

Appendix I Air Quality Assessment



Final Report

Air Quality Impact Assessment - Expansion Works at the East Arm Wharf

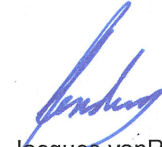
4 MAY 2011

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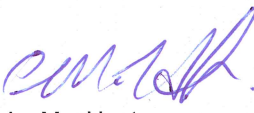
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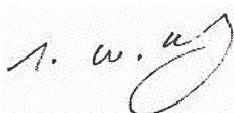
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Reference:

42214003/01/01

Status:

Final

URS

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Abbreviations

Abbreviation	Description
AWS	Automatic Weather Station
BoM	Bureau of Meteorology
CBD	Central Business District
CO	Carbon monoxide
DLP	Department of Lands and Planning
DLPE	Department of Lands, Planning and Environment
DPC	Darwin Port Corporation
EAW	East Arm Wharf
EIS	Environmental Impact Statement
NEPC	National Environmental Protection Council
NEPM	National Environmental Protection Measure
NOI	Notice of Intent
NO _x	Oxides of nitrogen
NTU	Northern Territory University
OU	Odour Units
PER	Public Environmental Report
PM ₁₀	Particulate Matter (less than 10 micron in diameter)
SO ₂	Sulphur dioxide
TSP	Total Suspended Particulate

Executive Summary

An air quality assessment has been undertaken for the East Arm Wharf (EAW) expansion project, which involved the provision of additional land and infrastructure. The additional infrastructure is required to meet expected increases in demand associated with EAW operations. This air quality assessment has focused on particulate matter emissions associated with the construction phase of the Project. Additionally, operational emissions including particulate matter emissions from the expected dry bulk operational areas and combustion emissions from vessels at port have also been assessed. The assessment of potential air quality impacts has been compiled through:

- A baseline assessment of the existing environment;
- A qualitative assessment of construction activities expected;
- A qualitative assessment of anticipated operational activities; and
- A quantitative assessment of construction and operational phases, incorporating conservative emission estimation in conjunction with conservative dispersion modelling.

The baseline assessment involved the summary of climatic, and air quality conditions within the Darwin air shed. The baseline assessment of air quality suggests low concentrations of key air pollutants exist in the area and sporadic episodes of elevated air pollutant concentrations are generally associated with natural events, such as bushfires...

The qualitative assessment indicated that generally air emissions associated with construction and operational activities would be minor, however, certain construction and operational activities were identified which required further (quantitative) assessment. This was undertaken using dispersion modelling and results from the modelling showed predicted concentrations at receptors to be below the adopted criteria, hence air quality impacts from these activities were considered to be low. Whilst impacts were generally shown to be minor, mitigation measures have been provided to ensure the emissions of air pollutants during the construction phase are contained to minimise adverse air quality impacts.

The assessment of operational air quality impacts has been provided as based on current information. Further consideration to the emissions associated with marine vessels and the additional wharf operation areas should be considered upon finalisation of the detailed design of the facility.

Introduction

1.1 General

URS Australia Pty Ltd (URS) was engaged by the Northern Territory Department of Lands and Planning (DLP) to prepare an Air Quality assessment for inclusion in the Environmental Impact Statement (EIS) being compiled to assess the proposed expansion of the East Arm Wharf (EAW) facility (the Project). The EIS is provided to assess the environmental impacts for the provision of additional land for use by the Darwin Port Corporation. Impacts associated with the provision of additional land is of prime interest, however impacts considering use of this land (i.e. operational) have also been included within this air quality assessment.

1.2 Objective

The objective of the air quality assessment was to consider the potential release of air pollutants primarily from activities associated with the construction and, to a lesser extent, operational phases of the project.

1.3 Scope of the Air Quality Impact Assessment

The scope of the assessment incorporates the following items:

- Description of the activities and emissions from the project that have the potential to impact on local air quality;
- Qualitative assessment of the construction and operational phases of the project area;
- Quantitative assessment of select scenarios (established from the qualitative assessment) through dispersion modelling; and
- Summary of the mitigation measures for the construction phase.

1.4 Approach to Assessment

The methodology adopted for the air quality assessment was to undertake a qualitative assessment of the key activities. If the qualitative assessment indicated potential adverse impact, then a quantitative assessment was undertaken.

A preliminary assessment of operation phases of the expansion has been undertaken (i.e. dry bulk areas), however no detailed design and functionality of these areas has been made available. It is expected that additional air quality studies and/or approval processes would be undertaken during provision of these areas.

Project Overview

2.1 Project Description

The Northern Territory DLP proposes to provide additional infrastructure at the EAW facilities and adjacent areas. The EAW Masterplan 2030 (GHD 2010) (Masterplan 2030) provides a blue print for the development of key infrastructure at the EAW over the next 20 years.

The Northern Territory Government (NTG) proposes expanding existing facilities at the EAW to address increased demands on the wharf to service the oil and gas industry, bulk minerals export, as well as requirements of the Department of Defence (Defence) and other industries (SKM 2009, AECOM 2009).

The proposed EAW Expansion (the Project) includes:

- Developing a Marine Supply Base (MSB) adjacent to EAW, primarily to service the existing and developing oil and gas industries in the Timor Sea, Browse Basin and adjacent areas;
- Constructing a barge ramp and hardstand, including berthing for barge and equipment loading and unloading;
- Establishing a rail loop enabling rakes of rail wagons carrying bulk material to be manoeuvred through the port, unloading material through a proposed rail dump facility to the adjacent stockpile areas; and
- Extending the EAW quay line, and construction of moorings to accommodate tugs and other smaller vessels.

2.2 Air Emissions Associated with the Project

Two main types of air emissions would be associated with the construction phase of the project, those being products of combustion from construction vehicles and particulate matter. Particulate matter is of prime concern regarding construction activities and has been the focus of the air quality assessment.

Air emissions during the operational phase of the project, specifically, wharf upkeep by the Darwin Port Corporation (DPC) and other operational activities (not under jurisdiction of DPC) that give rise to combustion emissions from maintenance vehicles or vessels are expected to have minimal adverse air quality impacts., given their scale when compared against other key operational areas. Consequently, no further assessment of these emissions has been included. However, the following air emissions associated with individual operational areas require further assessment;

- Particulate matter from the open and enclosed 'dry bulk' storage and loading areas (including the rail spur);
- Volatile organic compounds (VOC) emissions from the expansion of the bulk liquid storage and loading areas. The EIS currently does not specifically cover the provision of areas for these areas, hence minimal attention is given to VOC emissions;
- Odour emissions from expansion of livestock deliveries. The EIS currently does not specifically cover the provision of areas for expansion livestock exports/imports, hence minimal attention is given to odour releases; and
- Combustion emissions from vessels as a result of an anticipated increase in growth of the EAW facility. A preliminary assessment of these emissions has been included.

The assessment of the operational emissions has focused on the dry bulk storage areas, and to a lesser extent emissions from vessels.

2 Project Overview

2.2.1 Exclusions

URS has not been made aware of any contamination issues associated with the planned dredging and reclamation activities, hence no provision to the release of contaminated dust or VOCs from dredged contaminated spoil has been accounted for. It is expected that the Construction and Operational Environmental Management Plans developed following the completion of the EIS process will specifically address issues associated with potentially contaminated dredged spoil.

2.3 Air Pollutants Assessed

The following sections provide a brief discussion on the air pollutants assessed, namely particulate matter, which is associated with construction and combustion emissions and oxides of nitrogen (NO_x), sulphur dioxide (SO_2) and carbon monoxide (CO), which are combustion products. Additionally, odour is also assessed, which may be related to odorous activities such as livestock transport or sediment dredging.

Other air pollutants such as metal dusts, acid mists, Semi-volatile organic compounds (SVOC) and ozone were not considered to be released from any of the sources in appreciable quantities, or formation of these compounds was considered to be negligible, consequently, these pollutants were not assessed.

2.3.1 Particulate Matter

Particulate matter (dust) is generally divided into two broad fractions, deposited and suspended. Deposited particulate matter is dust that, because of its aerodynamic diameter and density, rapidly falls from the air. In general terms, deposited particulate has a diameter of greater than about 20 μm .

However there is no distinct dividing line between these particles and the smaller particles of suspended matter fall less readily or slowly out of the air. Because of the size of the particulate matter, most of this material will not enter the body. Hence deposited particulate is primarily considered as a nuisance, and unlikely to represent a health risk.

Suspended particulate matter is dust or aerosol that stays suspended in the atmosphere for significant periods. Particles with a diameter of less than about 10 μm are respirable, and do pose a potential risk to human health, with effects including increases in mortality, aggravation of existing respiratory and cardiovascular disease, increased hospital admissions and increased asthma incidents (NEPC, 1998).

The nomenclature used to describe fractions of suspended particulate are:

- PM_{10} : particulate matter with an average aerodynamic diameter equal to or less than 10 microns (μm) in diameter; and
- TSP: total suspended particulate, generally less than 50 μm in diameter.

Major natural sources of background particulate levels include bush fires, pollen and windblown dust from exposed areas. Anthropogenic sources include stationary and mobile combustion sources, road dust, agriculture, minor, major fires and emissions from industrial processes. Background levels vary widely depending on location, meteorology and proximity of major point or area sources.

2 Project Overview

2.3.2 Oxides of Nitrogen

Oxides of nitrogen (NO_x) are the sum of nitric oxide (NO) and nitrogen dioxide (NO_2), expressed in terms of NO_2 . Elevated levels of NO_2 have been linked to respiratory illnesses (NEPC 1998); however, elevated concentrations of NO have a lesser impact on humans, hence NO_2 is the primary compound assessed in air quality assessments.

