SINCLAIR KNIGHT MERZ

SKM

Oakajee Port Development

DUST MODELLING

- Rev 3
- 10 June 2010

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LIMITATIONS STATEMENT

The sole purpose of this report and the associated services performed by Sinclair Knight Merz ('SKM') is to provide air quality modelling in connection with the proposed port development at Oakajee. The services were provided in accordance with the scope of services set out in the contract between SKM and the Client. That scope of services, as described in this report, was developed with the Client.

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EXECUTIVE SUMMARY

Oakajee Port is a proposed deep water port development approximately 24 km north of Geraldton. This development includes a train unloading facility, a multi user stockyard with stacking and reclaiming operations, a lump rescreening plant and a shiploading facility. The port has a nominal throughput of 45 Mtpa of iron ore. Sinclair Knight Merz (SKM) was requested to conduct a dust assessment of iron ore operations for the purpose of obtaining regulatory approval.

The proposed port development in Oakajee has the potential to impact on local sensitive receptors in and around the Geraldton region. This report estimates and quantifies potential air quality impacts based on proposed operations for the port.

For the purposes of this assessment, the following criteria are used for comparison to the modelled concentrations of dust:

- 50 $\mu g/m^3$ for PM_{10} as a maximum 24-hour average at residential and rural receptors (based on NEPM PM_{10} Standard) as determined at all sensitive receptors
- 150 $\mu g/m^3$ (24-hour average) and 260 $\mu g/m^3$ (24-hour average never to be exceeded) for TSP within the industrial estate (based on Kwinana EPP Area A Standard)
- 90 $\mu g/m^3$ (24-hour average) and 260 $\mu g/m^3$ (24-hour average never to be exceeded) for TSP within the buffer zone (based on Kwinana EPP Area B Standard)
- 90 $\mu g/m^3$ (24-hour average) and 150 $\mu g/m^3$ (24-hour average never to be exceeded) for TSP at residential and rural receptors outside the buffer zone (based on Kwinana EPP Area C Standard)
- 2 g/m^2/month maximum increase in total dust deposition (based on NSW EPA Dust Deposition Standard) as determined at all sensitive receptor locations.

Sensitive receptors are defined in this assessment as individuals, communities, or components of the environment which could be adversely affected by dust emissions, such as dwellings, schools, hospitals, offices, protected wetlands or public recreation areas that currently exist. For this assessment, background data have been sourced from the DEC monitoring station in Geraldton. The data indicate summer and autumn are the times of year when the Geraldton region has its highest dust concentrations. It is possible that wind erosion from local sand dunes and areas exposed by land clearing and pastoral activities are the main causes of existing dust in the region.

The dust modelling assessment utilised the July 2007 to June 2008 meteorological dataset, consistent with that used in the Oakajee Industrial Estate Buffer Assessment (Air Assessments 2009). As this assessment is on a facility not yet constructed, dust emissions have been calculated using established estimation methodologies from the Dampier Port 145 Mtpa Environmental Protection Statement (SKM 2007) hereafter referred to as the Dampier 145 EPS. Wind erosion (stockpile and open area) produces the highest emission rates, with maximum wind erosion emissions an order of magnitude larger than any other emission source.

Air quality impacts from the proposed port development at Oakajee have been assessed using the Victorian EPA’s AUSPLUME (Version 6.0) computer dispersion model, which is one of the primary air dispersion models used for assessing air quality impacts from industrial sites within Australia.

The model results show existing dust concentrations across the region are large compared to any predicted impact from Port operations.

The model predictions show the small contribution expected from operations at points distant (greater than 4 km) to the Port. Locations closer to operations will experience a higher impact, though these points are shown to still be dominated by existing dust concentrations. Quantification of dust from operations (in monitoring programs for example) will need to take background dust concentrations into account when determining dust contributions from Port emissions across the region.

24-hour average concentrations meet the specified criteria, with the exception of small zones in the industrial estate and buffer zone. However, the background data show periods where the 1-hour (or smaller) concentrations are high, especially during high winds. Given it is likely these events are caused by local wind erosion, it is likely that wind erosion from site will contribute further to these high short term events. For this reason, it is recommended that application of temporary controls (such as chemical suppressants and extra water trucks) be ready at all times, especially during summer and autumn months.

Further emission reduction protocols that could be considered include:

- Minimising and re-vegetation of unused open areas. As well as preventing surface erosion, re-vegetation helps to reduce surface wind speed and thus erosion of surrounding areas.

- Open areas such as lay-down and machinery maintenance areas should be packed with lump or gravel material to reduce wind erosion. This has the effect of reducing exposure of particulates that are susceptible to eroding winds and wheel movements. Depending on availability and suitability, lump material of a suitable size is used on some sites.
- Use advanced meteorological forecasting to develop a proactive approach to dust management and reduction.
- Ongoing education and awareness of all site personnel in regard to responsibilities for control and reporting of dust emissions. Appropriate reporting and response procedures should be established and deployed.

CONTENTS

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1. INTRODUCTION

1.1 Project Background and Overview

Oakajee Port is a proposed deep water port development approximately 24 km north of Geraldton (see **Figure 1-1**). This development includes a train unloading facility, a multi user stockyard with stacking and reclaiming operations, a lump rescreening plant and a shiploading facility. The port has a nominal throughput of 45 Mtpa of iron ore. Sinclair Knight Merz (SKM) was requested to conduct a dust assessment of iron ore operations for the purpose of obtaining regulatory approval.

1.2 Overview of this Report

The proposed port development in Oakajee has the potential to impact on local sensitive receptors in and around the Geraldton region. This report estimates and quantifies potential air quality impacts based on proposed operations for the port. The primary pollutant of concern from the development is the dust arising from material handling of iron ore at the port. The major sources include:

- stacking, reclaiming and miscellaneous port operations
- wind erosion
- vehicles and wheel generated dust.

This report focuses on particulate with an aerodynamic diameter 10 microns or less (PM_{10}) and total suspended particulate (TSP) emissions to estimate dust concentrations and deposition.

The report is structured as follows:

- a review of air quality standards and criteria (**Section 2**)
- analysis of local meteorological and environmental conditions (**Section 3**)
- estimation of dust emissions from proposed site operations (**Section 4**)
- discussion on model inputs and model methodology (**Section 5**)
- model results and conclusions (**Sections 6** and **7**).

Figure 1-1 Regional Map

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2. AIR QUALITY CRITERIA

A discussion of ambient air quality guidelines and those relevant to Oakajee Port is provided below.

2.1 PM_{10}

PM_{10} is defined as particulate matter with an aerodynamic diameter of 10 microns or less.

2.1.1 National Environmental Protection Measure (NEPM)

The National Environment Protection Measure (NEPM) for Ambient Air Quality provides a set of ambient air standards for six pollutants, (CO, NO_2, O_3, SO_2, Lead, Particulates as PM_{10}). Of these only PM_{10} was considered in the scope of this study as the others are deemed to be emitted in insignificant quantities from the proposed port operations. The NEPM standards are designed to protect human health and as such apply primarily to sensitive receptors such as residences, hospitals, schools and other places where people may congregate including sporting and recreational venues. The applicable standards for PM_{10} are provided in **Table 2-1**. The Environmental Protection Authority (EPA) proposes to incorporate the NEPM standards in a State Environmental Policy (SEP) which would apply across all areas of WA excluding industrial areas and residence free buffer zones (Government of Western Australia 2009).

Table 2-1 National Environment Protection Measure Standards and Goals for PM_{10}

Pollutant	Averaging Period	Maximum Concentration (µg/m^3)	Maximum allowable exceedences
Particles as PM_{10}	1 day	50	5 days per year

2.1.2 PM_{10} Human Health Impacts

The health effect of particulates in the PM_{10} range is mainly the exacerbation of respiratory problems. The population that is most susceptible includes the elderly, people with existing respiratory and/or cardiovascular problems and children (USEPA 2006). Larger particles, approximately greater than 10 µm in diameter, generally adhere to the mucus in the nose, mouth, pharynx and larger bronchi and can be removed by swallowing or clearing of the mouth or lungs.

2.2 Total Suspended Particulate

Total Suspended Particulate (TSP) for this assessment is defined as airborne particulate with an aerodynamic diameter 50 microns or less.

2.2.1 Western Australian Department of Environment and Conservation

The only legislated dust criteria for Western Australia are those prescribed in the Kwinana Environmental Protection Policy (EPP) (WA EPA 1999). The EPP specifies air quality Standards and Limits for TSP, expressed as a 24 hour average, within the Kwinana Industrial Area (Area A), an intermediate buffer zone area (Area B) and surrounding residential areas (Area C). The EPP defines a Standard as a concentration that is desirable not to be exceeded, and a Limit as the concentration that is not to be exceeded. The EPP Standards and Limits are listed in **Table 2-2**.

In addition to the 24-hour Standards, the Kwinana EPP also outlines a short-term (15-minute average) limit of 1,000 $\mu g/m^3$ for very short term dust events. This limit was originally established to control nuisance-causing dust from stock holding paddocks.

Table 2-2 Total suspended particulate standards and limits for the Kwinana policy area

Species	Area	Averaging Period	Standard[1] ($\mu g/m^3$)	Limit ($\mu g/m^3$)
Particles	A,B,C	15-minute	-	1,000
	A	24-hour	150	260
	B	24-hour	90	260
	C	24-hour	90	150

Notes:

Area A:	the area of land on which heavy industry is located
Area B:	the area surrounding industry designated as buffer zone, plus other outlying land zoned for industrial use
Area C:	land beyond areas A and B used predominantly for rural and residential purposes.

This assessment applies the Area A criteria within the strategic and general industrial zones (shaded orange in **Figure 2-1**), Area B outside the industrial estate within the buffer zone (shaded green in **Figure 2-1**), and Area C outside the buffer zone (shaded yellow in **Figure 2-1**). The coastal zone has not been assigned a zone for this assessment, due the expectation that only the port will be operating within this zone. The Kwinana EPP standard (desirable to be met) is compared to model results in **Section 6**. The short term limit is not considered in this assessment.

