 pm Monday to Saturday -

Are particularly noisy activities such as impact piling envisaged? ....

4.2 Where construction activity is likely to take place outside the hours 7.00 am to 7.00 pm Monday to Saturday –

(a) Estimate total sound power for all sources on site –

- daytime 125..dB(A)
- nighttime 125..dB(A)

(b) Distance to nearest residence 4500..m

(c) Plot (a) against (b) on Graph 1 above.

(d) ***Is construction noise above either line in Graph 1?*** YES..............

5. Blasting

(a) ***Is the construction/operation likely to involve blasting?*** YES..............

Source Sound Power Levels

			1/1 Octave Band Linear Sound Power Level dB								
	1/1 Octave Band Centre Frequency (Hz)		**32 Hz**	**63 Hz**	**125 Hz**	**250 Hz**	**500 Hz**	**1000 Hz**	**2000 Hz**	**4000 Hz**	**8000 Hz**
Plant	**Sound Power Level**	**General Model Scenario Location**									
Front End Loaders (994)	117 dBA	Stockpiles / blending	112	122	120	113	113	112	109	104	98
Excavators (Hitachi/Leibherr)	114 - 119 dBA	Pits	111	117	117	116	112	110	111	105	107
Haul trucks (Komatsu 630E, CAT 777 and 785 based on CAT 789 & 793)	120 dBA	Haul roads	119	131	125	120	114	112	111	109	105
Water trucks	110 dBA (based on Volvo F724)	Unsealed roads, mainly haul routes	112	111	112	110	106	105	103	97	92
Dozer (D10)	116 dBA	Surface / pits	120	121	112	115	114	109	107	105	101
Grader	115 dBA (based on CAT 16G)	Unsealed roads, mainly haul routes	112	122	118	117	108	111	107	103	93
Fuel service truck	110 dBA (based on Volvo F724 water cart)	Various along roads	112	111	112	110	106	105	103	97	92
Light vehicle	90 dBA	Various along roads	76	86	81	84	81	80	77	70	63
Generators and light plant	105 dBA (typical)	Fixed plant areas	106	104	111	108	102	96	95	90	86
Production drills	130 dBA (based on Gardner Denver 3500BV)	Pit benches	126	117	110	113	119	117	125	126	122
Contour drills	113 dBA (generic data)	Pit benches	105	107	118	112	108	108	105	98	92

Source Sound Power Levels

			1/1 Octave Band Linear Sound Power Level dB								
	1/1 Octave Band Centre Frequency (Hz)		32 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Conveyors	82 - 85 dBA per metre (based on information supplied)	As shown on mine plans	78	75	77	80	83	80	72	66	60
Conveyor drives	109 - 117 dBA (Primary and secondary drives)	As advised	115	114	120	119	113	115	109	101	93
Primary crusher	124 dBA	As shown on mine plans	123	127	123	123	121	119	116	112	106
Secondary crusher	117 dBA	As shown on mine plans	113	113	115	113	113	112	110	105	99
Tertiary crusher	111 dBA	As shown on mine plans	101	107	106	104	104	106	106	103	97
Travelling stackers	100 dBA	As shown on mine plans	100	92	90	90	92	94	95	92	89
Transfer stations	116 dBA	As shown on mine plans	117	115	112	109	108	105	103	99	92
Screens (inc scalping)	112 - 118 dBA	As shown on mine plans	115	117	114	109	108	107	108	108	104
Locomotives (corrections for wheel squeal etc applied as required in model)	110 dBA	Rail spur	114	123	114	105	108	107	104	99	90

Appendix I

CONCAWE Results

Sound Propagation Calculation Sheet - Sheet No. 1

Project:	75-1122
Location:	Cundaline
Sound Source:	Crushing and screening plant 2011
Path to:	Yarrie Accommodation Camp

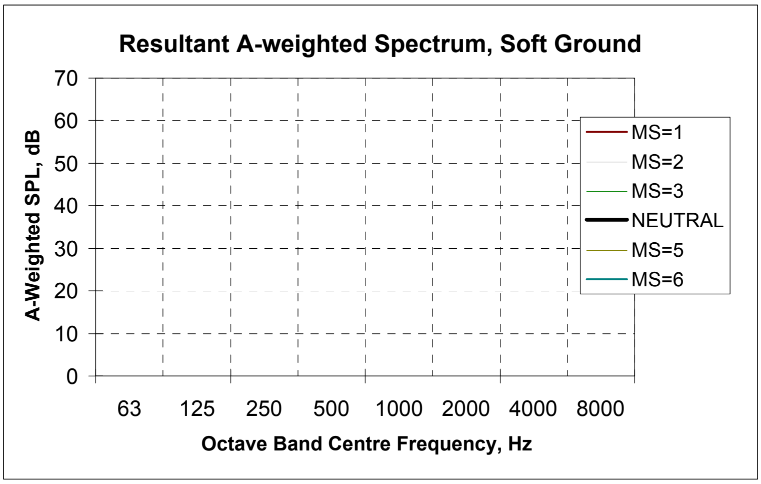
Inputs:

Area of Radiating Surface, sq m =	1000
Air Temperature, Celsius =	15
Relative Humidity, % =	50
Atmospheric Pressure, KPa =	101
Q of Propagation =	2

	X	Y	Z	H	
Source	207627	23818	160	10	(metres)
Receiver	216816	21100	133	1.8	

True Separation, m = 9583

Gamma = 0.999 Phi = 0.1



Quantity	**Unit**	**Value of Lw / Attenuation / Lp**							
Inputs: Frequency	**A**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Source Sound Power, Lw	dB	103	111	117	121	122	121	118	111
Directivity	dB	0	0	0	0	0	0	0	0
Barrier Attenuation path diff,m	dB	25	25	25	25	25	25	25	25

Outputs:

Soft Ground Attenuation	dB	13	14	21	11	8	10	13	13
Air Absorption	dB	1	4	11	23	42	104	340	1201
Divergence Attenuation	dB	88	88	88	88	88	88	88	88
Meteorological State Effects	Attenuations Variable with Distance								
Upwind 1	dB	9	7	5	10	12	7	9	9
Upwind 2	dB	3	2	5	7	11	7	8	8
Upwind 3	dB	2	2	4	4	6	5	5	5
Neutral 4	dB	0	0	0	0	0	0	0	0
Downwind & Stable 5	dB	-2	-4	-6	-7	-5	-3	-5	-5
Downwind & Stable 6	dB	-3	-4	-6	-7	-5	-4	-7	-7

Sound Pressure Level Prediction At Receiver, A wtd Overall and Octave Band Values.