Additionally, NO and NO_2 are linked in a circular reaction with oxidants such as ozone which generates NO_2 from NO and sunlight which breaks down NO_2 to NO . Due to this reaction sequence, the exact amount of NO and NO_2 within emissions is often difficult to quantify, consequently the sum of emission of both species is quoted. For the purposes of this assessment, it has been conservatively assumed that all NO_x emissions are emitted as NO_2 .

2.3.3 Sulphur Dioxide

As SO_2 is released into the atmosphere it combines with water within the atmosphere to generate acid rain which acidifies lakes, results in the destruction of forest and damages buildings constructed of limestone. The sulphuric acid may also damage the moist parts of the nose, mouth, pharynx and larger bronchiole (NEPC, 1998). SO_2 is primarily generated through the combustion of sulphur containing fuels such as coal, petrol and diesel. Sulphur is typically found at low levels within fuel requirements to reduce the sulphur content of vehicle fuels will be reduced in the coming years.

2.3.4 Carbon Monoxide

Carbon monoxide (CO) binds more readily with red blood cells than oxygen forming carboxyhaemoglobin (COHb) which deprives the human body of the oxygen needed to function (NEPC 1998). In ambient concentrations found within non-urban environments, carbon monoxide does not generally exist at concentrations which incur an adverse impact on human health.

In high traffic environments where pollutants become trapped within street canyons, such as in congested urban centres CO concentrations are known to build to concentrations which may result in health impacts such as headaches (NEPC 1998).

Carbon monoxide is produced due to the incomplete combustion of any fuel containing carbon, where there is too little oxygen within the mix or the fuel is burnt at too high a temperature. The most common generation of this is in motor vehicles which are driving at low speeds, idling or coasting downhill.

2.3.5 VOC

VOCs are those organic compounds that exert specific physical properties (i.e. vapour pressure) that enable volatilisation and entrainment within the local air environment. VOCs are typically associated with the chemical and fuel handling or production industries, however are also apparent as a product of combustion.

Given the project scope, VOC emissions are limited to fuel handling, which is anticipated to occur at the bulk liquids area. Benzene has been taken as a suitable indicator for VOCs for the purpose of this assessment, given it is generally considered to be the most hazardous VOC associated with hydrocarbon fuel.

2 Project Overview

2.3.6 Odour

An odour is defined as the property of a substance that gives it a characteristic scent or smell. Odours are very subjective, with responses varying greatly from individual to individual. Whilst odour complaints generally occur at concentrations above 5 odour units (OU), whether an odour is perceived as being pleasant or unpleasant, thus eliciting a complaint, is often based on personal opinion.

Regulatory Framework

3.1 General

There are three main types of regulatory criteria relevant to air emissions associated with the project developments. These are:

- **Emission Standards** – which specify maximum allowable in-stack or emission source pollutant concentrations specified for particular industrial activities and plant types;
- **Air Impact Assessment Criteria** – ambient criteria designed for use in air dispersion modelling and air quality impact assessment for new or modified emission sources, and
- **Ambient Air Quality Standards** – regional standards against which ambient air quality monitoring results may be assessed.

3.1.1 Emission Standards

Emission standards generally relate to concentration limits for significant point sources i.e. stacks. No point source discharges are associated with the construction activities hence no emission standards have been referenced. Similarly, no significant point source emissions associated with proposed operational activities have been identified during this investigation, consequently emissions standards are not considered relevant for this assessment.

3.1.2 Air Impact Assessment Criteria

Currently no air impact assessment criteria exist for the Northern Territory; consequently National Ambient Air Quality Criteria have been utilised (as discussed below).

3.1.3 Ambient Air Quality Criteria

Ambient air quality criteria are provided in *National Environmental Protection Measure (Ambient Air Quality)* NEPC (2003), and in *National Environmental Protection Measure (Air Toxics)* NEPC (2004). The guidelines contained in the protection measures are designed for use in assessing regional air quality and are not intended for uses as site boundary or atmospheric dispersion modelling criteria.

As no impact assessment criteria exist for the Northern Territory, these guidelines have been adopted. This is considered a suitable approach, as the NEPC criteria are typically consistent with impact assessment criteria used in other States. **Table 3-1** outlines the compounds of relevance to the proposal and the ambient air concentration guidelines

Table 3-1 Adopted Air Quality Criteria (NEPC 2003 & 2004)

Compound	Averaging Time	Criteria (ppm)	Criteria (µg/m ³)	Reference
Nitrogen Dioxide	1 hour	0.12	246	Ambient Air NEPM
	1 year	0.03	62	Ambient Air NEPM
Sulphur Dioxide	1 hour	0.20	570	Ambient Air NEPM
	1 day	0.08	228	Ambient Air NEPM
	1 year	0.02	60	Ambient Air NEPM
Carbon Monoxide	8 hours	9.0	10,000	Ambient Air NEPM
PM ₁₀	24 hours	-	50	Ambient Air NEPM
Benzene	1 year	0.003	10	Air Toxics NEPM

Existing Environment

4.1 Climate

A number of Bureau of Meteorology (BoM) Automatic Weather Stations (AWS) are located within the local and wider region of the EAW facility, including stations at Darwin Airport, Batchelor Airport, Middle Point Ranges, and Dum in Mirrie Island. For the purposes of this assessment, Darwin Airport (Station No 014015) was chose to represent the climate at the proposed development location. Monthly climatic data for Darwin Airport is presented in **Table 4-1**, with notable measured climatic conditions described below:

- Maximum temperature of 38.9 degrees Celsius;
- Minimum temperature of 10.4 degrees Celsius; and
- A mean annual rainfall of 1712 mm over an average of 112.1 rain days per year, with rain occurring predominantly during the months of the wet season.

4.2 Meteorology

Meteorological conditions for the site and surrounding area have been considered as part of the quantitative assessment. The TAPM (v4) modelling suite has been utilised for creating a site-specific meteorological file for use in dispersion modelling. An assessment of the meteorological data generated is provided in **Appendix A**, and has been compared against real observations measured at Darwin Airport AWS operated by BoM. It is considered that the meteorological data prepares is suitable for incorporation into dispersion modelling.

4.3 Sensitive Receptors

The nearest sensitive receptors have nominated as:

- **Receptor 1:** Government House / Darwin Waterfront (located approximately 5 km from the wharf across the bay); and
- **Receptor 2:** Kormilda College (located approximately 5 – 6km to the northeast of the project area).

These receptors are consistent with previous assessments for facilities in the EAW, e.g. the EAW Quarantine Waste Treatment Facility, GHD (2006).

4 Existing Environment

Table 4-1 Monthly Climate Data for Darwin Airport (BoM, 2010)

Statistic Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann	Start Year	End Year
Mean maximum temperature (° C)	31.8	31.4	31.9	32.7	32	30.6	30.5	31.3	32.5	33.2	33.3	32.6	32	1941	2010
Highest temperature (° C)	35.6	36	36	36.7	36	34.5	34.8	37	37.7	38.9	37.3	37	38.9	1941	2010
Lowest maximum temperature (° C)	25.7	25.6	25.7	24.6	22.7	22.7	21.1	25.1	27.6	24.7	26.2	24	21.1	1941	2010
Mean minimum temperature (° C)	24.8	24.7	24.5	24	22.1	20	19.3	20.4	23	24.9	25.4	25.3	23.2	1941	2010
Lowest temperature (° C)	20.2	17.2	19.2	16	13.8	12.1	10.4	13.2	14.3	19	19.3	19.8	10.4	1941	2010
Highest minimum temperature (° C)	29.3	29.4	29.2	28.3	26.6	25.6	26.6	25.6	27.2	28.8	29.7	29.7	29.7	1941	2010
Mean rainfall (mm)	423.3	365.6	319	100.3	21.1	1.9	1.2	5.1	15.4	68.7	139	250.4	1712.5	1941	2010
Highest rainfall (mm)	940.4	814.5	1013.6	396.2	298.9	50.6	26.6	83.8	129.8	338.7	370.8	664.5	2776.6	1941	2010
Lowest rainfall (mm)	136.1	103.3	88	0.6	0	0	0	0	0	0	17.2	18.8	1024.7	1941	2010
Highest daily rainfall (mm)	290.4	250.2	240.6	142.7	89.6	46.8	19.2	80	70.6	95.5	96.8	277	290.4	1941	2010
Mean number of days of rain	21.3	20.4	19.5	9.2	2.2	0.6	0.5	0.7	2.3	6.5	12.2	16.7	112.1	1941	2010
Mean number of clear days	0.6	0.7	1.9	6.2	12.1	16.3	17.6	19	15.3	9.2	3.6	0.9	103.4	1954	2010
Mean number of cloudy days	24.2	21.6	19.6	11.5	6.5	3.8	3.4	2.6	3.2	5.5	11.5	20.4	133.8	1954	2010
Mean daily evaporation (mm)	6.0	5.7	5.8	6.4	6.8	6.8	6.8	7.2	7.7	8.0	7.4	6.6	6.8	1957	2010
Mean 9am temperature (° C)	28	27.7	27.6	27.4	25.6	23.3	22.8	24.4	27	28.7	29.2	28.8	26.7	1954	2010
Mean 9am wet bulb temperature (° C)	25.5	25.5	25.2	23.9	21.1	18.4	18	19.9	22.8	24.4	25.2	25.6	23	1954	2010
Mean 9am dew point temperature (° C)	24.3	24.5	24.1	22.1	18.2	14.5	14	16.6	20.4	22.2	23.4	24.1	20.7	1954	2010
Mean 9am relative humidity (%)	81	83	82	74	65	60	60	64	68	69	72	76	71	1954	2010
Mean 9am cloud cover (okas)	6.5	6.5	5.7	4.4	3.3	2.7	2.5	2.3	2.9	3.9	5	6	4.3	1954	2010
Mean 9am wind speed (km/h)	11.4	11.1	9	10.5	13.6	14.7	13	10.7	9	8.8	8.7	9.9	10.9	1941	2010
Mean 3pm temperature (° C)	30.2	30	30.5	31.7	31.2	29.9	29.6	30.2	31.2	32	31.9	31.2	30.8	1954	2010
Mean 3pm wet bulb temperature (° C)	26	25.9	25.6	24.2	22.1	20.2	19.8	20.8	22.8	24.5	25.5	25.9	23.6	1954	2010
Mean 3pm dew point temperature (° C)	24	24.2	23.4	20.1	16.4	13	12.3	14	17.8	20.6	22.4	23.6	19.3	1954	2010
Mean 3pm relative humidity (%)	70	72	67	52	43	38	37	40	47	52	58	65	54	1954	2010
Mean 3pm cloud cover (oktas)	6.5	6.5	6	4.8	3.6	2.8	2.4	2.2	2.6	3.3	4.7	5.9	4.3	1954	2010
Mean 3pm wind speed (km/h)	17.8	18.6	16.4	16.5	17	16.2	17.1	19	20.8	19.9	17.7	17.5	17.9	1941	2010