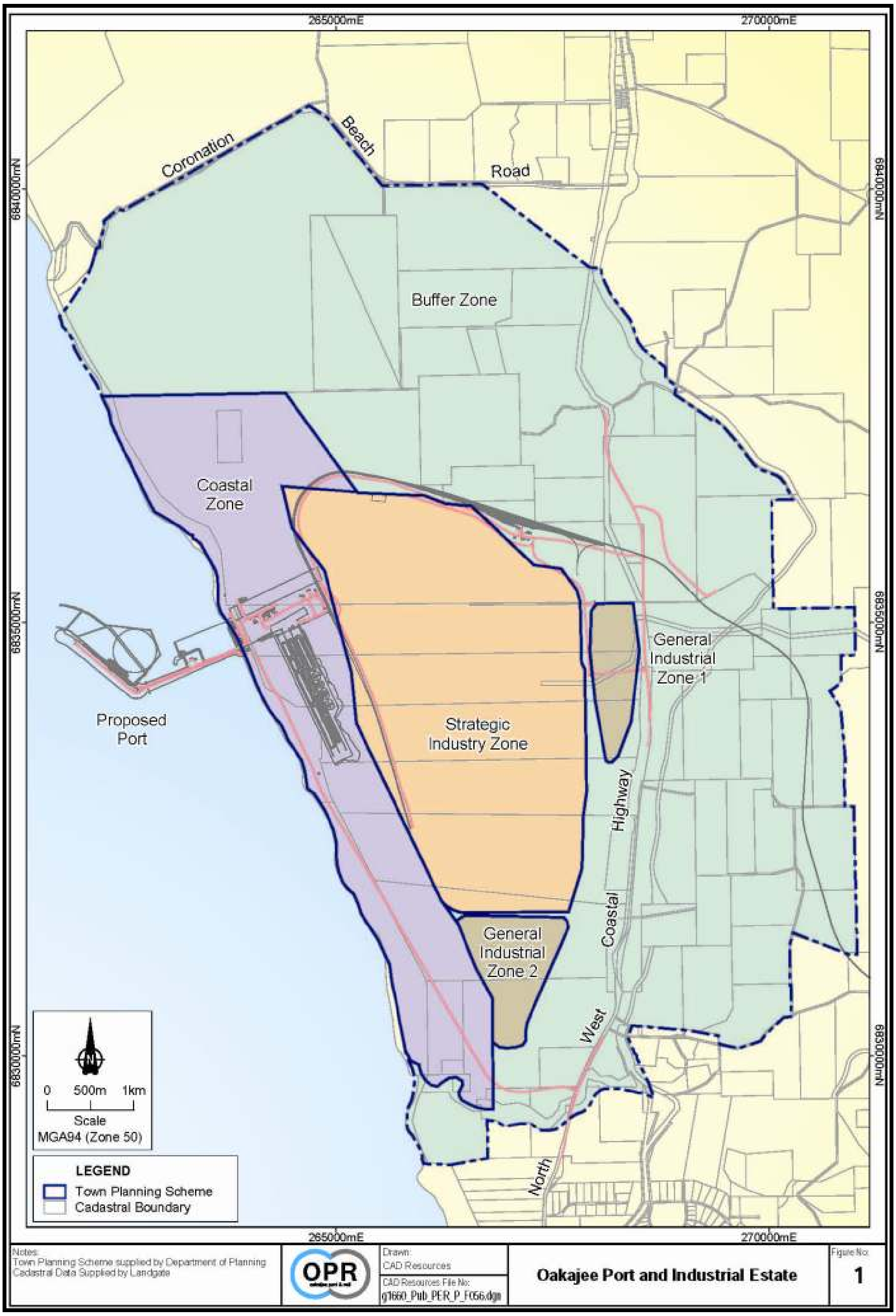


Figure 2-1 Oakajee Port Industrial and Buffer Zones

2.2.2 TSP Amenity Impacts

Particulate matter can affect amenity by reducing visibility. Deposition of particulate matter on fabrics (such as laundry), house roofs and movement of dust into water tanks can also occur, potentially generating community concern. The deposition of larger particles can also cause aesthetic or chemical contamination of water bodies or vegetation. This can lead to forest and farm crop damage and the reduction in diversity of ecosystems and effects on personal comfort, amenity and health (USEPA 2006).

2.3 Dust Deposition

Currently there is no criteria for dust deposition within Western Australia, however an impact assessment criteria does exist in NSW (NSW EPA 2005). The criteria states that the maximum allowable increase from background contributions in deposited dust is 2 g/m^2/month with a total allowable maximum of 4 g/m^2/month. In the absence of Western Australian specific criteria, the NSW criteria for allowable increases have been used in this assessment. For this assessment, the deposition criterion is also applied within the industrial estate and buffer zone.

2.4 Criteria Used in this Assessment

For the purposes of this assessment, the following criteria are used for comparison to the modelled concentrations of dust:

- 50 μg/m^3 for PM_{10} as a maximum 24-hour average at residential and rural receptors (based on NEPM PM_{10} Standard) as determined at all sensitive receptors (as defined in **Section 5.5.2**)

- 150 μg/m^3 (24-hour average) and 260 μg/m^3 (24-hour average never to be exceeded) for TSP within the industrial estate (based on Kwinana EPP Area A Standard)

- 90 μg/m^3 (24-hour average) and 260 μg/m^3 (24-hour average never to be exceeded) for TSP within the buffer zone (based on Kwinana EPP Area B Standard)

- 90 μg/m^3 (24-hour average) and 150 μg/m^3 (24-hour average never to be exceeded) for TSP at residential and rural receptors outside the buffer zone (based on Kwinana EPP Area C Standard)

- 2 g/m^2/month maximum increase in total dust deposition (based on NSW EPA Dust Deposition Standard) as determined at all sensitive receptor locations (**Section 5.5.2**).

3. EXISTING ENVIRONMENT

3.1 Climate

3.1.1 Overview

Oakajee is a coastal region approximately 24 km north of Geraldton, Western Australia. Characterised by hot dry summers and mild wet winters, the area is influenced by a high pressure band called the sub-tropical ridge, and during warmer months, a low pressure system known as the ‘West Coast Trough’ extending from the tropics (BoM 2008a).

The meteorological data used for modelling in this assessment is the July 2007 to June 2008 dataset used in the Oakajee Industrial Estate Buffer Assessment (Air Assessments 2009). This dataset was derived using wind speed, direction and temperature data from the Oakajee meteorology station (verified against multiple meteorology data sources in the region), stability class calculated using the Turner method (USEPA 2000) with cloud data sourced from the Bureau of Meteorology (BoM) measurements at Geraldton airport, and mixing heights predicted from CALMET using a temperature profile generated from TAPM. The meteorological analysis and model setup used to derive meteorology for this assessment is detailed further in **Appendix A**. Long term rainfall, temperature and humidity data used in this assessment was obtained from BoM Geraldton airport station online records (BoM 2008b).

3.1.2 Wind

The seasonal wind roses for the 2007/2008 dataset are presented in **Figure 3-1** to **Figure 3-4** and show that a dominant southerly wind occurs in the spring and summer months. Summer and autumn also demonstrate strong easterlies, though these are infrequent in summer. There is very little wind from the north throughout the year.

Wind speeds in the region are shown to be consistently high throughout most of the year with southerly winds consistently greater than 5.7 m/s. The wind roses also indicate easterly winds often exceed 11.1 m/s. Under these conditions, wind erosion will be a high risk for dust emissions.

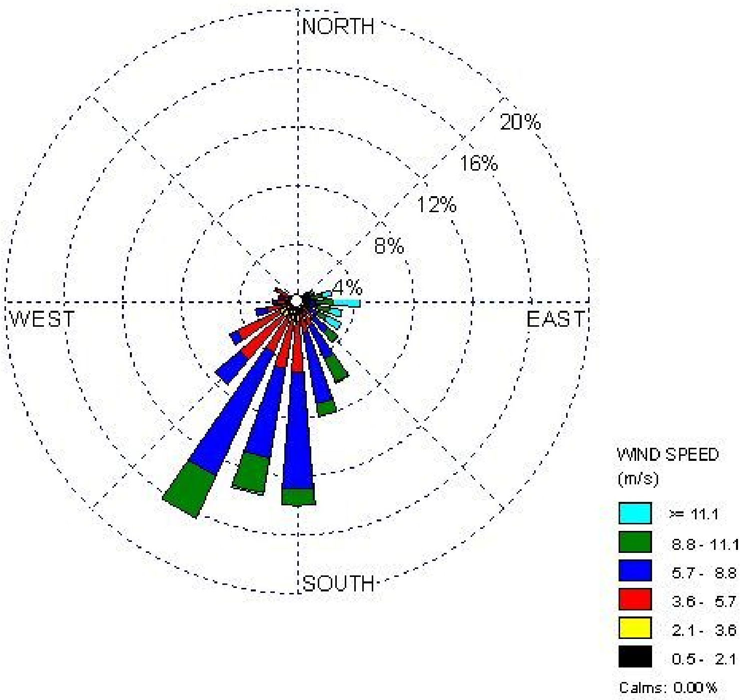


Figure 3-1 Summer (Dec – Feb) wind rose 2007/2008

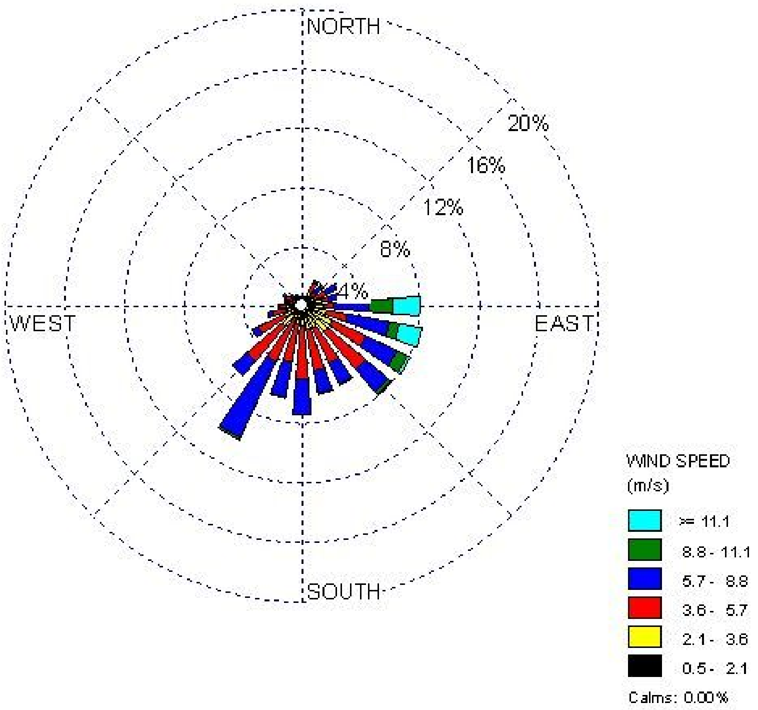
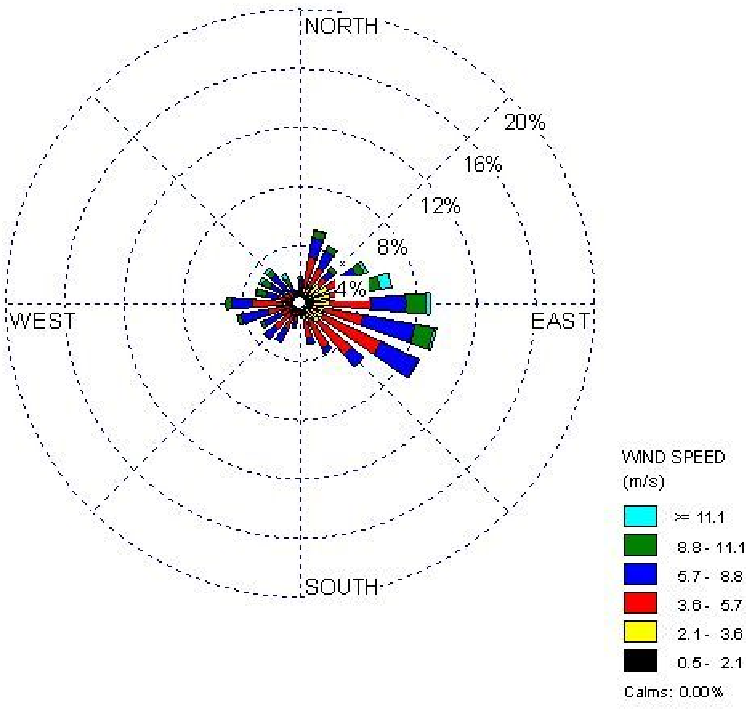


Figure 3-2 Autumn (Mar – May) wind rose 2007/2008



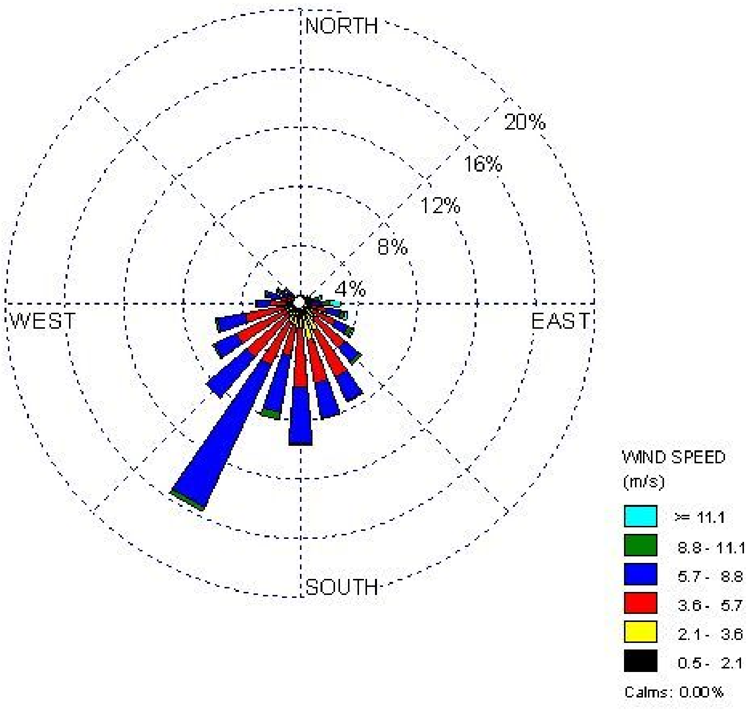


Figure 3-3 Winter (Jun – Aug) wind rose 2007/2008

Figure 3-4 Spring (Sep – Nov) wind rose 2007/2008

3.1.3 Rainfall

Rainfall in Geraldton is limited mostly to mid year between May and August with very little rainfall occurring between late spring and early autumn. This is confirmed in **Figure 3-5** which shows the mean rainfall and highest recorded rainfall measured between 1941 to 2008 (BoM 2008b). The mean number of days with rain greater than or equal to 1 mm is presented in **Table 3-1**. The low average rainfall in the region means that dry deposition will be the major form of dust deposition from port operations.