Ground and Met State	**dB(A)**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Upwind 1, Soft Ground	-24	-32	-26	-34	-36	-52	-114	-356	-1224
Upwind 1, Hard Ground	-9	-19	-12	-12	-25	-45	-103	-343	-1211
Upwind 2, Soft Ground	-20	-27	-22	-34	-32	-51	-114	-356	-1223
Upwind 2, Hard Ground	-5	-14	-7	-12	-18	-38	-101	-340	-1207
Upwind 3, Soft Ground	-19	-26	-21	-33	-29	-46	-111	-353	-1220
Upwind 3, Hard Ground	-5	-13	-7	-12	-18	-38	-101	-340	-1207
Neutral 4, Soft Ground	**-17**	**-23**	**-19**	**-29**	**-26**	**-40**	**-106**	**-348**	**-1216**
Neutral 4, Hard Ground	**-2**	**-10**	**-5**	**-7**	**-15**	**-32**	**-96**	**-335**	**-1203**
Downwind 5, Soft Ground	-12	-21	-15	-22	-19	-35	-103	-343	-1211
Downwind 5, Hard Ground	3	-8	-1	-1	-8	-27	-93	-330	-1198
Downwind 6, Soft Ground	-12	-21	-15	-22	-18	-35	-102	-340	-1208
Downwind 6, Hard Ground	3	-8	-1	-1	-7	-27	-91	-327	-1195

Sound Propagation Calculation Sheet - Sheet No. 2

Project: 75-1122
Location: Cundaline
Sound Source: Crushing and screening plant 2013
Path to: Yarrie Accommodation Camp

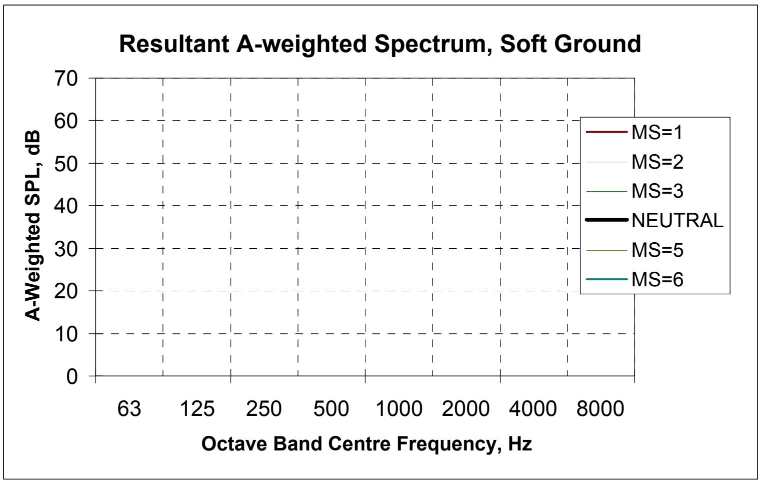
Inputs:

Area of Radiating Surface, sq m =	1000
Air Temperature, Celsius =	15
Relative Humidity, % =	50
Atmospheric Pressure, KPa =	101
Q of Propagation =	2

	X	Y	Z	H
Source	207627	23818	160	10
Receiver	216816	21100	133	1.8

(metres)

True Separation, m = 9583
Gamma = 0.999 Phi = 0.1



Quantity	Unit	Value of Lw / Attenuation / Lp							
Inputs: Frequency	**A**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Source Sound Power, Lw	dB	104	112	117	121	123	121	118	111
Directivity	dB	0	0	0	0	0	0	0	0
Barrier Attenuation path diff,m	dB	25	25	25	25	25	25	25	25

Outputs:

Soft Ground Attenuation	dB	13	14	21	11	8	10	13	13
Air Absorption	dB	1	4	11	23	42	104	340	1201
Divergence Attenuation	dB	88	88	88	88	88	88	88	88
Meteorological State Effects	Attenuations Variable with Distance								
Upwind 1	dB	9	7	5	10	12	7	9	9
Upwind 2	dB	3	2	5	7	11	7	8	8
Upwind 3	dB	2	2	4	4	6	5	5	5
Neutral 4	dB	0	0	0	0	0	0	0	0
Downwind & Stable 5	dB	-2	-4	-6	-7	-5	-3	-5	-5
Downwind & Stable 6	dB	-3	-4	-6	-7	-5	-4	-7	-7

Sound Pressure Level Prediction At Receiver, A wtd Overall and Octave Band Values.