4 Existing Environment

4.4 Background Air Quality

Obtaining monitored background air quality data for the region is necessary to establish existing local air quality to provide an indication of the likely cumulative impacts associated with the project. Background air monitoring data provides an indication of the quality of the existing air environment and the capacity within the local air sheds for future increases associated with new developments. Background air quality monitoring data for the local region has been collected and investigated within a number of studies as follows:

- ***A Pilot Study of Air Quality in Darwin, N.T. for the Northern Territory Government, Department of Lands Planning and Environment (CSIRO 2001).*** This report discusses the results for a pilot study of air quality in Darwin, and was a joint project between the Northern Territory Government Department of Lands Planning and Environment (DLPE), the Northern Territory University (NTU) and CSIRO Atmospheric Research. The aim of the study was to provide an assessment of selected Air NEPM components in the Darwin area from March 2000 to October 2000. The study involve measurements of PM₁₀, airborne lead within PM₁₀, NO₂, SO₂ and ozone, at select locations in Berrimah and the NTU Casuarina campus.
- ***Summary Report Darwin LNG Project – Environmental Monitoring Studies and Results for Annual Reporting Period 23 June 2004 to 22 June 2005 (URS 2005).*** This report provides baseline air quality monitoring data necessary to meet commitments in the Public Environmental Report (PER) for the approvals process of the Darwin LNG Project. The baseline data collection involved the collection of ambient air concentrations of SO₂, NO_x, and meteorological conditions within the Darwin CBD and on the Middle Arm Peninsula.
- ***Annual Compliance Report for the Northern Territory 1 January – 31 December 2006, Ambient Air NEPM Report to the National Environment Protection Council (NRETAS 2006)***
- ***Annual Compliance Report for the Northern Territory 1 January – 31 December 2007, Ambient Air NEPM Report to the National Environment Protection Council (NRETAS 2007)***
- ***Annual Compliance Report for the Northern Territory 1 January – 31 December 2008, Ambient Air NEPM Report to the National Environment Protection Council (NRETAS 2008).*** These reports discuss monitoring data collected during 2006, 2007, 2008 and an assessment of compliance with the Ambient Air NEPM. Particulate matter monitoring data collected and summated for the Casuarina location.
- ***Darwin LNG Plant – 2008 Ambient Air Monitoring Programme (URS 2008).*** This report summates ambient air monitoring undertaken by URS Australia Pty Ltd on behalf of ConocoPhillips to meet licence requirements for the operating Darwin LNG plant. As with the baseline assessment the monitoring involved the measurement of SO₂, NO_x and meteorological parameters at two locations.
- ***Ichthys Gas Field Development Project – Onshore Air Quality Study (SKM 2010).*** This report provides an onshore air quality assessment for the Inpex EIS. The baseline air quality data presented within the study was based on modelled predictions rather than measured data for NO_x, SO₂ and ozone.

Figure 1 (refer to figures section) shows the location of referenced monitoring locations in relation to the project area.

4 Existing Environment

4.4.1 Particulate Matter

Particulate matter measurements undertaken and summarised in CSIRO (2001) were taken using a tapered element oscillating mass balance (TEOM) at the CSIRO site in Berrimah. Gravimetric mass and airborne PM₁₀ loadings were also determined using filter collections. The study provides the following information:

- PM₁₀ mass loadings were typically less than 10 ug/m³ during the wet season, and increased to around 20 ug/m³ in the dry season.
- Smokey periods were also observed that resulted in PM₁₀ concentrations exceeding the NPEM standard of 50 ug/m³ over a 24 hour period, with a maximum 24 hour PM₁₀ loading of 70 ug/m³ being recorded.

Further particulate monitoring conducted in 2006 – 2008 (NRETAS, 2006, 2007 & 2008) utilising both a TEOM (measuring PM₁₀) sampler and a Partisol Dichotomous sampler (measuring PM₁₀ and PM_{2.5}) provided the following information:

- No recordings of PM₁₀ above 50 ug/m³ for the measurements obtained at Casuarina in 2006, with a highest PM₁₀ reading of 44.1 ug/m³ (over a 24 hour period);
- No recording of PM₁₀ above 50 ug/m³ for the measurements obtained at Casuarina in 2007, with a highest PM₁₀ reading of 45.3 ug/m³ (over a 24 hour period);
- One recording of PM₁₀ above 50 ug/m³ for the measurements obtained at Casuarina in 2008, of 64.8 ug/m³;

Elevated particulate matter levels were often associated with bushfires or firework displays. **Table 4-2** summarises particulate matter monitoring for the Casuarina monitoring station in 2007 and 2008.

Table 4-2 PM₁₀ Monitoring for CDU Casuarina Campus 2007 and 2008

Year	Maximum	Percentiles					
		99 th	98 th	95 th	90 th	75 th	50 th
2008 ¹	64.8	40.6	37.8	33	27.3	19	14
2007 ²	45.3	38.4	32.2	27.8	24.1	18.6	11.9

Notes: All units in ug/m³, and over a 24 hour averaging period

¹ Sourced from NRETAS (2008)

² Sourced from NRETAS (2007)

In this study, the 95th percentile PM₁₀ concentration (33 ug/m³) has been adopted as the background level for the assessment of cumulative impacts. This percentile has been applied given the impacts associated with bushfire and firework events as described above.

4.4.2 Oxides of Nitrogen

NO_x monitoring has been undertaken as part of the environmental studies conducted for the ConocoPhillips Darwin LNG Facility. URS (2005) presents baseline monitoring data of Nitrogen Oxides with subsequent monitoring being presented in URS (2008). These studies provided concentration data for two locations: the Darwin CBD and Middle Arm Peninsula.

URS (2005) presented the following results for the dry season in 2004:

- Maximum 1 hour average NO₂ levels in Darwin CBD were observed to vary between 11 – 71 ug/m³;
- Maximum 1 hour average NO₂ levels at the Middle Arm Peninsula ranged from 2 – 34 ug/m³;

4 Existing Environment

URS (2005) also presented the following results for the wet season in 2005:

- Existing maximum 1 hour average NO₂ levels in Darwin CBD were observed to vary between 2 – 34 ug/m³
- Maximum ambient 1 hour average NO₂ levels at Middle Arm Peninsula ranged from 1 – 16 ug/m³

Subsequent monitoring conducted presented in URS (2008) is detailed below:

- Maximum 1 hour average NO₂ levels in Darwin CBD during the wet season were between 1 – 46 ug/m³, as compared with levels at the Middle Arm Peninsula between 1 – 22 ug/m³;
- Maximum 1 hour average NO₂ levels in Darwin CBD during the dry season were between 6 – 138 ug/m³, as compared with levels at the Middle Arm Peninsula between 4 – 85 ug/m³;

SKM (2010) reported modelled baseline NO₂ concentrations of 56 ug/m³ and 4 ug/m³ for averaging periods of 1 hour and 1 year respectively. These values are lower than the maximum measured concentrations reported in other studies, and so have not been incorporated into this assessment. As a conservative approach the maximum measured 1 hour concentration of NO₂ (138 ug/m³) has been adopted as the background level for the assessment of cumulative impacts.

4.4.3 Sulphur Dioxide

SO₂ monitoring was also presented within URS (2005) and URS (2008). As with the NO_x monitoring, the SO₂ monitoring station was situated in the Darwin CBD and at the Middle Arm Peninsula.

URS (2005) presented the following results for the dry season in 2004:

- Maximum 1 hour average SO₂ levels in Darwin CBD were observed to vary between 0 – 42 ug/m³;
- Maximum 1 hour average SO₂ levels at the Middle Arm Peninsula ranged from 0 – 8 ug/m³;

URS (2005) also presented the following results for the wet season in 2005:

- Existing maximum 1 hour average SO₂ levels in Darwin CBD were observed to vary between 0 – 41 ug/m³;
- Maximum ambient 1 hour average SO₂ levels at Middle Arm Peninsula ranged from 0 – 5 ug/m³.

Subsequent monitoring conducted presented in URS (2008) is detailed below:

- Maximum 1 hour average SO₂ levels in Darwin CBD during the wet season were between 0 – 415 ug/m³, as compared with levels at the Middle Arm Peninsula between 2 – 23 ug/m³;
- Maximum 1 hour average SO₂ levels in Darwin CBD during the dry season were between 1 – 71 ug/m³, as compared with levels at the Middle Arm Peninsula between 4 – 34 ug/m³;

URS (2008) suggests that *"In general, SO₂ concentrations were extremely low and not of concern. The one very high, short term event that registered 72.6% of the NEPM hourly standard was very much atypical of both the wet and dry season for both monitoring locations, and was most probably caused by an idling diesel service truck parked close to the wharf air monitoring station sampling inlet"*. The second highest SO₂ reading has therefore been utilised as the background level for the assessment of cumulative impacts.