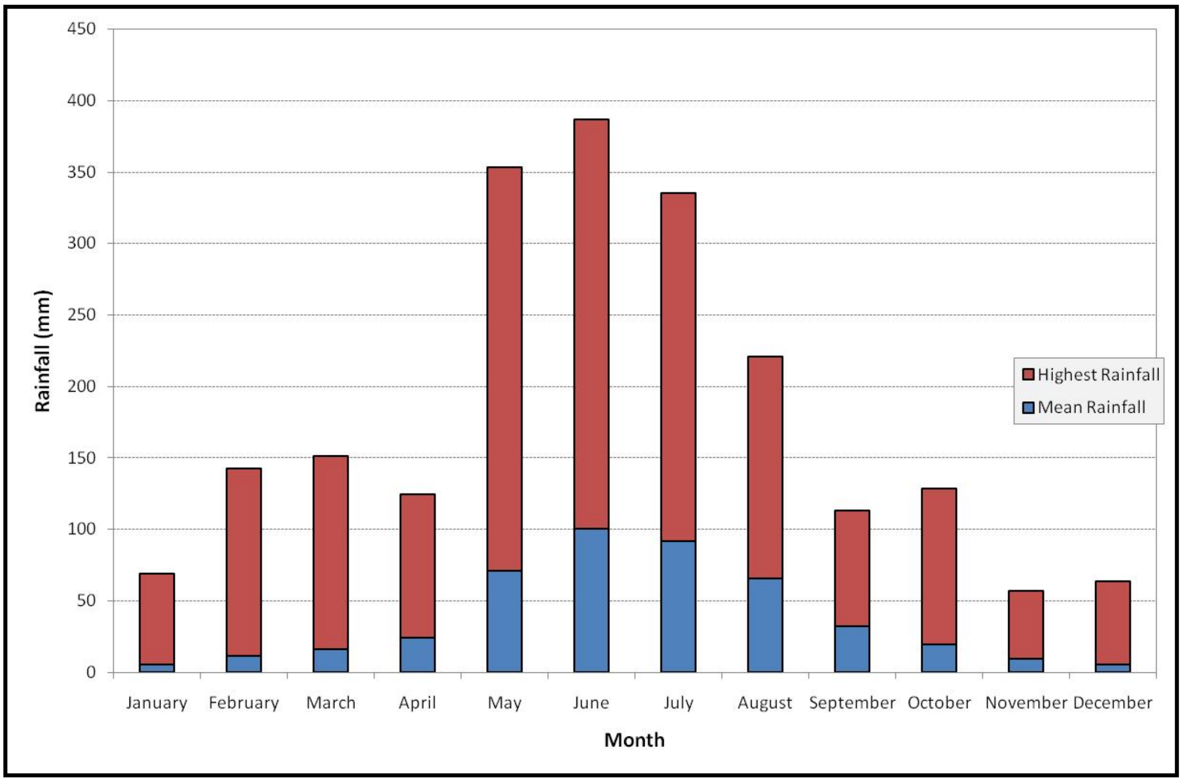


Figure 3-5 Seasonal rainfall data for Geraldton (BoM 2008b)

Table 3-1 Mean number of days of rain greater than or equal to 1 mm.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No. Days	0.8	1.2	1.6	4	7.7	10.7	11.4	9	6.3	4.1	2.1	1.1

3.1.4 Temperature

The long term monthly temperatures for the Geraldton region are presented in **Figure 3-6**. This figure contains the average monthly maxima and minima as well as the highest and lowest temperature recorded between 1941 to 2007 From this figure it can be seen that the average temperatures in Geraldton range from 16 °C to 32 °C during summer, with maximums of up to 47 °C recorded. During winter the temperature can vary from 9 °C through to 19 °C, with minimum temperatures just above 0 °C.

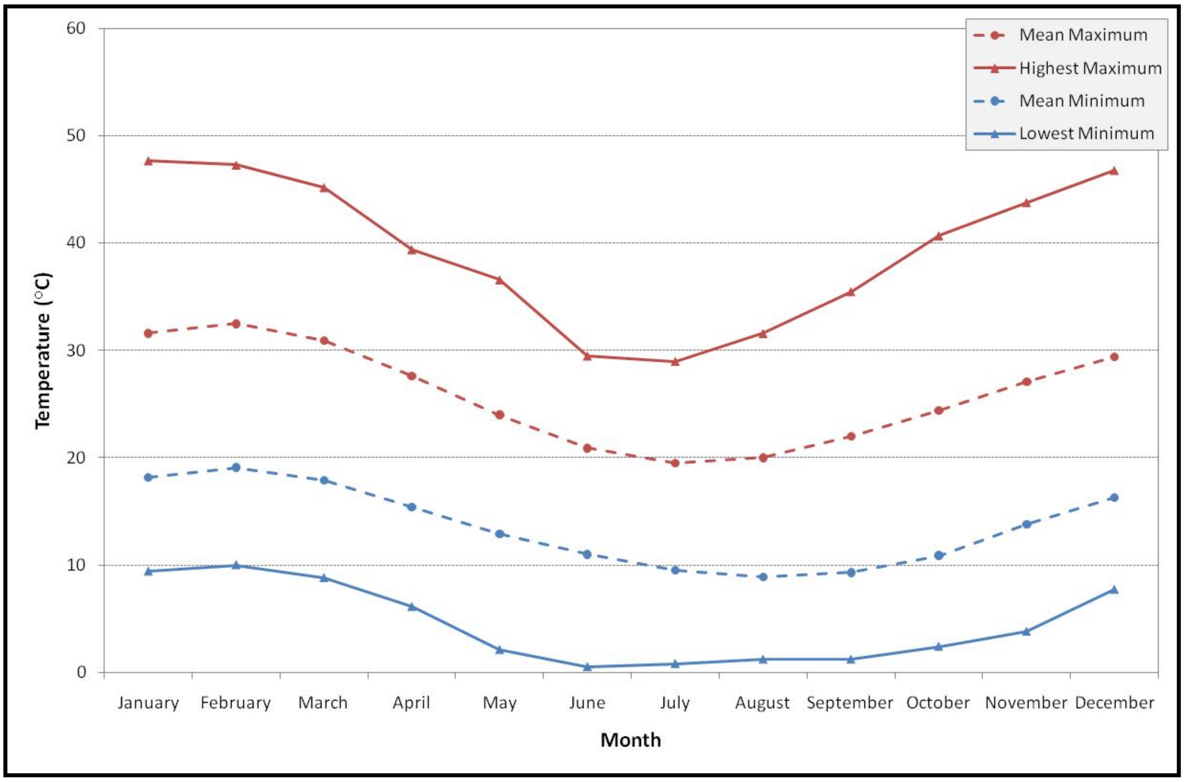


Figure 3-6 Seasonal temperature for Geraldton (BoM 2008b)

3.1.5 Humidity

The long term humidity in the Geraldton area at 9 am and 3 pm is presented in **Figure 3-7**. This figure shows that the humidity is typically higher during the winter months and is generally low during the summer period due to seasonal rainfall.

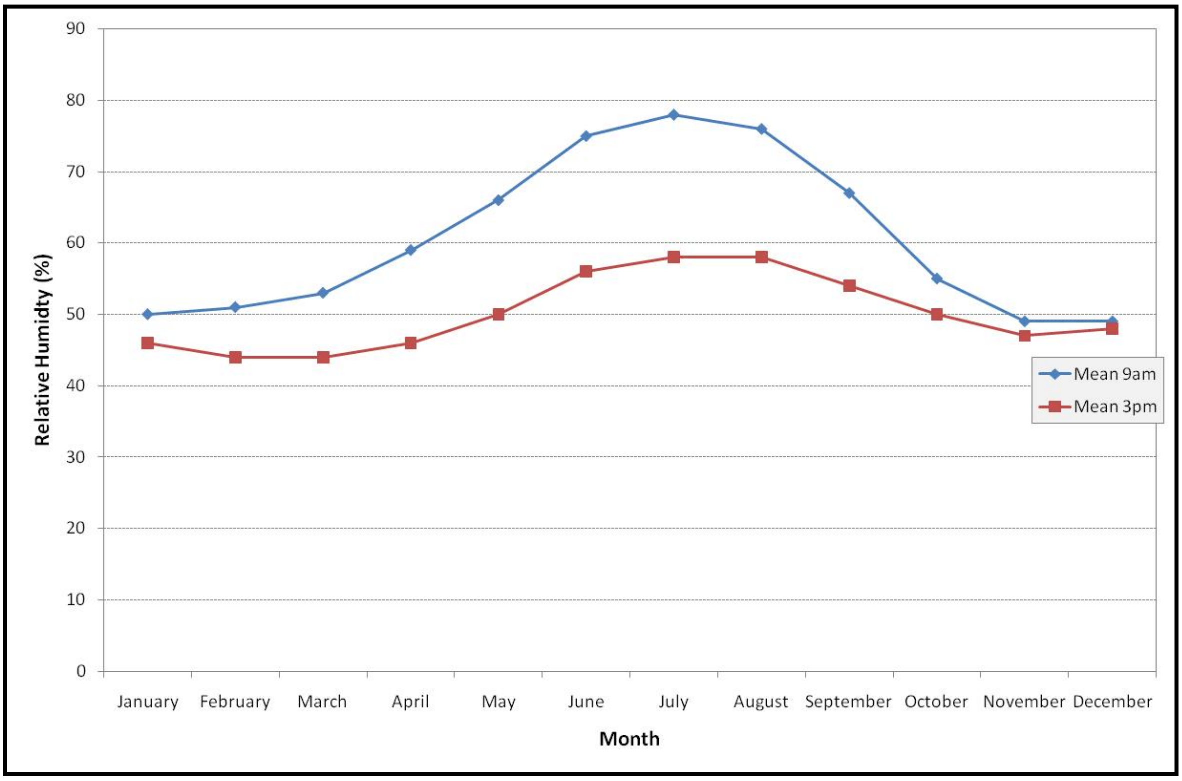


Figure 3-7 Mean humidity data for Geraldton (BoM 2008b)

3.2 Existing Dust Concentrations

There is currently no industry located in the vicinity of the proposed Oakajee Port.