Ground and Met State	**dB(A)**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Upwind 1, Soft Ground	-24	-32	-25	-33	-35	-52	-113	-356	-1224
Upwind 1, Hard Ground	-8	-19	-11	-12	-24	-44	-103	-343	-1211
Upwind 2, Soft Ground	-20	-26	-21	-34	-32	-51	-113	-355	-1223
Upwind 2, Hard Ground	-4	-13	-6	-12	-18	-38	-100	-339	-1207
Upwind 3, Soft Ground	-19	-25	-20	-33	-29	-45	-111	-352	-1220
Upwind 3, Hard Ground	-4	-12	-6	-12	-18	-38	-100	-339	-1207
Neutral 4, Soft Ground	**-16**	**-23**	**-19**	**-28**	**-25**	**-39**	**-106**	**-347**	**-1216**
Neutral 4, Hard Ground	**-2**	**-10**	**-5**	**-7**	**-14**	**-32**	**-95**	**-334**	**-1203**
Downwind 5, Soft Ground	-12	-21	-14	-22	-18	-34	-103	-342	-1211
Downwind 5, Hard Ground	3	-8	0	-1	-7	-27	-92	-329	-1198
Downwind 6, Soft Ground	-11	-20	-14	-22	-18	-34	-101	-340	-1208
Downwind 6, Hard Ground	3	-7	0	-1	-7	-27	-91	-327	-1195

Sound Propagation Calculation Sheet - Sheet No. 3

Project: 75-1122
Location: Cundaline
Sound Source: Mining plant 2011
Path to: Yarrie Accommodation Camp

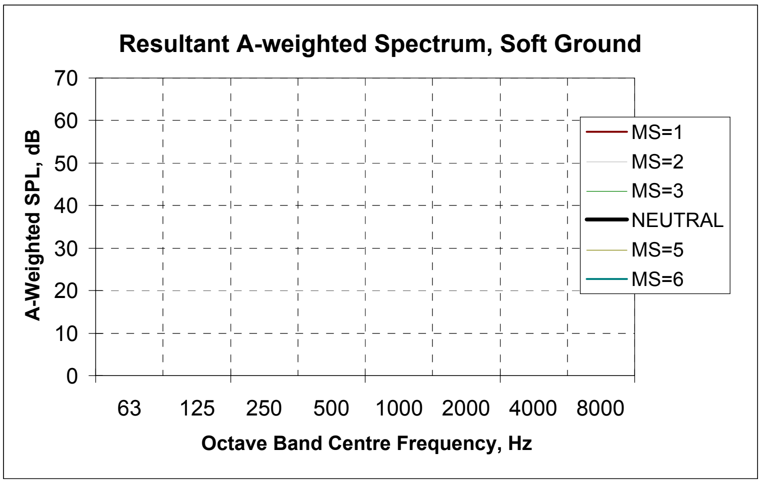
Inputs:

Area of Radiating Surface, sq m = 5000
Air Temperature, Celsius = 15
Relative Humidity, % = 50
Atmospheric Pressure, KPa = 101
Q of Propagation = 2

	X	Y	Z	H
Source	208259	22639	236	5
Receiver	216816	21100	133	1.8

(metres)

True Separation, m =8695
Gamma = 1 Phi = 0.0



Quantity	Unit	Value of Lw / Attenuation / Lp							
Inputs: Frequency	**A**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Source Sound Power, Lw	dB	98	104	110	112	113	114	108	106
Directivity	dB	0	0	0	0	0	0	0	0
Barrier Attenuation path diff,m	dB	22	25	25	25	25	25	25	25

Outputs:

Soft Ground Attenuation	dB	13	14	21	11	8	10	13	13
Air Absorption	dB	1	4	10	21	38	94	308	1090
Divergence Attenuation	dB	87	87	87	87	87	87	87	87
Meteorological State Effects	Attenuations Variable with Distance								
Upwind 1	dB	9	7	5	10	12	7	9	9
Upwind 2	dB	3	2	5	7	11	7	8	8
Upwind 3	dB	2	2	4	4	6	5	5	5
Neutral 4	dB	0	0	0	0	0	0	0	0
Downwind & Stable 5	dB	-2	-4	-6	-7	-5	-3	-5	-5
Downwind & Stable 6	dB	-3	-4	-6	-7	-5	-4	-7	-7

Sound Pressure Level Prediction At Receiver, A wtd Overall and Octave Band Values.

Ground and Met State	dB(A)	63	125	250	500	1000	2000	4000	8000
Upwind 1, Soft Ground	-29	-34	-32	-38	-41	-57	-110	-333	-1117
Upwind 1, Hard Ground	-13	-21	-18	-17	-30	-50	-100	-321	-1104
Upwind 2, Soft Ground	-25	-29	-28	-38	-38	-56	-110	-333	-1116
Upwind 2, Hard Ground	-10	-16	-13	-16	-24	-43	-97	-317	-1100
Upwind 3, Soft Ground	-24	-28	-27	-37	-35	-51	-107	-330	-1113
Upwind 3, Hard Ground	-9	-15	-13	-16	-24	-43	-97	-317	-1100
Neutral 4, Soft Ground	**-21**	**-25**	**-25**	**-33**	**-31**	**-45**	**-102**	**-325**	**-1108**
Neutral 4, Hard Ground	**-7**	**-12**	**-11**	**-12**	**-20**	**-37**	**-92**	**-312**	**-1095**
Downwind 5, Soft Ground	-17	-23	-21	-26	-24	-40	-99	-320	-1103
Downwind 5, Hard Ground	-2	-10	-7	-5	-13	-32	-89	-307	-1090
Downwind 6, Soft Ground	-17	-22	-21	-26	-24	-40	-98	-317	-1101
Downwind 6, Hard Ground	-2	-9	-7	-5	-13	-32	-88	-304	-1088

Sound Propagation Calculation Sheet - Sheet No. 4

Project: 75-1122
Location: Cundaline
Sound Source: Mining plant 2013
Path to: Yarrie Accommodation Camp

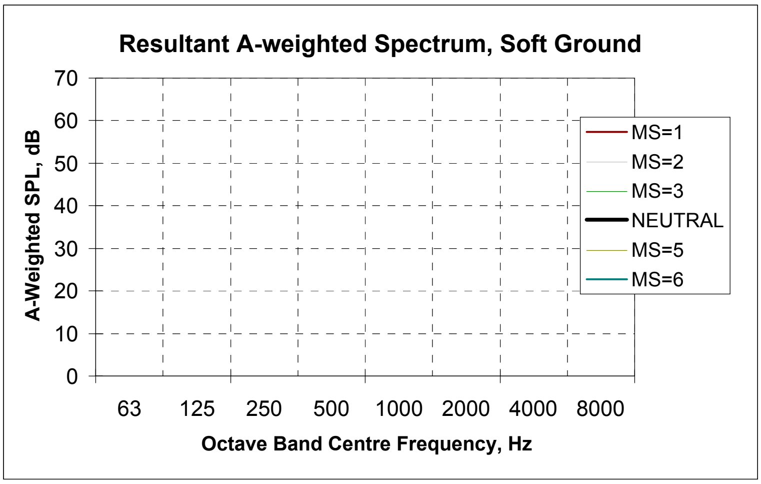
Inputs:

Area of Radiating Surface, sq m =	5000
Air Temperature, Celsius =	15
Relative Humidity, % =	50
Atmospheric Pressure, KPa =	101
Q of Propagation =	2

	X	Y	Z	H
Source	208259	22639	236	5
Receiver	216816	21100	133	1.8

(metres)

True Separation, m = 8695
Gamma = 1 Phi = 0.0



Quantity	Unit	Value of Lw / Attenuation / Lp							
Inputs: Frequency	**A**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Source Sound Power, Lw	dB	102	107	114	121	122	129	130	124
Directivity	dB	0	0	0	0	0	0	0	0
Barrier Attenuation path diff,m	dB	22	25	25	25	25	25	25	25

Outputs:

Soft Ground Attenuation	dB	13	14	21	11	8	10	13	13
Air Absorption	dB	1	4	10	21	38	94	308	1090
Divergence Attenuation	dB	87	87	87	87	87	87	87	87
Meteorological State Effects	Attenuations Variable with Distance								
Upwind 1	dB	9	7	5	10	12	7	9	9
Upwind 2	dB	3	2	5	7	11	7	8	8
Upwind 3	dB	2	2	4	4	6	5	5	5
Neutral 4	dB	0	0	0	0	0	0	0	0
Downwind & Stable 5	dB	-2	-4	-6	-7	-5	-3	-5	-5
Downwind & Stable 6	dB	-3	-4	-6	-7	-5	-4	-7	-7

Sound Pressure Level Prediction At Receiver, A wtd Overall and Octave Band Values.

Ground and Met State	dB(A)	63	125	250	500	1000	2000	4000	8000
Upwind 1, Soft Ground	-25	-30	-29	-34	-32	-48	-94	-311	-1099
Upwind 1, Hard Ground	-9	-17	-15	-13	-21	-41	-84	-298	-1086
Upwind 2, Soft Ground	-21	-25	-25	-34	-29	-47	-94	-311	-1098
Upwind 2, Hard Ground	-6	-12	-10	-12	-15	-34	-82	-295	-1082
Upwind 3, Soft Ground	-20	-24	-24	-33	-26	-42	-92	-308	-1095
Upwind 3, Hard Ground	-6	-11	-10	-12	-15	-34	-82	-295	-1082
Neutral 4, Soft Ground	**-17**	**-21**	**-23**	**-29**	**-22**	**-36**	**-87**	**-303**	**-1090**
Neutral 4, Hard Ground	**-3**	**-8**	**-8**	**-8**	**-11**	**-28**	**-77**	**-290**	**-1077**
Downwind 5, Soft Ground	-12	-19	-18	-22	-15	-31	-84	-298	-1085
Downwind 5, Hard Ground	3	-6	-4	-1	-4	-23	-74	-285	-1072
Downwind 6, Soft Ground	-12	-18	-18	-22	-15	-31	-82	-295	-1083
Downwind 6, Hard Ground	3	-5	-4	-1	-4	-23	-72	-282	-1070

Sound Propagation Calculation Sheet - Sheet No. 5

Project: 75-1122
Location: Cundaline
Sound Source: Rail Loadout 2011 and 2013
Path to: Yarrie Accommodation Camp

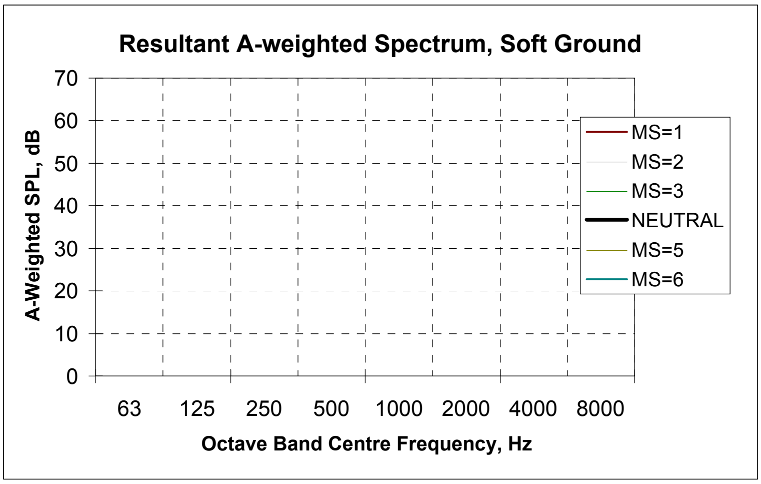
Inputs:

Area of Radiating Surface, sq m = 1000
Air Temperature, Celsius = 15
Relative Humidity, % = 50
Atmospheric Pressure, KPa = 101
Q of Propagation = 2

	X	Y	Z	H
Source	207627	23818	160	5
Receiver	216816	21100	133	1.8

(metres)

True Separation, m =9583
Gamma = 1 Phi = 0.0



Quantity	Unit	Value of Lw / Attenuation / Lp							
Inputs: Frequency	**A**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Source Sound Power, Lw	dB	100	102	103	110	117	109	105	95
Directivity	dB	0	0	0	0	0	0	0	0
Barrier Attenuation path diff,m	dB	25	25	25	25	25	25	25	25

Outputs:

Soft Ground Attenuation	dB	13	14	21	11	8	10	13	13
Air Absorption	dB	1	4	11	23	42	104	340	1201
Divergence Attenuation	dB	88	88	88	88	88	88	88	88
Meteorological State Effects	Attenuations Variable with Distance								
Upwind 1	dB	9	7	5	10	12	7	9	9
Upwind 2	dB	3	2	5	7	11	7	8	8
Upwind 3	dB	2	2	4	4	6	5	5	5
Neutral 4	dB	0	0	0	0	0	0	0	0
Downwind & Stable 5	dB	-2	-4	-6	-7	-5	-3	-5	-5
Downwind & Stable 6	dB	-3	-4	-6	-7	-5	-4	-7	-7

Sound Pressure Level Prediction At Receiver, A wtd Overall and Octave Band Values.