SKM (2010) reported modelled baseline SO₂ concentrations of 26 ug/m³, 16 ug/m³ and 5 ug/m³ for averaging periods of 1 hour, 24 hours and 1 year respectively. These values differ (some higher, some lower) than values measured in the URS studies; however the values are of a similar order of magnitude, suggesting the background values adopted in this assessment are suitable.

4 Existing Environment

4.5 Summary of Background / Baseline Air Quality Data

As discussed, the background air quality concentrations of assessable air pollutants are generally present at low concentrations, which are within the NEPM criteria. A summary of the adopted background concentrations for use in dispersion modelling follows:

- PM₁₀ concentration of 33 ug/m³, 95th percentile, NRETAS(2008), for averaging period of 24 hours;
- NO₂ concentration of 138 ug/m³, URS(2008), for averaging period of 1 hour;
- NO₂ concentration of 9.7 ug/m³, for an annual averaging period, which was adopted from an average of 24 hour (averaged) concentrations reported in URS(2008) (Fort hill Wharf location in the dry season),;
- SO₂ concentration of 42 ug/m³, URS (2005), for averaging period of 1 hour;
- SO₂ concentration of 9 ug/m³, for averaging period of 24 hours, which was adopted from the maximum 24 hour concentration reported in URS(2008) (Fort Hill Wharf location during the dry season). As noted previously the atypical value was disregarded; and
- SO₂ concentration of 2.4 ug/m³, URS (2008), for an annual averaging period., which was adopted from the average of 24 hour concentrations reported in URS(2008) (Fort Hill Wharf location, during the dry season).

Qualitative Assessment of Air Quality Impacts

The potential for adverse air quality impacts associated with the Project is dependent upon the intensity, frequency and proximity of activities to sensitive receptors.

This assessment has been performed by qualitatively considering the following characteristics of activities associated with the Project:

- Emission source potential;
- Frequency and duration of emissive activities; and
- Proximity of emissive activities to sensitive receptors.

A risk-based approach has been applied to each development area and construction activity, with consideration to the above items, to provide a risk rating (low, medium or high) in terms of their potential for air quality impacts. The risk rating is determined by considering the likelihood and the consequences of air quality impacts associated with each area activity, as demonstrated in the table below.

	Consequences		
Likelihood	Major	Moderate	Minor
<i>Likely</i>	High	High	Med
<i>Possible</i>	High	Med	Low
<i>Unlikely</i>	Med	Low	Low

Those areas deemed of higher risk have then been carried on for further consideration.

Table 5-1 provides the qualitative assessment of activities during the construction phase of the project and are primarily associated with emissions of particulate matter. **Table 5-2** provides the qualitative assessment of operational phase emissions.

5 Qualitative Assessment of Air Quality Impacts

Table 5-1 Qualitative Assessment of Construction Phase

Project Area	Activity and Source	Likelihood	Consequences	Risk
Barge ramp facility	Bund Construction	Unlikely	Minor	Low
	Delivery of Imported fill (phyllite)	Possible	Moderate	Medium
	Further Bund Construction	Unlikely	Minor	Low
	Armouring of bund slopes	Unlikely	Minor	Low
	Inner area filling with imported fill	Medium	Moderate	Medium
	Concrete barge construction	Unlikely	Minor	Low
	Road sealing	Unlikely	Minor	Low
	Dredging	Possible	Moderate	Medium
Marine supply base	Dredging	Possible	Moderate	Medium
	Drive steel piles	Unlikely	Minor	Low
	Construction of reinforced concrete decks	Possible	Moderate	Medium
	Fitting of fenders and bollards	Unlikely	Minor	Low
	Service provision	Unlikely	Minor	Low
Tug and Small Vessel Moorings	Dredging	Possible	Moderate	Medium
	Drive steel piles to locate pontoons	Unlikely	Minor	Low
	Erect fixed walkway	Unlikely	Minor	Low
	Installation of prefabricated pontoons	Unlikely	Minor	Low
	Installation of ramps	Unlikely	Minor	Low
Railway Loop	Remove the mud on the route of the loop	Unlikely	Minor	Low
	Dump earth fill to form the bund core	Possible	Moderate	Medium
	Provide rock armour to the seaward slopes	Unlikely	Minor	Low
	Provide riprap to the inner slopes	Unlikely	Minor	Low
Dredged Spoil Ponds	Remove the mud at the location of the bund walls	Possible	Minor	Low
	Dump earth fill to form the bund core	Possible	Moderate	Medium
	Provide rock armour to the seaward slopes	Unlikely	Minor	Low
	Provide riprap to the inner slopes	Unlikely	Minor	Low

5 Qualitative Assessment of Air Quality Impacts

Table 5-2 Qualitative Assessment of Operational Phase

Project Area	Activity and Source	Likelihood	Consequences	Risk
Barge ramp facility	Combustion emissions from vessels	Possible	Moderate	Medium
	VOC emissions from vessel refuelling	Unlikely	Low	Low
Marine supply base	Combustion emissions from vessels	Possible	Moderate	Medium
	VOC emissions from vessel refuelling	Unlikely	Low	Low
	Marine vessel repair	Possible	Low	Low
Tug and Small Vessel Moorings	Combustion emissions from vessels	Possible	Moderate	Medium
	VOC emissions from vessel refuelling	Unlikely	Low	Low
Railway Loop	Particulate Matter Releases from dry bulk trade	Likely	Moderate	High
	Combustion emissions from vessels	Likely	Moderate	High
Future Operations	Increase in combustion emissions from vessels	Possible	Moderate	Medium
	Odour releases from increase in livestock trade	Possible	Moderate	Medium
	VOC emissions from increase in bulk liquids trade	Possible	Moderate	Medium

5 Qualitative Assessment of Air Quality Impacts

5.1 Construction Phase

The initial qualitative assessment of the construction phase of the project has established that the following activities present the greatest risk in terms of air quality impacts:

- Dredging – specifically where large amounts of material are used for reclamation purposes and are de-watered, stored and used on site; and
- Material handling – specifically the delivery, handling and use of fill material (i.e. sand, gravel etc)

Current estimates on material and equipment use of significance in terms of particulate matter releases include the following:

- Small to medium size Cutter Suction Dredge. Dredge volumes of 62,000 m³, 750,000 m³, and 159,000 m³ for the barge ramp facility, marine supply base, and small vessel mooring areas respectively. All unsuitable dredged spoil is anticipated to be disposed offshore. Up to 300,000 m³ maybe suitable for reclamation, and would require de-watering for reclamation purposes;
- Road trains delivering fill and rock. Approximately 1,000,000 m³ of material (dredged sand or gravel) is required to fill the reclamation ponds with additional ‘topping up’ of land sourced fill.
- Operation of bulldozers within construction areas.

Given the potential for adverse air quality impacts associated with the large volumes of material handled by the activities, a quantitative assessment was undertaken. This has been conducted and is provided in **Chapter 6**.

5.2 Operational Phase

The initial qualitative assessment of the operational phase of the project has established that the following activities present the greatest risk in terms of air quality impacts:

- The increase in the trade of dry bulk material which is incorporated within the additional open storage areas (manganese and iron ore) and enclosed storage areas (copper concentrate and phosphate). These operations would contribute to particulate matter (and nuisance dust) releases;
- Combustion emissions associated with the increase in vessels to the wharf. These emissions would be primarily associated with large Panamax-size vessels (iron ore bulk carriers).

The potential air quality impacts associated with these activities has indicated that a quantitative assessment be undertaken. This has been conducted and provided in **Chapter 6**.

Future expansions to the wharf area, not directly associated with proposed activities within this EIS, namely:

- The increase in bulk liquid trade, and potential VOC emissions; and
- The increase in livestock trade, and potential odorous emissions;

Have been assessed using a qualitative approach and is further discussed below.

5.2.1 Odour Impacts from Livestock

Potential odour impacts from an increase in the livestock trade to the East Arm Wharf have been qualitatively assessed through a literature review. HGM (2002) provided a Buffer Definition Study for Fremantle Inner Harbour which incorporated the results of Odour impacts associated with livestock facilities at the Fremantle ports. The study provided the following results:

5 Qualitative Assessment of Air Quality Impacts

- Odour concentrations from 4 – 11 Odour Units (OU) were apparent at a distance of approximately 400 – 500 m from the operational Berths. Higher concentrations (i.e. 11 OU) were apparent when multiple Berths were in operation; and
- The facilities received 133 livestock ships in 1999 handling 553,000 t of livestock and feed;

Based on the above results and given that the nearest sensitive receivers to the East Arm Wharf are approximately 4 – 5 km from the site, and that predicted livestock forecasts are approximately 300,000 t/a, it is expected that adverse odour impacts are unlikely. However odour impacts should be considered in further detail when further expansion (incorporating livestock area) is considered.

5.2.2 VOC Emissions from Bulk Liquid Facilities

Potential VOC impacts from an increase in the bulk liquid facilities have also been qualitative assessed through a literature review. SKM (2007) provided an Air Quality Impact Assessment of a Bulk Liquids Berth at Botany, NSW. The study summated VOC impacts as follows:

- “Benzene impacts are anticipated to be in the order of 0.0094 mg/m³” (at the site boundary); and
- The nearest sensitive receptor was approximately 800 – 900 m from the assessed site.

The above results, suggest the predicted peak values of benzene to be present at concentrations approximately equal to the benzene criteria of 0.003 ppm (NEPC 2004). On the basis that the nearest sensitive receivers to the East Arm Wharf are approximately 4 -5 km from the site, elevated concentrations of benzene and other VOCs from this operation are unlikely. Further considerations to the bulk liquids facilities should however, be considered in future wharf expansions not covered within this study.