For this assessment, background data have been sourced from the DEC monitoring station in Geraldton. This station measures PM_{10} concentrations and does not have TSP data available. To obtain a TSP dataset for assessment the PM_{10} data from 2007/2008 was multiplied by a conversion factor of 1.41. This value represents the ratio of TSP to PM_{10} from the Port Hedland airport monitoring data of the same period. The use of Port Hedland monitoring data for this conversion factor was due to the unavailability of regional data, though it is considered to be a reasonable approximation for the purposes of this assessment.

Statistics of the DEC monitoring station data are presented graphically in **Figure 3-8** and tabulated in **Table 3-2**.

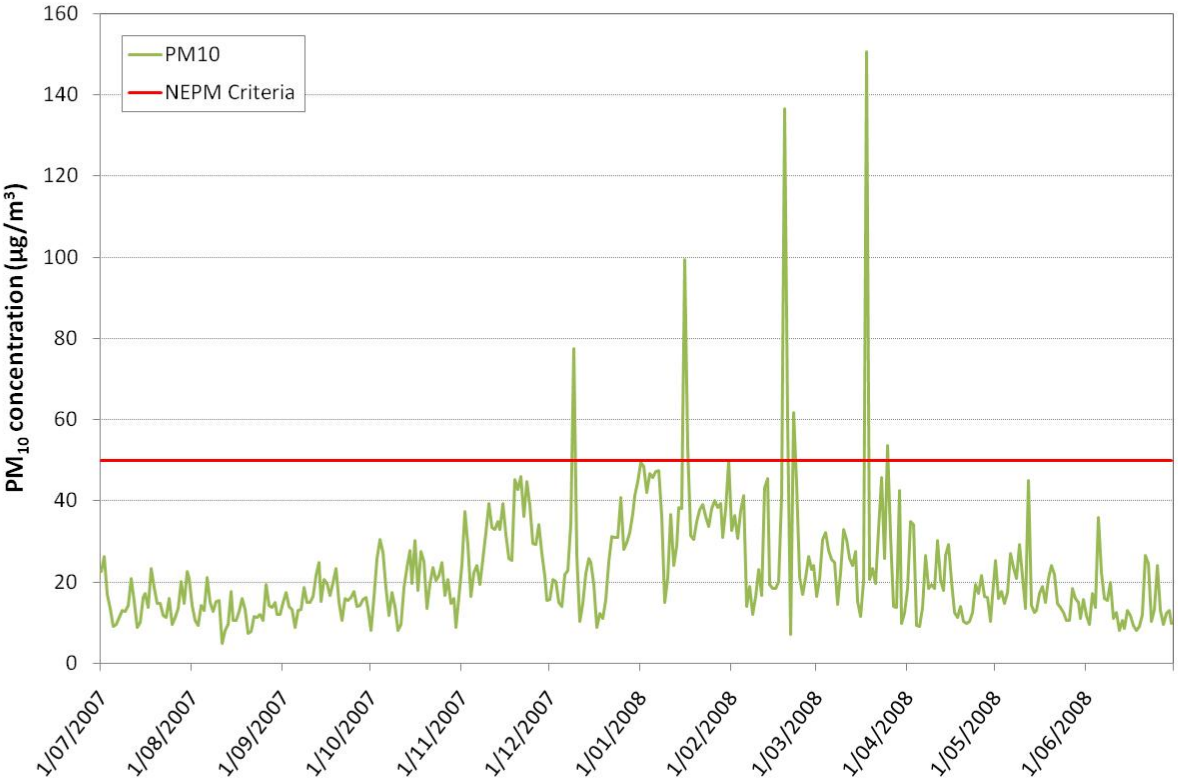


Figure 3-8 Recorded PM_{10} data from Geraldton DEC monitoring station July 2007- June 2008

Table 3-2 Statistics of PM_{10} concentrations at Geraldton DEC monitoring station July 2007 – June 2008

Statistic	PM_{10} Concentration				
	Annual	Summer	Autumn	Winter	Spring
Maximum	150.7	136.6	150.7	35.8	45.9
99th Percentile	67.3	103.1	62.3	27.5	45.4
95th Percentile	45.2	56.4	38.4	23.8	39.4
90th Percentile	38.4	47.4	32.1	21.0	34.9
70th Percentile	25.5	38.1	24.0	15.2	25.7
Average	22.8	32.8	21.9	14.2	22.2
Days above 50 µg/m^3 (NEPM criteria with goal of no more than 5 exceedances per year)	8	6	2	0	0

These data indicate summer and autumn are the times of year when the Geraldton region has its highest dust concentration, already exceeding the NEPM criteria. With 8 exceedences of the NEPM standard, the goal of no more than 5 exceedences was not achieved for this period.

The hourly PM_{10} concentrations for the peaks displayed in **Figure 3-8** are detailed further in **Appendix B**. These graphs show that days exceeding the 50 µg/m^3 NEPM target do so because of extreme dust events in the range of 200 to 900 µg/m^3 occurring for up to a third of the day, and because of dust concentrations in the range of 50 to 300 µg/m^3 persisting for up to half the day.

The wind speeds during background concentration peaks presented in **Figure 3-8** range between 5 and 12 m/s with wind directions usually within a south easterly wind arc between 70 to 180 degrees. The 15 – 18 January period is the only time where winds outside this wind arc are linked to exceedence of the NEPM criterion. Concentrations during this time are shown to be persistently around the 50 µg/m^3 target with no elevated peaks recorded.

A review of the DEC monitoring report for 2008 (DEC 2009) indicates dust is the cause for exceedences, though the source of dust is not specified.

4. EMISSION ESTIMATES

As this assessment is on a facility not yet constructed, dust emissions have been calculated using established estimation methodologies from the Dampier Port 145 Mtpa Environmental Protection Statement (SKM 2007) hereafter referred to as the Dampier 145 EPS. This assessment modelled the dust impact from Pilbara Iron export operations from Dampier Port, with emission estimates based upon on-site measurements. It is noted that emissions from this assessment are based around Pilbara haematite which may differ from mid-west magnetite. Laboratory work is being conducted to establish magnetite potential emissions, but until these data are available the modelling assumptions in the Dampier 145 EPS are considered appropriate for this assessment.

4.1 Dust Emission Sources

The handling of iron ore products through the port is expected to generate dust at multiple points of operation. These sources include:

- port facilities (such as car dumper and lump rescreening plant)
- conveyor belts
- miscellaneous transfer points
- stacking and reclaiming operations
- stockpile wind erosion
- shiploading
- open area wind erosion
- wheel generated dust (light vehicles).

4.2 Tonnages

The annual tonnage expected to pass through the port is quoted as up to 45 Mtpa (45 000 000 tonnes). The model has assumed the maximum in-loading and out-loading tonnages to the port to be at 12 000 tonnes per hour in line with best practice car dumpers and shiploaders. To keep estimates as conservative as possible, this hourly rate was used to produce the maximum possible emission rate for operations. Tonnages throughput at various operations at different hours was simulated using a mathematical random number generator to determine the times of car dumping and shiploading. Once shiploading commenced it was then assumed to run continuously for the next 33 hours (with three 1-hour breaks). All operations which were tied to either the shiploader or car dumper were then assumed to operate for this hour (i.e. for the shiploader, this is the reclaimer, lump rescreening plant, outgoing conveyors and transfers).

4.3 Emission Calculations

All emission rates, unless specified, are the PM_{10} emission rate. TSP emission rates are estimated by multiplying the PM_{10} emission rate by 2.86. This value has been established from validation studies of iron ore export facilities in Port Hedland by comparing measurements made on PM_{10} and TSP HiVol samplers on-site (SKM 2006).

It is noted this value is different to the background conversion factor described in **Section 3.2**. The background PM_{10} to TSP conversion factor takes into account the deposition of heavier particles over distance/time, which has the effect of reducing the ambient PM_{10}/TSP ratio. The source conversion value of 2.86 reflects the higher content of particulate sizes outside the PM_{10} range at the point of dust emission.

4.3.1 Car Dumping

Car dumping is treated in the Dampier 145 EPS (SKM 2007) as a flat TSP emission rate of 0.35 g/s. Using the conversion factor described in **Section 4.3**, the PM_{10} emission rate is equivalent to 0.12 g/s.

4.3.2 Conveyors

There are two main conveyor sources modelled in this assessment; the conveyor leading from the car dumper to the stockpile area, and from the stockpile area to the shiploader. The emission rate from the conveyors given in the Dampier 145 EPS (SKM 2007) is presented in **Equation 4-1**.

Equation 4-1 Conveyor emission rate

$$PM_{10}(g/s) = 0.00084U^3\left(1-\left(\frac{5.4^2}{U^2}\right)\right)$$

Where: U = wind speed (m/s)

The Dampier 145 EPS describes the U value as the forcing wind speed, taken as a vector addition of conveyor belt and wind velocities. Given the variability of belt operation (pausing during ship hatch changes or tripping out due to faults) within each hour, estimates have used only the wind speed to calculate emissions.

4.3.3 Stacking, Reclaiming, Transfers, Screening and Shiploading

Emissions from stacking, reclaiming, transfer stations, screening and shiploading were calculated consistent with the Dampier 145 EPS (SKM 2007) using **Equation 4-2**.

Equation 4-2 Miscellaneous product handling emission rate

$$PM_{10}(g/s) = KU^{p}$$

Where: K = source specific empirical constant (g/m)
U = wind speed (m/s)
p = source specific empirical exponent

The values of ‘K’ and ‘p’ used in this assessment are presented in **Table 4-1** for the various sources using this emission equation. These were obtained from the Dampier 145 EPS (SKM 2007). Note: these values are the average of multiple identical source types.

Table 4-1 K and p parameters for stacking, reclaiming, transfer stations, screening and shiploading

Source	K	p
Transfer stations	0.085	1.4
Stackers	0.145	1.4
Reclaimer	0.235	1.4
Screening plant	1.613	0.5
Shiploader	0.19	1.4

4.3.4 Wind Erosion

To estimate wind erosion emissions, the formulae used for determining wind erosion presented in the Dampier 145 EPA (SKM 2007) was used, and is presented as **Equation 4-3**.

Equation 4-3 Wind erosion emission equation

$$PM_{10}(g/m^2/s) = KU^3\left(1-\frac{U_0{}^2}{U^2}\right) \qquad \text{for } U > U_0$$

$$PM_{10}(g/m^2/s) = 0 \qquad \text{for } U < U_0$$

Where: U = wind speed (m/s);
U_0 = threshold for dust lift off (m/s) set to 5.5 m/s; and
K = a constant set to $3\text{x}10^{-6}$.

For this assessment, the K and U_0 values were set to reflect the values used in the Dampier 145 EPS (SKM 2007). These are $5.2 \text{ x } 10^{-7}$ for K and 7.5 m/s for U_0. Wind erosion estimates are reduced by 50% due to the effect of water cannons on stockpiles (DEH 2001).

4.4 Vehicles and Wheel Generated Dust

Vehicles emissions were calculated using **Equation 4-4**.

Equation 4-4 Wheel generated dust emission rate (light vehicles only)

$$PM_{10}(g/s) = \frac{VKT \times EF \times 1000}{60}$$

Where: VKT = vehicle kilometres travelled (per hour)
EF = emission factor (kg/VKT)

The EF value used in this assessment was obtained from the Dampier 145 EPS and represents paved operational areas at any time of day. This value is 0.13 kg/VKT. The VKT values used in estimation were defined by a series of estimates based on:

- expected vehicle traffic for a port of 45 Mtpa throughput
- size dimensions of port
- time of day/week (12 hour day/night shift rotation and variable weekday/weekend traffic)

The VKT estimates are presented in **Table 4-2**.