Ground and Met State	dB(A)	63	125	250	500	1000	2000	4000	8000
Upwind 1, Soft Ground	-32	-35	-35	-48	-47	-58	-125	-369	-1241
Upwind 1, Hard Ground	-18	-22	-21	-26	-36	-51	-115	-356	-1228
Upwind 2, Soft Ground	-27	-30	-31	-48	-43	-57	-125	-368	-1240
Upwind 2, Hard Ground	-13	-17	-16	-26	-29	-44	-112	-352	-1224
Upwind 3, Soft Ground	-26	-29	-30	-47	-40	-52	-122	-365	-1237
Upwind 3, Hard Ground	-13	-16	-16	-26	-29	-44	-112	-352	-1224
Neutral 4, Soft Ground	**-24**	**-26**	**-29**	**-43**	**-37**	**-46**	**-117**	**-360**	**-1232**
Neutral 4, Hard Ground	**-10**	**-13**	**-15**	**-21**	**-26**	**-38**	**-107**	**-347**	**-1219**
Downwind 5, Soft Ground	-20	-24	-24	-36	-30	-41	-114	-355	-1227
Downwind 5, Hard Ground	-7	-11	-10	-15	-19	-33	-104	-342	-1214
Downwind 6, Soft Ground	-20	-24	-24	-36	-29	-41	-113	-353	-1225
Downwind 6, Hard Ground	-6	-11	-10	-15	-18	-33	-103	-340	-1212

Sound Propagation Calculation Sheet - Sheet No. **5**

Project:	75-1122
Location:	Cundaline
Sound Source:	Road Trains 2011 and 2013
Path to:	Yarrie Accommodation Camp

Inputs:

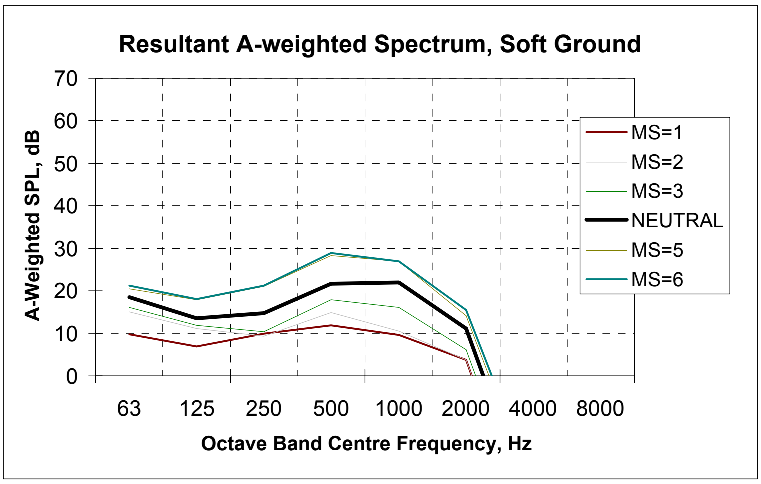
Area of Radiating Surface, sq m =	1000
Air Temperature, Celsius =	15
Relative Humidity, % =	50
Atmospheric Pressure, KPa =	101
Q of Propagation =	2

	X	Y	Z	H
Source	5957	8583	121	3.5
Receiver	6871	9833	132	1.8

(metres)

True Separation, m = 1549

Gamma = 0.993 Phi = 0.2



Quantity	Unit	Value of Lw / Attenuation / Lp							
Inputs: Frequency	**A**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Source Sound Power, Lw	dB	97	99	106	108	108	107	102	93
Directivity	dB	0	0	0	0	0	0	0	0
Barrier Attenuation path diff,m	dB	0	0	0	0	0	0	0	0

Outputs:

Soft Ground Attenuation	dB	6	13	18	11	8	7	8	8
Air Absorption	dB	0	1	2	4	7	17	55	194
Divergence Attenuation	dB	72	72	72	72	72	72	72	72
Meteorological State Effects	Attenuations Variable with Distance								
Upwind 1	dB	9	7	5	10	12	7	9	9
Upwind 2	dB	3	2	5	7	11	7	8	8
Upwind 3	dB	2	2	4	4	6	5	5	5
Neutral 4	dB	0	0	0	0	0	0	0	0
Downwind & Stable 5	dB	-2	-4	-6	-7	-5	-3	-5	-5
Downwind & Stable 6	dB	-3	-4	-6	-7	-5	-4	-7	-7

Sound Pressure Level Prediction At Receiver, A wtd Overall and Octave Band Values.