Quantitative Assessment of Air Quality Impacts

6.1 Approach

This section provides a summary of the emission estimations and dispersion modelling conducted for activities identified as having the potential for adverse air quality impact. Three scenarios were identified as requiring quantitative assessment, as follows:

- Scenario 1 – Particulate matter impacts associated with construction activities;
- Scenario 2 – Particulate matter impacts associated with operation of the expanded bulk solids area; and
- Scenario 3 – Combustion product impacts associated with ships at berth.

6.2 Emission Estimation

Emission estimations have been established through the use of available published emission factor data. Where lack of published information is available or uncertainties exist, conservative assumptions have been made. This section outlines the emission estimates for relevant pollutants for the scenarios considered.

6.2.1 Construction

Particulate matter emissions during construction have been established using the *National Pollutant Inventory Emission Estimation Technique Manual for Mining* (NPI, 2001). Specifically, emission estimates have been established for the following:

- Operation of two bulldozers within construction area;
- Delivery of fill for reclamation purposes; and
- Wind erosion of stored, dredged, de-watered material

Emissions from dredging and disposal offshore have been considered negligible given that they would exhibit high moisture contents limiting particulate matter releases. Only emissions from de-watered materials have been included.

Table 6-1 below summarises the emission factors and activity data adopted in conjunction with the calculated emission rates for sources considered during construction.

Table 6-1 Emission Inventory for Construction

Activity / Source	Emission Factor		Activity Data ²		Emission Rate	
	PM ₁₀	Units	Value	Units	PM ₁₀	Units
Bulldozer operating in construction area ¹	4	kg/h	-	-	1.11	g/s
Bulldozer operating in construction area ¹	4	kg/h	-	-	1.11	g/s
Delivery of fill for reclamation ²	0.0043	kg/t	1,500,000	t	2.05 x 10 ⁻⁷	g/s
Wind erosion of exposed surfaces ³	0.4	kg/ha/h	1.5	ha	0.17	g/s

Notes: ¹ Default emission factor for bulldozers operating on material other than coal adopted

² Default emission factor for trucks dumping overburden, assuming 1,000,000 m³ material with a density of 1,500 kg/m³ being delivered over 6 months (5 days per week, 10 hrs per day)

³ Default emission factor for Wind erosion assuming 1.5 ha exposed

6 Quantitative Assessment of Air Quality Impacts

6.2.2 Bulk Solid Transfer – During Operation

Particulate matter emissions from the bulk solids expansion have been established using the *National Pollutant Inventory Emission Estimation Technique Manual for Mining* (NPI, 2001). Specifically emission estimates have been established for the following;

- Transfer of bulk solid material from rail wagons to dump hoppers;
- Transfer of material from conveyors to open storage stockpiles;
- Reclamation of material from storage stockpiles;
- Transfer of material to export vessels; and
- Wind erosion of open area stockpiles.

At the time of this assessment, actual layouts and detailed design are unknown, thus appropriate assumptions have been made, as follows:

- Emissions from conveyors have been considered as covered or adequately controlled, negating any potential particulate matter emissions.
- Emissions from concentrates (within enclosed areas) have been considered negligible. Whilst emissions from concentrates are of prime concern in terms of air quality, the controls (i.e. complete enclosure) are typically enforced for these material types to limit potential releases.
- The emission factor equation adopted for miscellaneous transfer points is provided as Equation 1 below, whilst a generic emission factor has been adopted for wind erosion of stockpiles.

$$E = k \times 0.0016 \left(\frac{U}{2.2} \right)^{1.3} \left(\frac{M}{2} \right)^{-1.4} \quad \text{Equation 1}$$

Where k (PM_{10} fraction) = 0.35;

U (mean wind speed in m/s) = 2.88 m/s (Annual TAPM generated wind speed – refer **Appendix A**);

M (material moisture content) = 2 % (Assumed)

Table 6-2 below summarises the emission factors and activity data adopted in conjunction with the calculated emission rates for sources considered.

Table 6-2 Emission Inventory for Dry Bulk Facilities

Activity / Source	Emission Factor		Activity Data		Emission Rate	
	PM_{10}	Units	Value	Units	PM_{10}	Units
Transfer of material from rail wagons to dump hoppers ¹	0.002	kg/t	10	Mt/a	0.67	g/s
Transfer of material to open storage area ¹	0.002	kg/t	10	Mt/a	0.67	g/s
Reclamation of material from open storage area ¹	0.002	kg/t	10	Mt/a	0.67	g/s
Transfer of material to vessels ¹	0.002	kg/t	10	Mt/a	0.67	g/s
Wind erosion of open storage area ²	0.4	kg/ha/h	1.8 10	ha/Mt Mt/a	0.2	g/s

Notes: ¹Emission factors for transfer points adopted from Equation 1 above with 10 Mtpa adopted from 'most likely' dry bulk forecast – EAW Masterplan 2030 (GHD 2010).

² Default emission factor for wind erosion adopted, with Average area for new stockpiles per throughput is 1.8 ha/MT – EAW Masterplan 2030 (GHD 2010)

6 Quantitative Assessment of Air Quality Impacts

6.2.3 Combustion Emissions – Ships at Berth during Operation

Emissions from combustion sources associated with marine vessels at berth (during operation) have been adopted from the California Environmental Protection Agency, Air Resources Board – *Emissions Estimation Methodology for Ocean-Going Vessels* (ARB 2005). Specifically emission estimates have been established for the following:

- Combustion of heavy fuel oil in the auxiliary engine of a bulk cargo vessel at berth;
- Combustion of heavy fuel oil in the auxiliary engine of a container vessel at berth;

The use of heavy fuel oil has been adopted, however. It is understood that some vessels operate on gas (lower emissions compared with diesel oil) or power (no emissions), whilst marine diesel oil would also typically be used. Emission estimates from auxiliary engines operating on heavy fuel oil have been compiled using **Equation 2**.

$$E_i = EF_i \times P \quad \text{Equation 2}$$

Where E_i = Emissions from pollutant i (g/hr)

EF_i = Emission factor for compound i (g/kW-hr)

P = Auxiliary power (kW-hr)

Table 6-3 below summarises the emission factors and activity data adopted in conjunction with the calculated emission rates for sources considered.

Table 6-3 Emission Inventory for Marine Vessels at Berth

Compound	Emission Factor		Emission Rate	
	Value	Units	Value	Units
Auxiliary Engines – Bulk Cargo Vessel at Berth				
NO _x	14.7	g/kW-hr	7.3	g/s
SO _x	12.3	g/kW-hr	6.1	g/s
Auxiliary Boilers – Container Vessel at Berth				
NO _x	14.7	g/kW-hr	27.8	g/s
SO _x	12.3	g/kW-hr	23.2	g/s

Notes: Bulk Cargo vessel engine size of 1776 kW (ARB 2005) adopted.
Container vessel engine size of 6800 kW (ARB 2005) adopted

Marine vessel emission estimations have only been considered as a preliminary approach. Further consideration to combustion emissions should be conducted through the life of the expansion, as exact vessel numbers and berth requirements become apparent.

6.3 Dispersion Modelling

Predictive dispersion modelling was completed using AUSPLUME (v6.0) utilising the following input parameters

- Constant emissions rates as tabulated previously for the three scenarios considered;
- TAPM (v4) generated meteorological data as described within **Appendix A**
- No inclusion of terrain data or terrain effects. Given the relatively flat topography of the port, terrain effects have been ignored.

6 Quantitative Assessment of Air Quality Impacts

- All sources for Scenario 1 (construction) and Scenario 2 (dry bulk operations) have been included as volume sources;
- Grid size of 100 m with 2 sensitive receptors;
- Scenario 3 (ships at Berth) incorporated the use of two stack sources, one auxiliary engine associated with a bulk cargo vessel and one associated with a container vessel. Stack parameters are unknown and have been adopted from ARB (2002) and outlined in **Table 6-4** below.

Table 6-4 Adopted Stack Parameters for Vessels at Berth

Parameter	Value	Unit
Auxiliary Engine Stack		
Height	37.6	m
Diameter	2	m
Temperature	222	Deg C
Exit Velocity	25.8	m/s

6.3.1 Dispersion Modelling Results

Results from the dispersion modelling conducted for all three scenarios are provided in **Table 6-5**. All results are presented in incremental and cumulative concentrations and concentrations at receptors are below the adopted criteria.

Table 6-5 Predicted Incremental and Cumulative Air Quality Impacts

Compound and Averaging Time	Background (ug/m³)	Receptor 1		Receptor 2		Criteria (ug/m³)
		Incremental¹ (ug/m³)	Cumulative² (ug/m³)	Incremental¹ (ug/m³)	Cumulative² (ug/m³)	
Scenario 1 – Construction						
PM₁₀ 24 hours	33	9.1	42.1	7.0	40.0	50
Scenario 2 – Operation – Dry Bulk Facilities						
PM₁₀ 24 hours	33	13.6	46.6	6.7	39.7	50
Scenario 3 – Operation – Vessels at Berth						
NO₂ 1 hour	138	40.2	178.2	16.0	154	246
NO₂ Annual	9.7	1.2	10.9	0.1	9.8	62
SO₂ 1 hour	42	33.6	75.6	13.4	55.4	570
SO₂ 24 hours	9	9.4	18.4	1.3	10.3	228
SO₂ Annual	2.4	1.0	3.4	0.1	2.5	60

Notes:

1 Incremental refers to the peak predicted impact from the source only.

2 Cumulative refers to the incremental impact combined with background ambient air concentrations.

Mitigation Measures

Whilst air quality impacts from construction activities are likely to be minor, the development should be undertaken to minimise the release of air pollutants, specifically particulate matter. The construction phase of the project would incorporate the following mitigation measures to minimise impacts associated with particulate matter releases:

- A detailed Air Quality Management Plan (AQMP), including a monitoring program would be developed and implemented. The AQMP would formulate a part of the Construction Environmental Management Plan (CEMP);
- The AQMP would also include a dust management plan, which would incorporate:
 - Monitoring of dust generating activities and the effectiveness of control measures being implemented through regular inspections, and the use of dust measurement instruments, where appropriate.
 - Control measures to be implemented. This may include wet suppression through stabilising agents or water vehicles, wind break walls and other erosion control techniques.
 - Vehicle control measures. This may include minimising vehicle speeds and movements on unsealed roads, the use of water sprays on vehicle access paths, and wheel wash areas.
 - A vegetation and soil erosion control plan incorporating erosion protection measures.
 - A dredging and dredge spoil disposal management plan which would incorporate mitigation measures for controlling particulate matter releases particularly with any dewatered and stored spoil.