Table 4-2 Vehicle kilometres travelled estimation input

Estimation parameter	Weekday		Weekend	
	Day	**Night**	**Day**	**Night**
Vehicles operating on site	20	5	5	2
Kilometres travelled in one hour	1.5	1.5	1.5	1.5
VKT/hr	30	7.5	7.5	3

4.5 Dust Controls

Dust controls applied in the model include:

- car dumper enclosed with scrubbers
- screening plant enclosed with scrubbers
- shiploader conveyor shielded and with water sprays
- water sprays on stackers and reclaimers
- variable stacker height (reduced drop height)
- water cannons on stockpiles
- water trucks on open areas.

As emissions estimates in this assessment are based on empirical measurements on sources where these controls have been applied, most sources do not require further reductions to estimates. Modelled sources with control factors applied include the shiploader conveyor, and wind erosion sources.

Control factors applied have been sourced primarily from Table 3 of the National Pollutant Inventory (NPI) Emission Estimation Technique (EET) Manual for Mining Version 2.3 (DEH 2001). This manual provides reduction factors that can be applied to sources depending on the type of controls applied – typically water application, enclosure and dust extraction technology. It is important to note that control factors applied from the NPI EET Manual for Mining are approximations only, and in reality, may vary due to engineering constraints. Application of these control factors are intended to provide an appropriate and reasonable reduction to emission estimates.

For this assessment the control factors applied to the shiploader conveyor are 70% for ‘enclosure’ (assumed to approximate shielding) and 90% for ‘water sprays with chemicals’ (in absence of a control factor for just water sprays). It is not expected that chemicals will be applied via water sprays on the conveyor. As such it is possible this control may underestimate emissions from the shiploader conveyor. However, as maximum wind erosion emission estimates are an order of magnitude higher than maximum conveyor emission estimates (see **Table 4-3**), this underestimate of emissions from the conveyors will not have a significant impact on model predictions. The control applied to wind erosion sources will be water cannons (for stockpiles) and water trucks (for flat open areas). Both provide an emission reduction factor of 50% to wind erosion sources (DEH 2001).

4.6 Rainfall

Rain is has the effect of both minimising dust emissions at source, typically through crustal formations of surface particulate. To simulate the effects of rainfall in the model a 24-hour rolling average of hourly rainfall data from the Oakajee monitoring station was calculated. When the average rainfall for a particular hour exceeded the evaporation emissions from wind erosion and wheel generated dust for that hour were set to zero. To keep the model impact conservative, wet deposition of suspended particulate was not considered.

4.7 Summary of Dust Emission Estimates

A summary of the dust emission rates for each source identified at the proposed Oakajee Port are summarised below in **Table 4-3** based on the July 2007/June 2008 Oakajee meteorological data.

Table 4-3 Calculated PM_{10} emission rates at Oakajee Port using 2007/2008 meteorology

Source	Source Acronym	Maximum (g/s)	99 Percentile (g/s)	95 Percentile (g/s)	90 Percentile (g/s)	70 Percentile (g/s)	Average (g/s)
Car Dumper	CD	0.12	0.12	0.12	0.12	0.12	0.05
Transfer Station 1	TS1	4.23	2.29	1.40	0.97	0.00	0.22
Transfer Station 2	TS2	4.56	2.20	1.37	0.97	0.00	0.22
Stacker 1	ST1	7.22	3.90	2.39	1.66	0.00	0.38
Stacker 2	ST2	7.78	3.74	2.34	1.66	0.00	0.38
Reclaimer	REC	11.20	7.44	4.94	3.87	1.81	1.24
Transfer Station 3	TS3	4.05	2.69	1.79	1.40	0.66	0.45
Lump Rescreening Plant	LRP	6.41	5.42	4.50	4.05	0.00	0.97
Rescreened Fines - Transfer Station	RSF-TS	4.05	2.53	1.51	1.12	0.00	0.27
Rescreened Fines - Stacker	RSF-ST	6.91	4.32	2.57	1.91	0.00	0.46
Transfer Station 4	TS4	4.05	2.69	1.79	1.40	0.66	0.45
Shiploader	SL	9.05	6.02	3.99	3.13	1.46	1.00
Vehicles	VEH	1.08	1.08	1.08	1.08	0.27	0.40
Wind Erosion 1	WE1	74.13	27.43	8.85	3.09	0.00	1.40
Wind Erosion 2	WE2	74.13	27.43	8.85	3.09	0.00	1.40
Wind Erosion 3	WE3	74.13	27.43	8.85	3.09	0.00	1.40
Wind Erosion 4	WE4	74.13	27.43	8.85	3.09	0.00	1.40
Wind Erosion 5	WE5	74.13	27.43	8.85	3.09	0.00	1.40
Wind Erosion 6	WE6	74.13	27.43	8.85	3.09	0.00	1.40
Wind Erosion 7	WE7	74.13	27.43	8.85	3.09	0.00	1.40
Wind Erosion 8	WE8	74.13	27.43	8.85	3.09	0.00	1.40
Conveyor 1A	CV1A	1.93	0.51	0.17	0.08	0.00	0.03
Conveyor 1B	CV1B	1.93	0.51	0.17	0.08	0.00	0.03
Conveyor 2A	CV2A	0.04	0.02	0.01	0.00	0.00	0.00
Conveyor 2B	CV2B	0.04	0.02	0.01	0.00	0.00	0.00

5. MODELLING METHODOLOGY

Atmospheric dispersion models are widely used to study the complex relationship between emissions and air quality as a function of source and meteorological conditions. Models used for estimating dispersion range from simple empirical expressions to very elaborate numerical solutions of the conservation equations governing pollutant concentration. Due to the complexity of atmospheric transport processes, practical or operational dispersion models rely heavily on empirical methods.

5.1 Background Influence on Model

As the NEPM and DEC criteria limits are for total dust concentrations, the background dust concentration for the region needs to be taken into account when modelling proposed port emissions. Ambient dust levels in the region are monitored in Geraldton by the DEC (**Section 3.2**).

Background dust has been incorporated in two ways for this assessment:

- the 24-hour averaged background has been added to model results to demonstrate the impact of operations in comparison to existing ambient dust in the area (**Figure 6-1** to **Figure 6-3**)
- the 70th percentile of all 24-hour averaged background data was added as a blanket value to model predictions as recommended by the Victorian Government Gazette (2001) to better display of operational impacts across the model, while maintaining a reasonable degree of conservatism in the applied background concentrations (**Figure 6-5** and **Figure 6-7**).

Model results for Oakajee Port without background concentrations are also presented (**Figure 6-4, Figure 6-6** and **Figure 6-8**) to show the extent of Oakajee dust impacts in isolation.

5.2 Modelling Methodology

Air quality impacts from the proposed port development at Oakajee have been assessed using the Victorian EPA's AUSPLUME (Version 6.0) computer dispersion model, which is one of the primary air dispersion models used for assessing air quality impacts from industrial sites within Australia. The model is designed to predict ground-level concentrations or dry deposition of pollutants emitted from one or more sources, which may be stacks, area sources, volume sources, or any combination of these. AUSPLUME is essentially a statistical Gaussian plume model that requires a time series of both meteorological and source emission data.

5.3 Model Suitability for Oakajee

AUSPLUME was selected over other models (e.g. TAPM, CALPUFF) for the following reasons:

- only ground level volume sources modelled; no elevated sources, eliminating the need to consider the thermal internal boundary layer in the modelling of coastal areas
- receptors within 10 km of operations
- required fast model run times due to the number of sources from operations
- little to no major local topographical features considered capable of influencing model predictions (Moresby ranges too distant).

5.4 AUSPLUME Modelling

AUSPLUME can be run for a number of different model options and meteorological data formats. In this report the main model options and assumptions used are:

- meteorological data from an annual file of hourly observations was used
- rural dispersion options
- assumption of no terrain
- dry depletion included
- average roughness length of 0.1 m.

5.4.1 Grid System

AUSPLUME can calculate concentrations both on a set grid (typically Cartesian) or at specified locations. The model was initially configured to predict the ground-level concentrations on a rectangular grid (19x21 units) with 500 m spacing between grid points. Further to this, a finer grid (350 x 350) was used over the industrial estate to predict in more detail the impact across this area. This grid approach was chosen to minimise the duration of model runs, while preserving a sufficient grid resolution to clearly display dust impacts in areas of interest.

5.4.2 Model Terrain

Complex terrain features such as hills and valleys affect dispersion and deposition of airborne particulate through various factors such as channelling wind flow and generating wake effects. These influences are poorly handled by AUSPLUME due to the constant wind vector it applies to modelled plumes, and the model resolution in comparison to the size of actual terrain features.

Because of these issues, and no local topographic features significant to modelling using AUSPLUME, the model was run without incorporating terrain effects. Any terrain effects would not be significant, compared to the uncertainties in source emission estimates.

5.4.3 Dry Depletion Method

Particles settle out of air onto land, either under the influence of rain (wet deposition) or more commonly under gravity (dry deposition). Calculation of dry deposition requires particle size distribution and particle density for each size fraction required. AUSPLUME calculates both a settling velocity and a deposition velocity for each of these size categories. The settling velocity is the rate of change that the plume centre-line moves downward and "tilts" towards the surface as it travels downwind, while the deposition velocity is used to calculate the flux of matter deposited at the surface. Plume depletion allows material to be removed from the plume as it is deposited on the surface.

As the plume of airborne particles is transported downwind, deposition near the surface reduces the concentration of particles in the plume, and thereby alters the vertical distribution of the remaining particles. Furthermore, the larger particles will also move steadily nearer the surface at a rate equal to their gravitational settling velocity. As a result, the plume centreline height is both reduced, and the vertical concentration distribution is no longer Gaussian.

Version 5 and later versions of AUSPLUME employ the deposition algorithm used in the US EPA model ISC3. This algorithm also tilts the plume downwards at an angle which depends on the particle settling velocities but now uses an improved method for estimating deposition at the ground (dry deposition).

The particle size distribution for particles from the proposed Oakajee development was taken as the same as that given in SKM (2006) for modelling Port Hedland iron ore operations, and is presented in **Table 5-1**.

Table 5-1 Particle size distribution (fraction by weight) used within model for dust depletion

Mid Range Particle Size (µm)	Mass Fraction	
	PM10	**TSP**
1	0.31	0.11
4	0.26	0.09
7	0.23	0.08
9	0.20	0.07
12		0.13
19		0.13
26		0.13
35		0.13
45		0.13

5.4.4 Dispersion Curves

Horizontal dispersion of plumes can be determined within AUSPLUME according to Pasquill stability classes or through the standard deviation in wind direction known as sigma theta (σ_θ). The latter is preferred where observations are available, as sigma theta is a direct measure of horizontal dispersion and the resultant lateral dispersion coefficient will be a continuous function, not discrete curves. In the absence of sigma theta measurements for Oakajee, horizontal dispersion was determined using the Pasquill-Gifford curves which are applicable to surfaces releases.

5.4.5 Time Series Meteorological Data

A time series air quality meteorological data file was required for the AUSPLUME modelling, including hourly averaged values of:

- wind speed and direction
- ambient air temperature
- Pasquill-Gifford stability class
- atmospheric mixing height.

This 2007/2008 meteorological data used in the Oakajee Industrial Estate Buffer Assessment (Air Assessments 2009) were used in this assessment. This data incorporate wind speed, direction and air temperature from the Oakajee meteorology station, stability classes calculated using the Turner method with cloud data from Geraldton airport, and mixing heights predicted from CALMET using a temperature profile generated from TAPM.

A summary of the stability, wind speeds, and mixing heights of this data is given in **Appendix C**.

5.5 Model Inputs

A model of the proposed port development was established to predict 24 hour ground level PM_{10} and TSP concentrations at sensitive receptors (**Section 5.5.2**) to the site. Inputs to the model include:

- meteorological file containing hourly data for July 2007 to June 2008 (**Section 5.4.5**)
- operational data and emissions release estimates (**Section 4**)
- source locations and dimensions
- receptor locations

5.5.1 Emission Sources

Modelled source locations are presented in **Figure 5-1**. The source abbreviations, characteristics and co-ordinates are detailed in **Appendix D**. An example of an AUSPLUME configuration file is presented in **Appendix E**.