Ground and Met State	dB(A)	63	125	250	500	1000	2000	4000	8000
Upwind 1, Soft Ground	17	10	7	10	12	10	4	-41	-189
Upwind 1, Hard Ground	30	16	20	27	23	17	11	-33	-181
Upwind 2, Soft Ground	20	15	11	9	15	11	4	-40	-188
Upwind 2, Hard Ground	33	22	25	28	29	23	14	-29	-178
Upwind 3, Soft Ground	22	16	12	10	18	16	6	-37	-185
Upwind 3, Hard Ground	33	23	25	28	29	23	14	-29	-178
Neutral 4, Soft Ground	**26**	**19**	**14**	**15**	**22**	**22**	**11**	**-32**	**-181**
Neutral 4, Hard Ground	**37**	**25**	**27**	**32**	**33**	**29**	**18**	**-25**	**-173**
Downwind 5, Soft Ground	32	20	18	21	28	27	14	-27	-176
Downwind 5, Hard Ground	43	27	31	39	39	34	21	-20	-168
Downwind 6, Soft Ground	32	21	18	21	29	27	16	-25	-173
Downwind 6, Hard Ground	43	28	31	39	40	34	23	-17	-165

Sound Propagation Calculation Sheet - Sheet No. **5**

Project:	75-1122
Location:	Yarrie Processing Facility
Sound Source:	Crushing and screening plant 2011 and 2013
Path to:	Yarrie Accommodation Camp

Inputs:

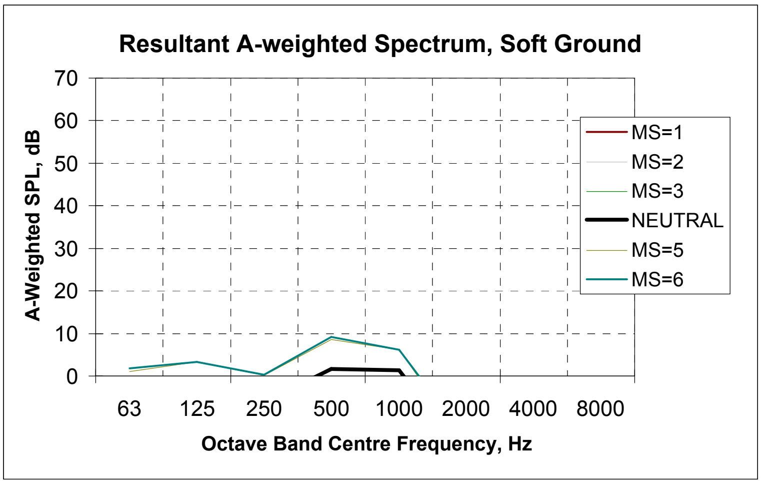
Area of Radiating Surface, sq m =	1000
Air Temperature, Celsius =	15
Relative Humidity, % =	50
Atmospheric Pressure, KPa =	101
Q of Propagation =	2

	X	Y	Z	H
Source	219168	18017	180	10
Receiver	217062	19833	133	1.8

(metres)

True Separation, m =2781

Gamma = 0.989 Phi = 0.2



Quantity	Unit	Value of Lw / Attenuation / Lp							
Inputs: Frequency	**A**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Source Sound Power, Lw	dB	104	112	117	121	123	121	118	111
Directivity	dB	0	0	0	0	0	0	0	0
Barrier Attenuation path diff,m	dB	18	21	24	25	25	25	25	25

Outputs:

Soft Ground Attenuation	dB	10	15	19	11	8	8	9	9
Air Absorption	dB	0	1	3	7	12	30	99	349
Divergence Attenuation	dB	77	77	77	77	77	77	77	77
Meteorological State Effects	Attenuations Variable with Distance								
Upwind 1	dB	9	7	5	10	12	7	9	9
Upwind 2	dB	3	2	5	7	11	7	8	8
Upwind 3	dB	2	2	4	4	6	5	5	5
Neutral 4	dB	0	0	0	0	0	0	0	0
Downwind & Stable 5	dB	-2	-4	-6	-7	-5	-3	-5	-5
Downwind & Stable 6	dB	-3	-4	-6	-7	-5	-4	-7	-7

Sound Pressure Level Prediction At Receiver, A wtd Overall and Octave Band Values.

Ground and Met State	dB(A)	63	125	250	500	1000	2000	4000	8000
Upwind 1, Soft Ground	-2	-10	-8	-11	-8	-11	-27	-101	-357
Upwind 1, Hard Ground	12	0	7	8	3	-4	-18	-91	-348
Upwind 2, Soft Ground	1	-4	-4	-12	-5	-10	-27	-100	-357
Upwind 2, Hard Ground	15	6	12	9	9	3	-16	-87	-344
Upwind 3, Soft Ground	3	-3	-3	-11	-2	-5	-24	-97	-354
Upwind 3, Hard Ground	16	7	12	9	9	3	-16	-87	-344
Neutral 4, Soft Ground	**7**	**-1**	**-1**	**-6**	**2**	**1**	**-19**	**-92**	**-349**
Neutral 4, Hard Ground	**19**	**9**	**13**	**13**	**13**	**9**	**-11**	**-83**	**-339**
Downwind 5, Soft Ground	12	1	3	0	9	6	-16	-87	-344
Downwind 5, Hard Ground	24	11	18	19	19	14	-8	-78	-334
Downwind 6, Soft Ground	12	2	3	0	9	6	-15	-85	-341
Downwind 6, Hard Ground	25	12	18	19	20	14	-6	-75	-332

Sound Propagation Calculation Sheet - Sheet No. 5

Project:	75-1122
Location:	Cundaline
Sound Source:	Mining plant 2011
Path to:	Yarrie Accommodation Camp

Inputs:

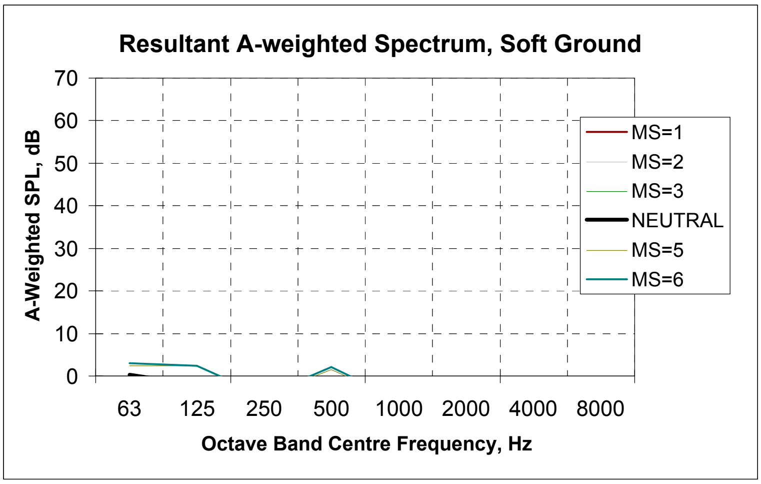
Area of Radiating Surface, sq m =	5000
Air Temperature, Celsius =	15
Relative Humidity, % =	50
Atmospheric Pressure, KPa =	101
Q of Propagation =	2