Mitigation measures for the operational areas anticipated for the expanded wharf areas should be assessed during the approvals process for these areas. Mitigation measures should give consideration to:

- The partial or complete enclosure of conveyors transferring dry bulk material from the open storage area to the vessel loading area;
- The partial or complete enclosure of material transfer points from conveyors to vessels and from train unloading areas (understood to be a bottom discharge facility);
- Specific control measures for the concentrate loading and operation facilities. The storage area is understood to be completely enclosed, and any material transfer points should also adequately capture particulate matter releases; and
- Stockpile management plans, incorporating particulate matter control measures (i.e. wet suppression).

Conclusions

A qualitative and quantitative air quality assessment has been undertaken for the construction phase and operational phase of the East Arm Wharf expansion project. The outcomes of the air quality assessment demonstrated that:

- The majority of activities undertaken during the construction and operational phases of the project are likely to result in negligible or minor and localised air quality impacts;
- Construction activities identified to have the potential to cause particulate matter releases comprise material handling operations;
- Operational activities identified to have the potential to cause particulate matter releases comprise the 'dry' bulk material handling facilities;
- Based on a dispersion modelling of identified construction and operational activities with the potential to result in elevated concentrations of air pollutants (PM₁₀, SO₂ and NO_x) the proposed releases are not likely to impact on the nearest sensitive receptors.

It is the conclusion of this assessment that through effective management and mitigation measures, potential adverse impacts from construction activities upon air quality is minor.

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Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Northern Territory Department of Lands and Planning and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 4 August 2010.

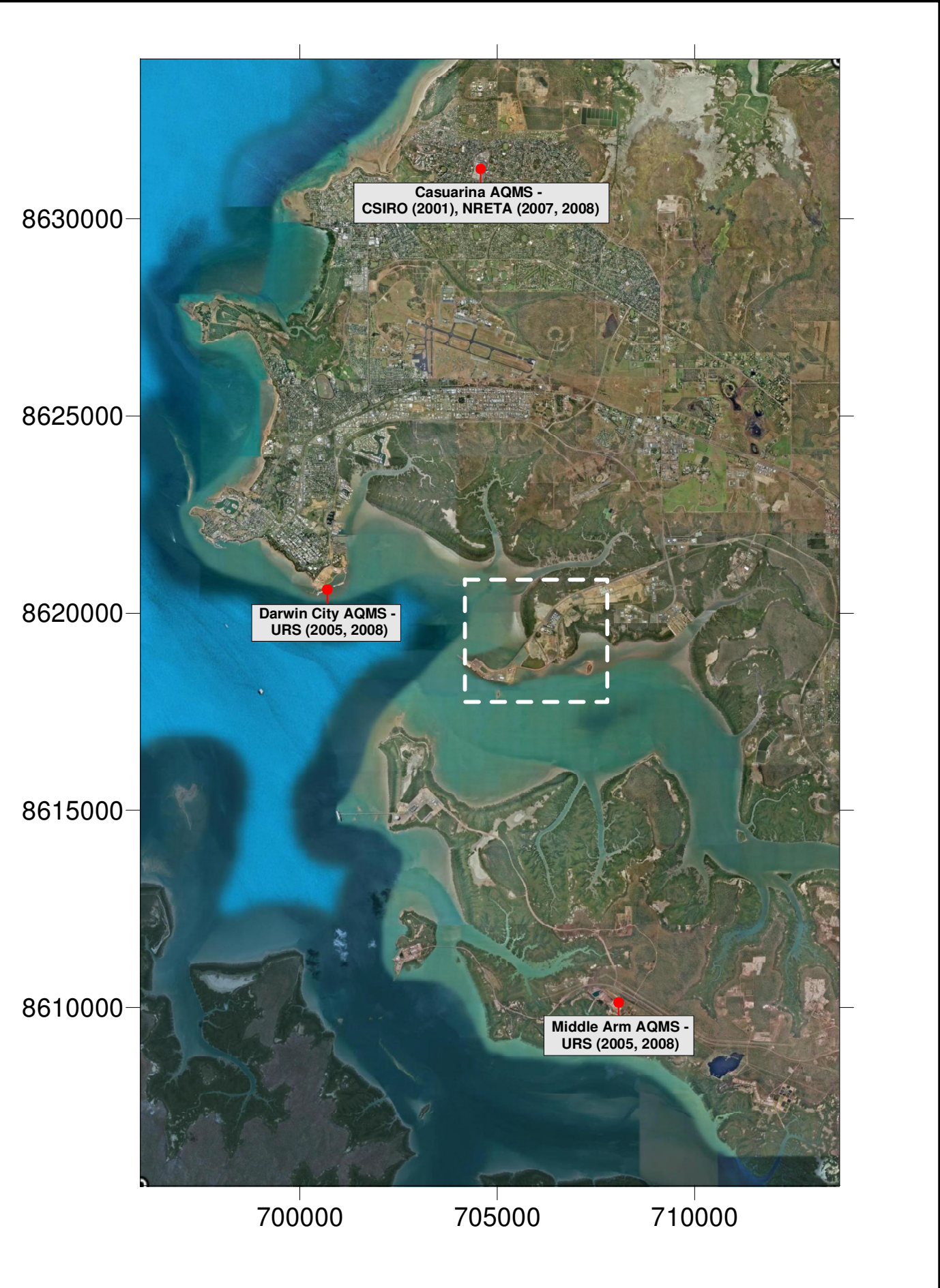
The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between November 2010 and February 2011 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Figures

Figure 1 Ambient Air Sample Locations



Client: NT Department of Lands and Planning		Project: Air Quality Impact Assessment - East Arm Expansion			Title: Location of Referenced Air Quality Monitoring Station (AQMS)	
						
		Drawn: RW	Approved: DRAFT	Date: 16/9/2010	Figure: 1	
		Job No: 42214003	File: Figure 1 - AQMS Locations.srf			
						Rev: A
						A4

Appendix A Meteorological Data Discussion

A.1 Assessment of Meteorological Data

The meteorological data needed for dispersion modelling is required to be site representative. The nearest weather station was found to be the Darwin Airport Automatic Weather Station (AWS), operated by the Bureau of Meteorology (BoM) located approximately 9 km from the EAW (the Site). Meteorological data from BoM weather stations is typically not viable for use in dispersion analysis, given the type of instrumentation often used at these monitoring sites especially in reporting of calm (i.e. low wind speed) conditions. Given this and the distance from the Site, local meteorological data was not sought for modelling purposes. Rather, URS adopted the approach of using The Air Pollution Model (TAPM) to conduct meteorological predictions for the local area, and to provide meteorological inputs into the dispersion model AUSPLUME. Meteorological data for 2008 was compiled, and the methodology for establishing meteorological parameters and model input and output parameters is further discussed in the following sections. For comparative purposes, wind rose diagrams for data obtained from the nearest BoM Station (Darwin Airport) have compiled and are provided as **Figure A-1**.

A.2 Meteorological Modelling

A.2.1 The Air Pollution Model (TAPM)

TAPM (v4) was run to calculate meteorological fields for the modelling domain. Through a number of verification studies (e.g. CSIRO 2005), TAPM has been identified as a suitable model to simulate meteorological fields in a number of situations.

TAPM is an incompressible, non-hydrostatic, primitive equation model with a terrain-following vertical co-ordinate for three-dimensional simulations. It includes parameterisations for cloud/rain micro-physical processes, turbulence closure, urban/vegetative canopy and soil, and radiative fluxes.

TAPM, with the use of the input databases provided by CSIRO, was used to generate a meteorological dataset for the year 2008 based on actual synoptic data. **Table A-1** details TAPM settings and input files that were used to generate the meteorological file for the site (Default options were selected, except where noted otherwise). **Figure A-2** provides windrose diagrams for a nominated location from the TAPM meteorological output files.