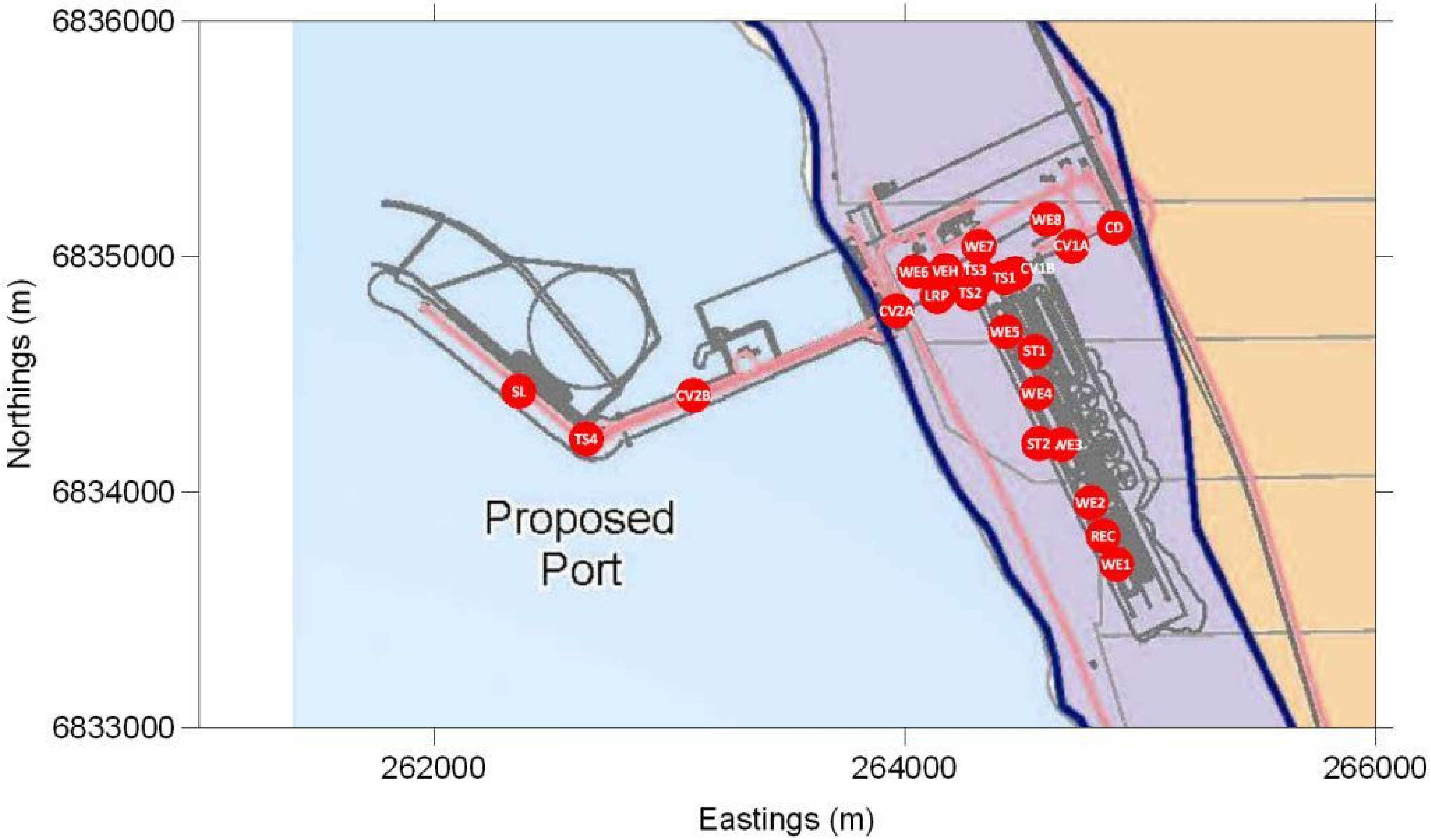


Figure 5-1 Plotted locations of modelled sources

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5.5.2 Receptors

For this assessment there are three types of receptors considered, with appropriate criteria applied to each.

Sensitive receptors are defined in this assessment as individuals, communities, or components of the environment which could be adversely affected by dust emissions, such as dwellings, schools, hospitals, offices, protected wetlands or public recreation areas that exist now and in the future. There are no sensitive receptors located within the buffer zone (**Figure 2-1**). Criteria applicable to these receptors include the NEPM PM_{10}, Kwinana EPP TSP (Area C), and NSW EPA deposition criteria.

Industrial receptors are defined as locations within the Oakajee Industrial Estate. These locations are conceptual only, and have been selected arbitrarily within the estate to demonstrate the impact at various points within the estate. Only the Kwinana EPP TSP (Area A) criterion is applicable to these receptors.

Buffer receptors are defined as locations within, or at the boundary of, the Oakajee Industrial Estate buffer zone. These locations are also conceptual points, and have been selected to show concentrations at the farthest reaches of the buffer zone. Only the Kwinana EPP TSP (Area B) criterion is applicable to these receptors.

For this assessment there are 25 receptors identified and plotted in **Figure 5-2**. Five of these are sensitive receptors (marked as blue triangles). The remaining receptors are conceptual only, included to provide predictions across the industrial estate (marked as orange triangles) and at the boundary of the buffer zone (marked as purple triangles).

The co-ordinates of modelled receptors are presented in **Appendix F**.

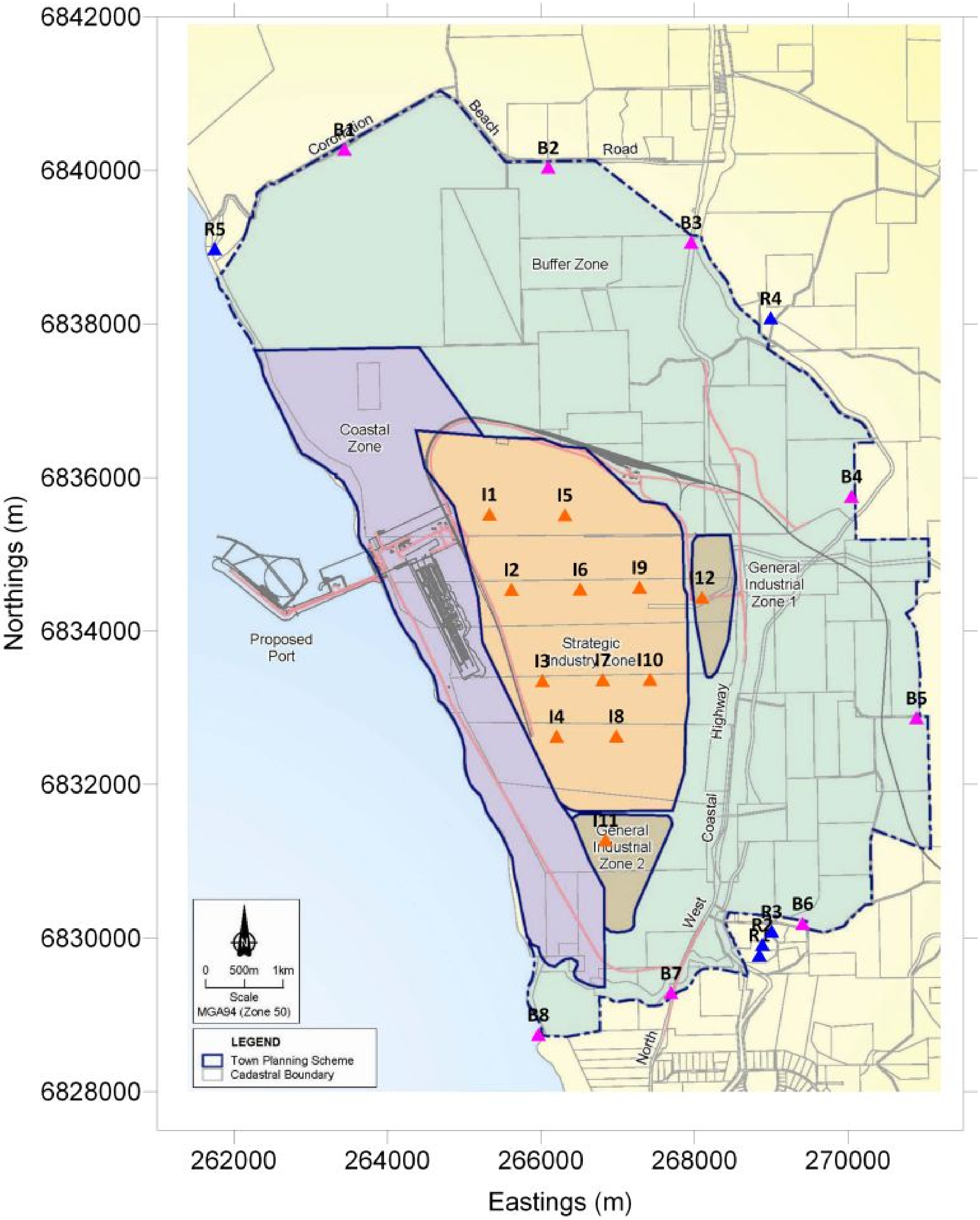

Figure 5-2 Location of receptors within the locality of the port

6. MODEL RESULTS

For the modelled year, dust concentrations across the region were predicted. The maximum impacts at any given time and location were plotted to give a ‘worst case scenario’ set of results so that any possible exceedences could be predicted.

6.1 Model Predictions

6.1.1 Influence of Background Dust

The impact of PM_{10} emissions from site compared to existing PM_{10} concentrations at select receptors is displayed in **Figure 6-1** to **Figure 6-3**. These graphs display predicted 24-hour port PM_{10} impact (in orange) added to 24-hour background dust data (in blue).

Impacts from the Port are shown to be a small fraction of total dust at Coronation Beach and at the buffer boundary to the north. The industrial receptor shows a larger contribution from Port emissions due to its proximity, but is still dominated by background dust.

6.1.2 Dust Impacts

To better demonstrate the impact of port operations over the Oakajee region, this section presents the 70th percentile of all 24-hour averaged background dust added as a blanket value to model predictions (25.5 $\mu g/m^3$ for PM_{10} and 36.0 $\mu g/m^3$ for TSP). There is no background applied to dust deposition as the criterion for comparison is for an increase above existing levels. Red lines in contour plots indicate relevant criteria targets.

Predicted PM_{10} concentrations are plotted across the Oakajee region in **Figure 6-4** (no background) and **Figure 6-5** (70th percentile background added). This shows that concentrations outside the industrial estate are not predicted to exceed the NEPM criteria. The cumulative modelling does indicate that there is some impact above the 50 $\mu g/m^3$ NEPM target across the industrial estate, though this is limited to the northwest and just inside the western boundary of the estate.

The TSP impact from the Port is plotted in **Figure 6-6** (no background) and **Figure 6-7** (70th percentile background added). The cumulative modelling shows the 90 $\mu g/m^3$ target for the Area B criterion is exceeded in a small part of the buffer zone near operations, and the 150 $\mu g/m^3$ target for the Part A criterion is exceeded within a small area in the northwest of the industrial estate. No 24-hour average concentration limits were exceeded for Area A and Area B, and no exceedence of the Area C criterion were predicted.

The dust deposition contour plot is displayed in **Figure 6-8** and shows no exceedence of the specified criteria. The criteria target of a maximum 2 g/m^2/month increase is located over the northwest and west of the industrial estate. Deposition levels outside the buffer zone are predicted to be an order of magnitude lower than criteria levels.

Predicted concentrations for all receptors are presented in **Appendix G**.