	X	Y	Z	H
Source	219056	15682	244	5
Receiver	217062	19833	133	1.8

(metres)

True Separation, m =4607

Gamma = 0.999 Phi = 0.1



Quantity	Unit	Value of Lw / Attenuation / Lp							
Inputs: Frequency	**A**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Source Sound Power, Lw	dB	113	117	120	123	123	130	130	124
Directivity	dB	0	0	0	0	0	0	0	0
Barrier Attenuation path diff,m	dB	18	21	24	25	25	25	25	25

Outputs:

Soft Ground Attenuation	dB	13	15	20	11	8	9	11	11
Air Absorption	dB	1	2	5	11	20	50	163	577
Divergence Attenuation	dB	81	81	81	81	81	81	81	81
Meteorological State Effects	Attenuations Variable with Distance								
Upwind 1	dB	9	7	5	10	12	7	9	9
Upwind 2	dB	3	2	5	7	11	7	8	8
Upwind 3	dB	2	2	4	4	6	5	5	5
Neutral 4	dB	0	0	0	0	0	0	0	0
Downwind & Stable 5	dB	-2	-4	-6	-7	-5	-3	-5	-5
Downwind & Stable 6	dB	-3	-4	-6	-7	-5	-4	-7	-7

Sound Pressure Level Prediction At Receiver, A wtd Overall and Octave Band Values.

Ground and Met State	dB(A)	63	125	250	500	1000	2000	4000	8000
Upwind 1, Soft Ground	-5	-9	-9	-16	-15	-23	-43	-159	-579
Upwind 1, Hard Ground	10	4	6	4	-4	-16	-34	-148	-568
Upwind 2, Soft Ground	0	-3	-5	-17	-12	-22	-43	-158	-578
Upwind 2, Hard Ground	14	10	11	5	2	-9	-32	-144	-564
Upwind 3, Soft Ground	1	-2	-4	-16	-9	-17	-41	-155	-575
Upwind 3, Hard Ground	15	11	11	5	2	-9	-32	-144	-564
Neutral 4, Soft Ground	**3**	**0**	**-2**	**-11**	**-5**	**-11**	**-36**	**-150**	**-570**
Neutral 4, Hard Ground	**17**	**13**	**13**	**9**	**6**	**-3**	**-27**	**-139**	**-559**
Downwind 5, Soft Ground	7	2	2	-5	2	-6	-33	-145	-565
Downwind 5, Hard Ground	22	15	17	16	12	2	-24	-134	-554
Downwind 6, Soft Ground	8	3	2	-5	2	-6	-31	-143	-563
Downwind 6, Hard Ground	22	16	17	16	13	2	-22	-132	-552

Sound Propagation Calculation Sheet - Sheet No. **5**

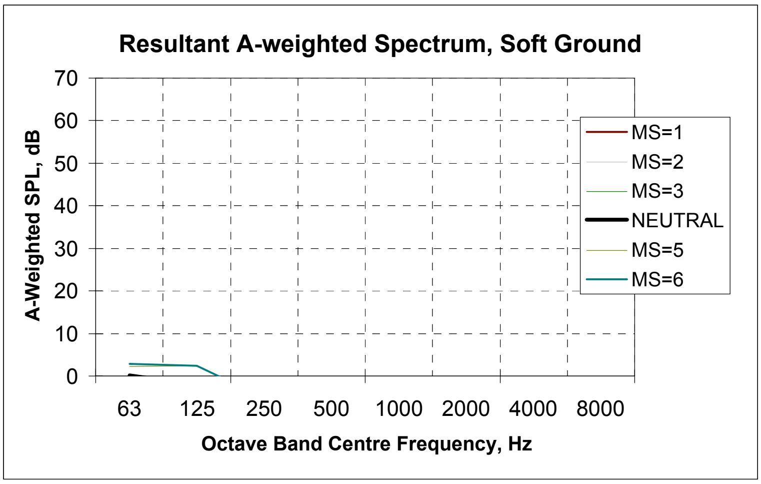
Project: 75-1122
Location: Cundaline
Sound Source: Mining plant 2013
Path to: Yarrie Accommodation Camp

Inputs:

Area of Radiating Surface, sq m = 5000
Air Temperature, Celsius = 15
Relative Humidity, % = 50
Atmospheric Pressure, KPa = 101
Q of Propagation = 2

	X	Y	Z	H	
Source	219056	15682	244	5	(metres)
Receiver	217062	19833	133	1.8	

True Separation, m = 4607
Gamma = 0.999 Phi = 0.1



Quantity	Unit	Value of Lw / Attenuation / Lp							
Inputs: Frequency	**A**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Source Sound Power, Lw	dB	113	117	119	120	121	121	118	113
Directivity	dB	0	0	0	0	0	0	0	0
Barrier Attenuation path diff,m	dB	18	21	24	25	25	25	25	25

Outputs:

Soft Ground Attenuation	dB	13	15	20	11	8	9	11	11
Air Absorption	dB	1	2	5	11	20	50	163	577
Divergence Attenuation	dB	81	81	81	81	81	81	81	81
Meteorological State Effects	Attenuations Variable with Distance								
Upwind 1	dB	9	7	5	10	12	7	9	9
Upwind 2	dB	3	2	5	7	11	7	8	8
Upwind 3	dB	2	2	4	4	6	5	5	5
Neutral 4	dB	0	0	0	0	0	0	0	0
Downwind & Stable 5	dB	-2	-4	-6	-7	-5	-3	-5	-5
Downwind & Stable 6	dB	-3	-4	-6	-7	-5	-4	-7	-7

Sound Pressure Level Prediction At Receiver, A wtd Overall and Octave Band Values.