Table A-1: Input parameters used for TAPM

Parameter	Value
Grid centre coordinates	12 degrees, 27.5 minutes latitude (South) 130 degrees, 55.5 minutes longitude (East)
Grid Nests	Meteorological grid consisting of four nests of 25 x 25 grid points at 30,10,3, and 1 km
Terrain and Landuse	Terrain at 9 arc second (approximately 270 m) resolution from the Geoscience Australia terrain database. Land characterisation data at approximately 1 km resolution, sourced from the US geological Survey, Earth Resources Observation System (EROS) Data Centre Distributed Active Archive Centre (EDC DAAC). Sea surface temperate data at 100 km grid intervals from the US National Centre for Atmospheric Research (NCA);
Synoptic Scale Meteorology	Six hourly synoptic scale meteorology from the BoM on a 75 to 100 km grid. This data is derived from the BoM LAPS (Limited Area Prediction System) output
Virtual Metrological Stations Used for Data Assimilation	No Data Assimilation Used

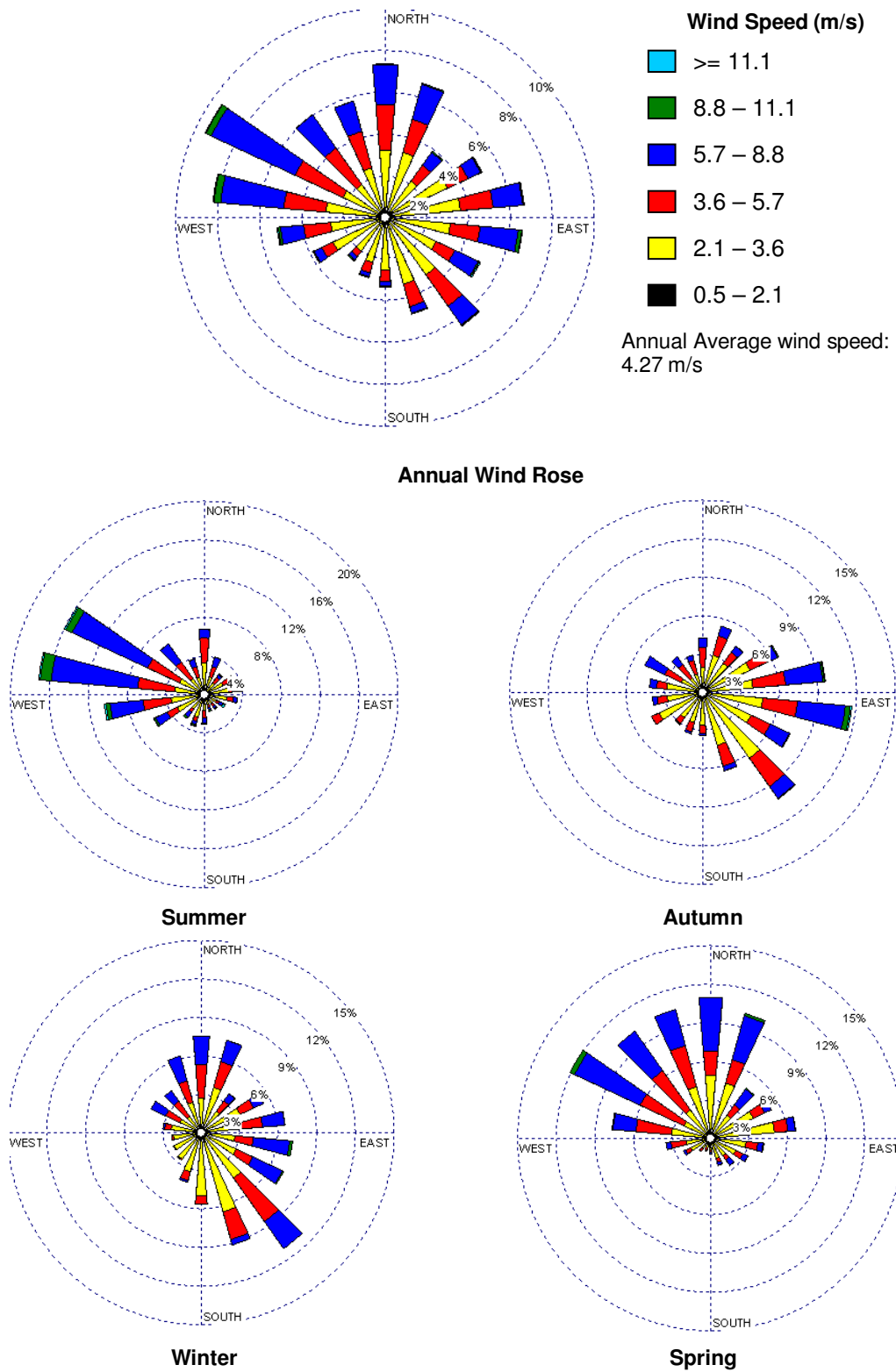


Figure A-1: Annual Windrose generated from data for Darwin Airport AWS, 2009 (BoM 2009)

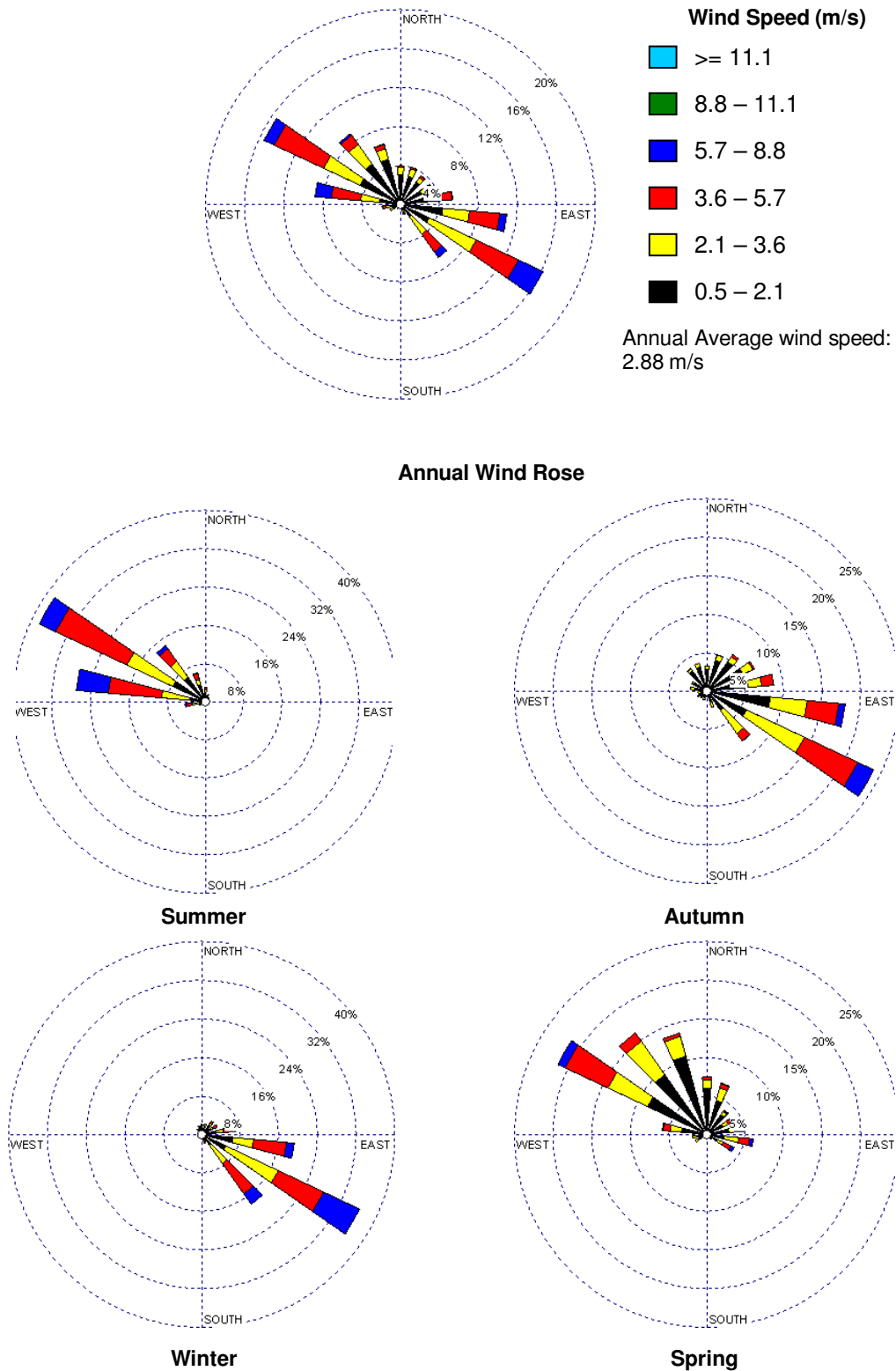


Figure A-2: Annual and Seasonal Windroses generated for the Site using TAPM, 2008

A comparison of the TAPM wind roses generally shows similar dominant wind directions to the measured BoM data (at Darwin Airport), however the TAPM generated data for Winter shows a smaller fraction of northerly winds than would be expected.

A.3 Mixing Height

Figure A-3 shows the Mixing Height (m) vs Time of Day (Hour) generated from the TAPM outputted meteorological data at the development site for 2008. The figure shows that the predicted mixing height increases with increasing solar radiation as a function of time of day. This is consistent with general atmospheric processes that show increased vertical mixing during the daytime associated with the increasing thermal radiation. Night time conditions are cooler, more stable and, as expected, winds are generally lighter thus vertical mixing is reduced leading to a lower mixing height.