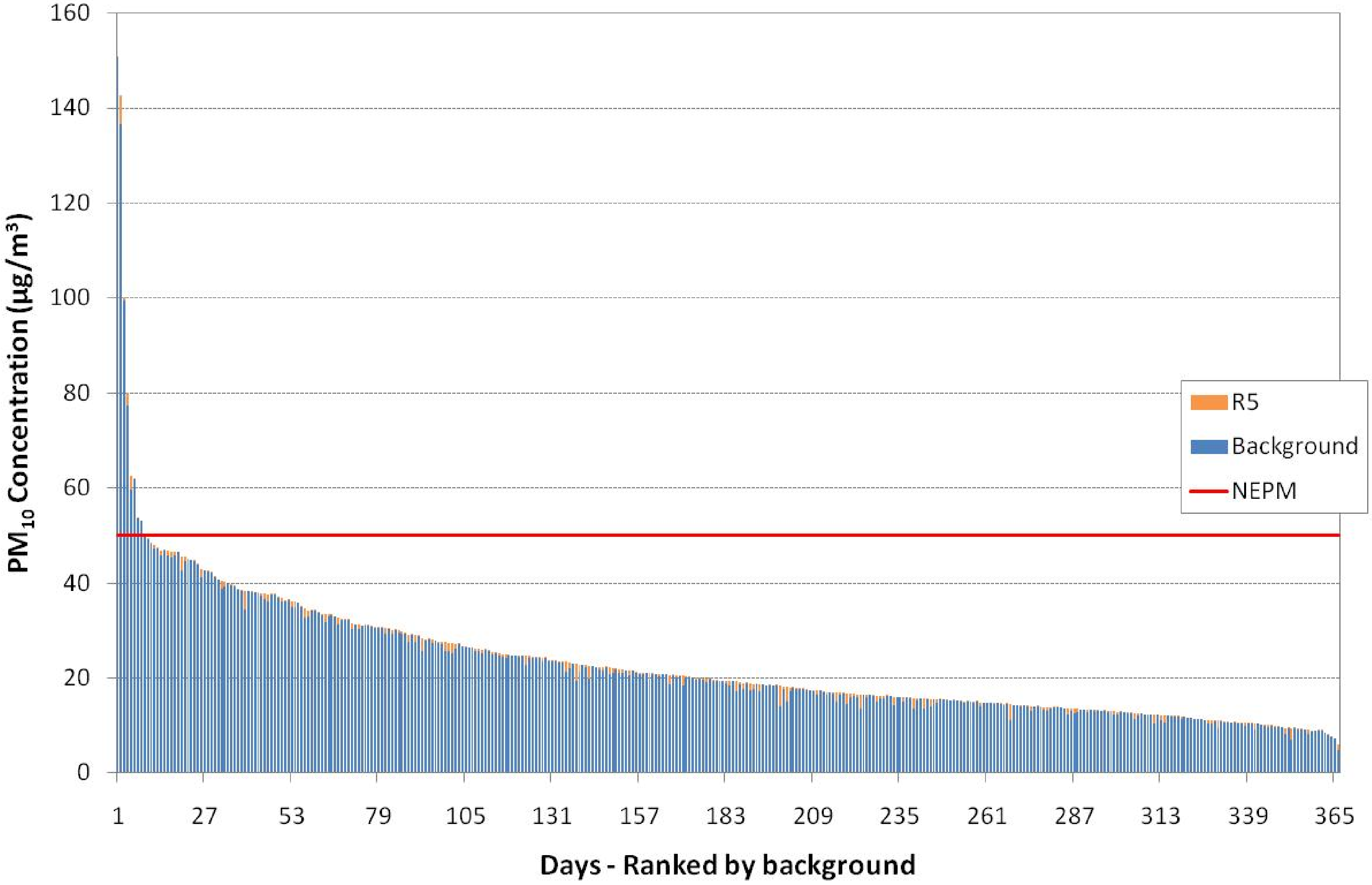

Figure 6-1 Ranked background (24-hour averaged) and PM_{10} impact from Port operations – Receptor 5 (Coronation Beach)

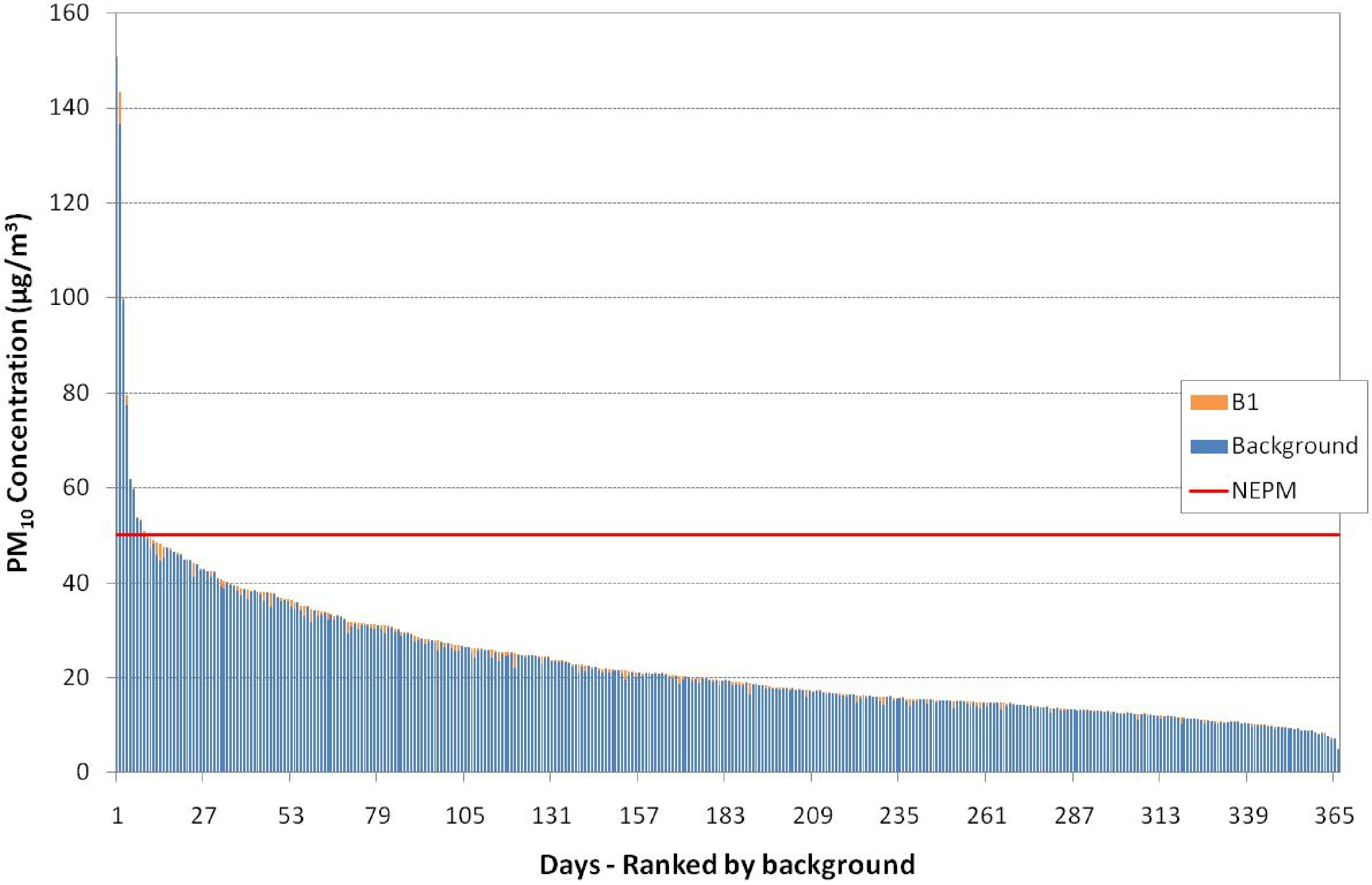

Figure 6-2 Ranked background (24-hour averaged) and PM_{10} impact from Port operations – Buffer receptor 1

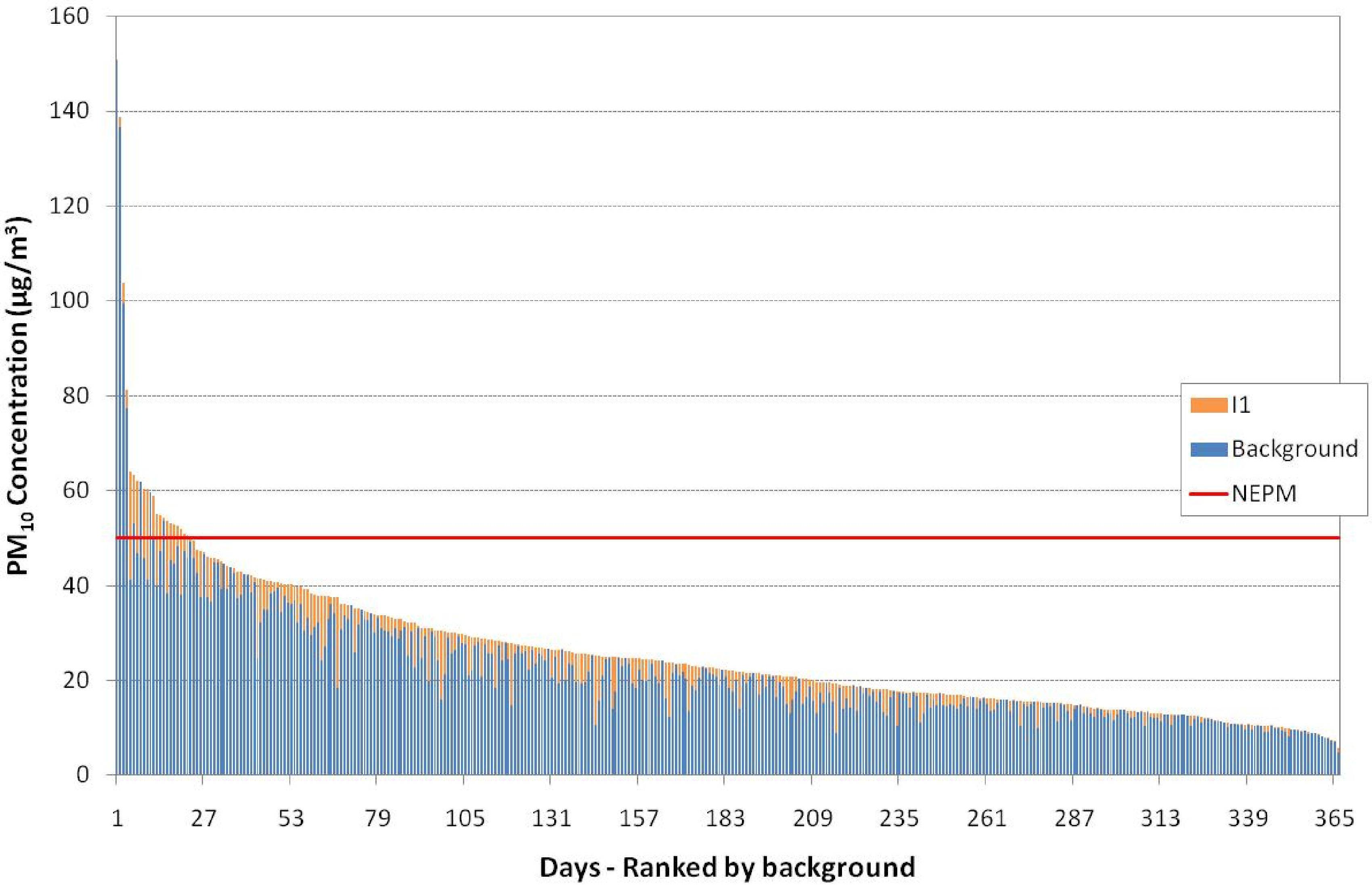

Figure 6-3 Ranked background (24-hour averaged) and PM$_{10}$ impact from Port operations – Industrial receptor 1