Ground and Met State		dB(A)	63	125	250	500	1000	2000	4000	8000
Upwind 1,	Soft Ground	-5	-9	-9	-17	-18	-26	-52	-171	-590
Upwind 1,	Hard Ground	10	4	6	4	-7	-18	-43	-160	-579
Upwind 2,	Soft Ground	-1	-3	-5	-17	-15	-25	-52	-170	-589
Upwind 2,	Hard Ground	14	10	11	4	-1	-12	-40	-156	-575
Upwind 3,	Soft Ground	0	-2	-4	-16	-12	-19	-49	-167	-586
Upwind 3,	Hard Ground	15	11	11	4	-1	-12	-40	-156	-575
Neutral 4,	Soft Ground	**3**	**0**	**-2**	**-12**	**-8**	**-13**	**-45**	**-162**	**-582**
Neutral 4,	Hard Ground	**17**	**13**	**13**	**9**	**3**	**-6**	**-35**	**-151**	**-571**
Downwind 5,	Soft Ground	7	2	2	-5	-1	-8	-42	-157	-577
Downwind 5,	Hard Ground	21	15	17	15	10	-1	-32	-146	-566
Downwind 6,	Soft Ground	7	3	2	-5	-1	-8	-40	-155	-574
Downwind 6,	Hard Ground	21	16	17	15	10	-1	-31	-144	-563

Sound Propagation Calculation Sheet - Sheet No. **5**

Project: 75-1122
Location: Cundaline
Sound Source: Rail Loadout 2011 and 2013
Path to: Yarrie Accommodation Camp

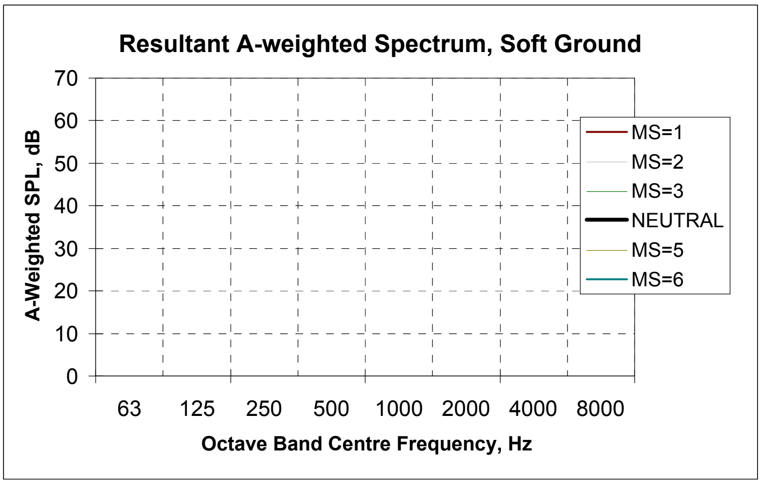
Inputs:

Area of Radiating Surface, sq m =	1000
Air Temperature, Celsius =	15
Relative Humidity, % =	50
Atmospheric Pressure, KPa =	101
Q of Propagation =	2

	X	Y	Z	H
Source	219061	17249	130	5
Receiver	217062	19833	133	1.8

(metres)

True Separation, m = 3267
Gamma = 0.997 Phi = 0.1



Quantity	Unit	Value of Lw / Attenuation / Lp							
Inputs: Frequency	**A**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Source Sound Power, Lw	dB	100	102	103	110	117	109	105	95
Directivity	dB	0	0	0	0	0	0	0	0
Barrier Attenuation path diff,m	dB	19	22	25	25	25	25	25	25

Outputs:

Soft Ground Attenuation	dB	11	15	20	11	8	9	10	10
Air Absorption	dB	0	1	4	8	14	35	116	409
Divergence Attenuation	dB	78	78	78	78	78	78	78	78
Meteorological State Effects	Attenuations Variable with Distance								
Upwind 1	dB	9	7	5	10	12	7	9	9
Upwind 2	dB	3	2	5	7	11	7	8	8
Upwind 3	dB	2	2	4	4	6	5	5	5
Neutral 4	dB	0	0	0	0	0	0	0	0
Downwind & Stable 5	dB	-2	-4	-6	-7	-5	-3	-5	-5
Downwind & Stable 6	dB	-3	-4	-6	-7	-5	-4	-7	-7

Sound Pressure Level Prediction At Receiver, A wtd Overall and Octave Band Values.

Ground and Met State	dB(A)	63	125	250	500	1000	2000	4000	8000
Upwind 1, Soft Ground	-14	-18	-21	-29	-22	-21	-45	-133	-437
Upwind 1, Hard Ground	-2	-6	-6	-10	-11	-13	-37	-123	-427
Upwind 2, Soft Ground	-10	-12	-17	-30	-19	-20	-45	-132	-436
Upwind 2, Hard Ground	3	-1	-1	-9	-5	-7	-34	-119	-423
Upwind 3, Soft Ground	-8	-11	-16	-29	-16	-14	-43	-129	-433
Upwind 3, Hard Ground	4	0	-1	-9	-5	-7	-34	-119	-423
Neutral 4, Soft Ground	**-4**	**-9**	**-14**	**-24**	**-12**	**-9**	**-38**	**-124**	**-428**
Neutral 4, Hard Ground	**7**	**3**	**0**	**-5**	**-1**	**-1**	**-29**	**-114**	**-418**
Downwind 5, Soft Ground	0	-7	-10	-18	-5	-4	-35	-119	-423
Downwind 5, Hard Ground	11	4	5	2	6	4	-26	-109	-413
Downwind 6, Soft Ground	1	-6	-10	-18	-5	-4	-33	-117	-421
Downwind 6, Hard Ground	12	5	5	2	6	4	-25	-107	-411