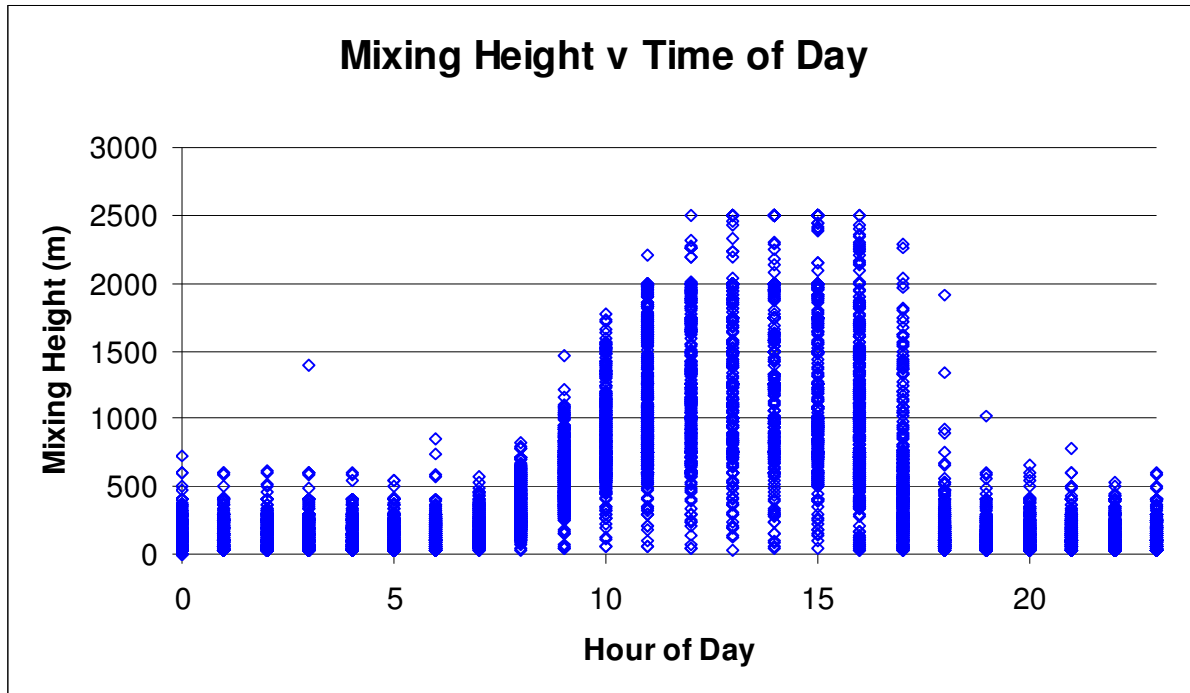


Figure A-3: Mixing Height (m) vs Time of Day (Hour of Day) of TAPM generated data

A.4 Atmospheric Stability

Stability class is used as an indicator of atmospheric turbulence for use in meteorological models. The class of atmospheric stability generally used in these types of assessments is based on the Pasquill-Gifford-Turner scheme where six categories are used (A to F) which represent atmospheric stability from extremely unstable to moderately stable conditions. The stability class of the atmosphere is based on three main characteristics, these being:

- Static stability (vertical temperature profile/structure);
- Convective turbulence (caused by radiative heating of the ground); and
- Mechanical turbulence (caused by surface roughness).

The Pasquill Gifford Stability classes are provided in **Table A-2**.

The stability classes for the site have been extracted from a generated meteorological file and are shown in **Table A-3**.

Table A-2 Modified Pasquill-Gifford Stability Classes (adapted from Turner, 1994)

Surface Wind Speed at 10m (m/s)	Insolation			Night-time cloud (Oktas)	
	Strong	Moderate	Slight	Thinly overcast of > 4/8 low cloud	< 3/8 Cloud
≤ 2	A	A-B	B	-	-
2 - 3	A-B	B	C	E	F
3 - 5	B	B-C	C	D	E
5 - 6	C	C-D	D	D	D
> 6	C	D	D	D	D

Notes:- : Generally referred to as strongly stable conditions.

The Pasquill Gifford Stability Classes, shown in **Table A-3** shows neutral atmospheric conditions (Stability Class D) is the most prevalent Stability Class of the area, with the extreme stability classes, namely Extremely Unstable (Stability Class A) being the least prevalent.

Table A-3 Site Representative Pasquill-Gifford Stability Classes

Stability Class	% of year
A (Extremely Unstable)	2.3 %
B (Moderately Unstable)	11.1 %
C (Slightly Unstable)	22.1 %
D (neutral)	33.7 %
E (Slightly Stable)	15.6 %
F (Moderately Stable)	15.2 %

In addition to their composition, Stability Classes were also predicted for the site as a function of time of day, as shown in **Figure A-4**. As expected, the Stability Classes show a tendency for the unstable classes (Stability Classes A, B and C) to occur during daytime, whilst the more stable conditions (Stability Classes D, E and F) are shown to occur primarily during night time. This is consistent with the values contained in **Table A-2**.

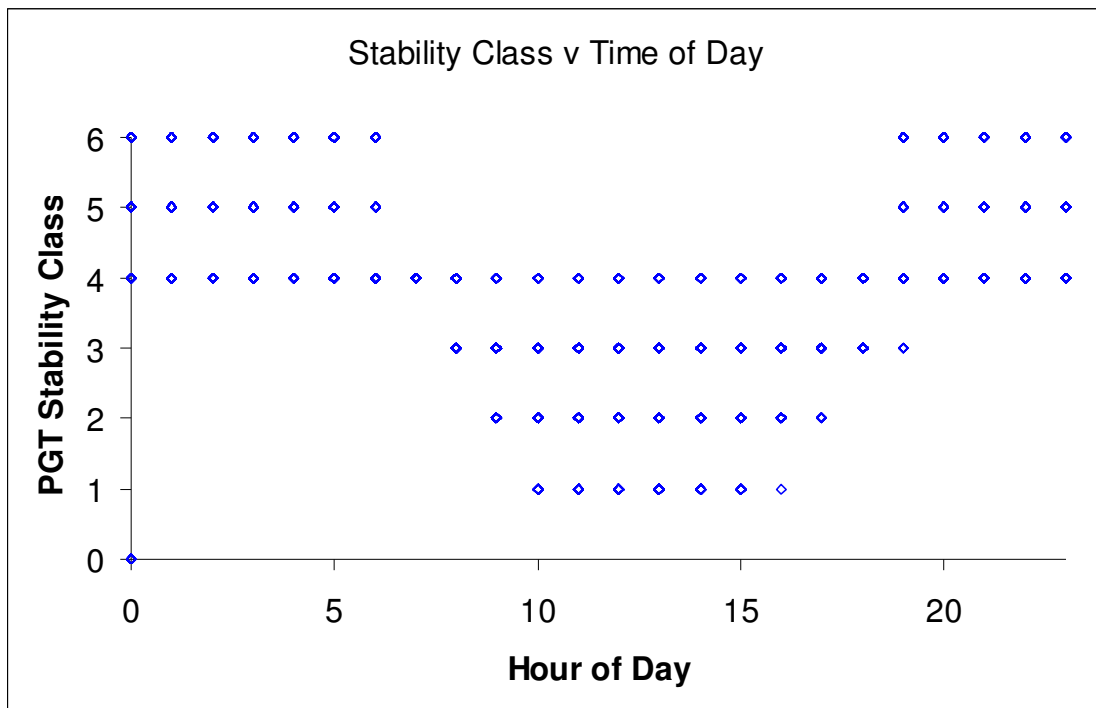


Figure A-4 Stability Class vs Time of Day

Stability Classes were also measured against wind speed, as shown in **Figure A-5**. As expected, the highest wind speeds are associated with Stability Classes C and D. The more unstable conditions (Stability Classes A and B) are associated with lower wind speeds, as it is under low winds (coupled with stronger solar insolation) where thermal turbulence is able to dominate. The more stable conditions (Stability Classes E and F) are also associated with low wind speeds. These data are consistent with the values contained in **Table A-2**.

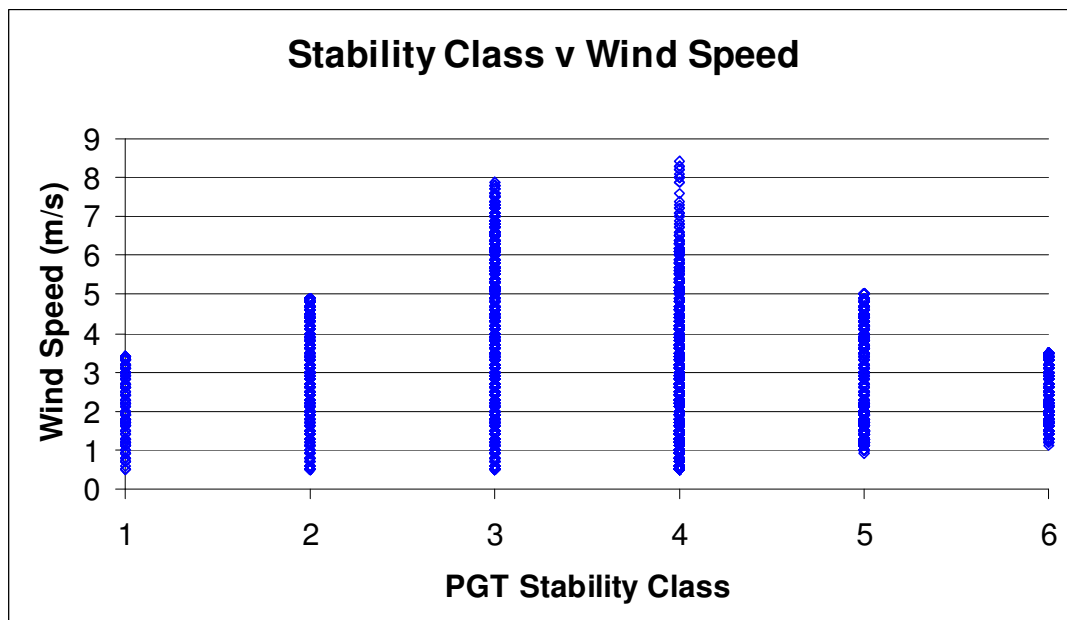


Figure A-5 Stability Class vs Wind Speed

A.5 Conclusion

Where site specific dispersion meteorological data may not be site representative, as is the case for the site, the predicted meteorological data used in the dispersion modelling is required to be representative of the surrounding area. It is accepted standard Australian practice, that in situations where adequate site-specific meteorological data does not exist, TAPM is used to synthetically generate meteorological data. TAPM is a sophisticated, 3D meteorological model that has been extensively validated.

The assessment of the predicted meteorology at the proposed development site was discussed and was shown to be consistent with general atmospheric parameters. It is therefore considered that the meteorological data used in dispersion modelling is appropriate.



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