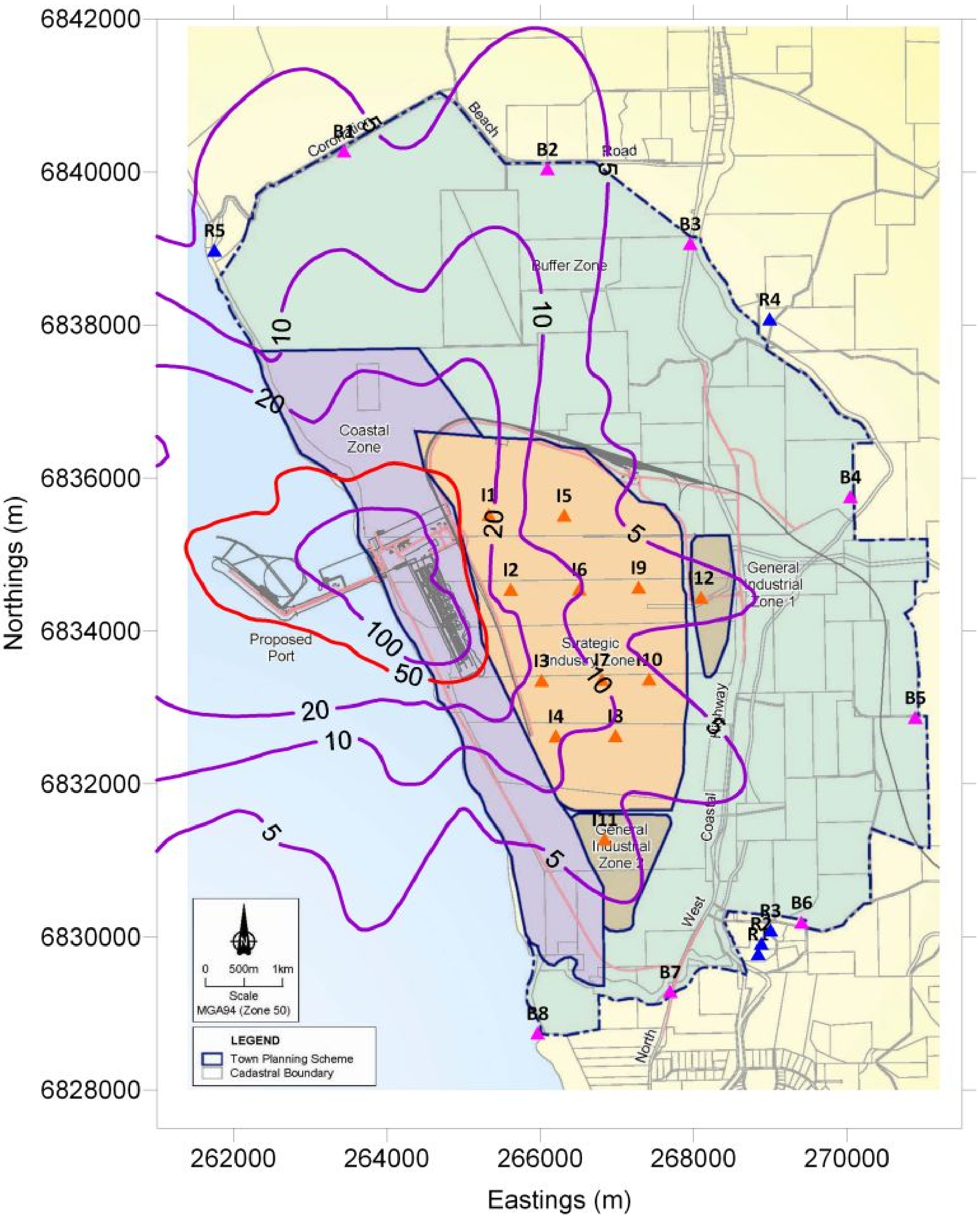

Figure 6-4 Predicted maximum 24-hr PM_{10} ground level concentrations (µg/m^3) for Oakajee Port (no background)

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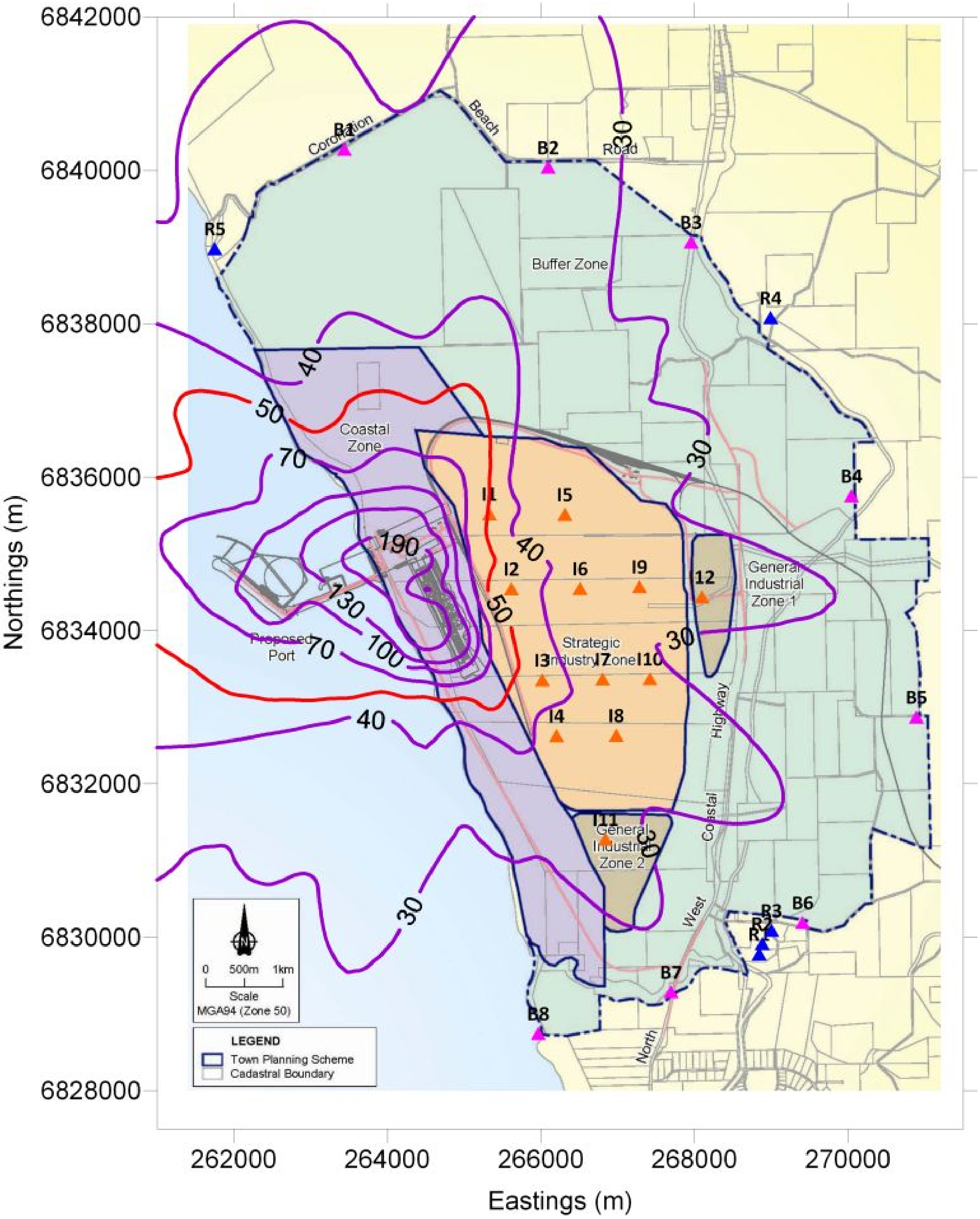

Figure 6-5 Predicted maximum 24-hr PM_{10} ground level concentrations (μg/m^3) for Oakajee Port (with annual 70th percentile background)

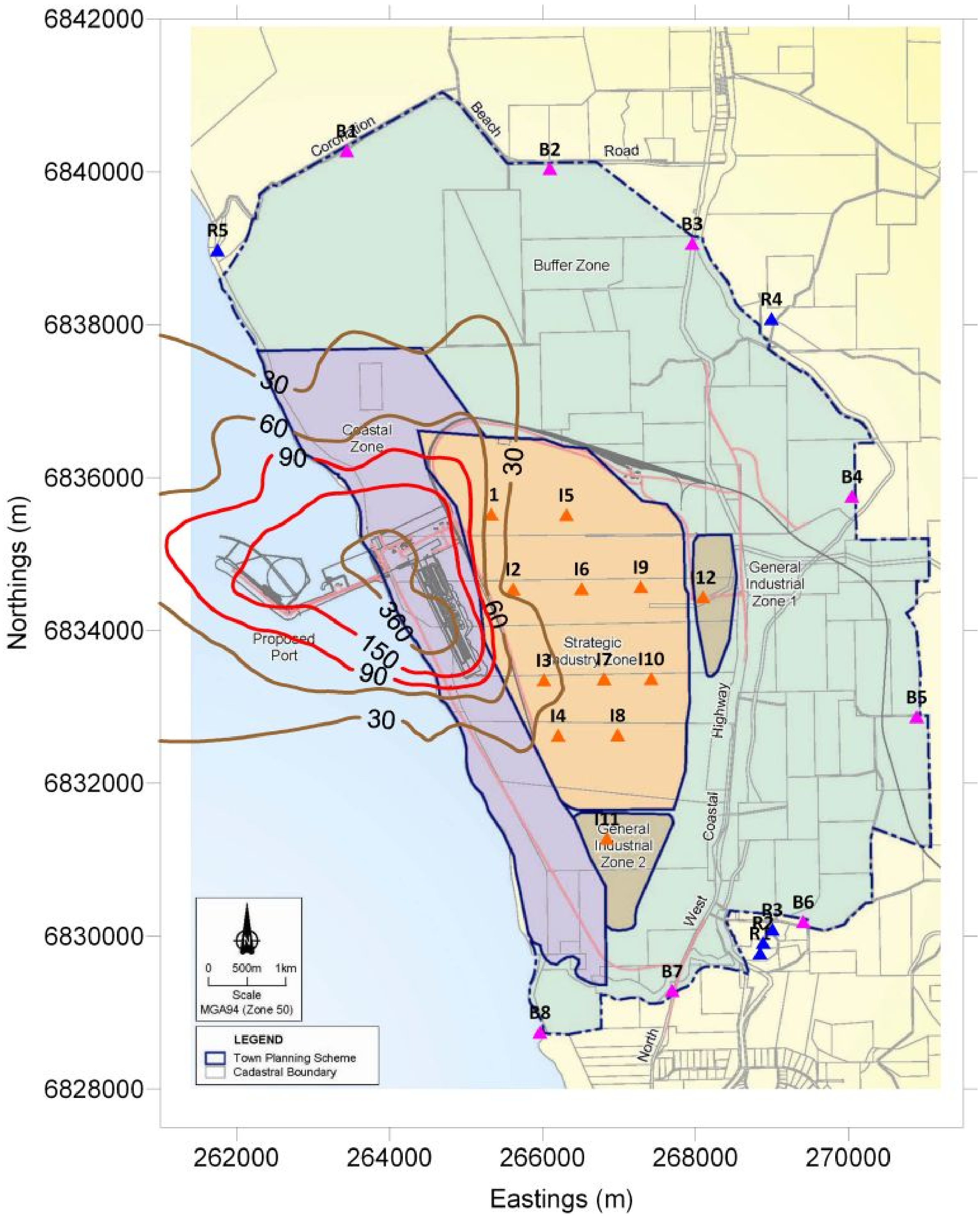

Figure 6-6 Predicted maximum 24-hr TSP ground level concentrations (µg/m^3) for Oakajee Port (no background)

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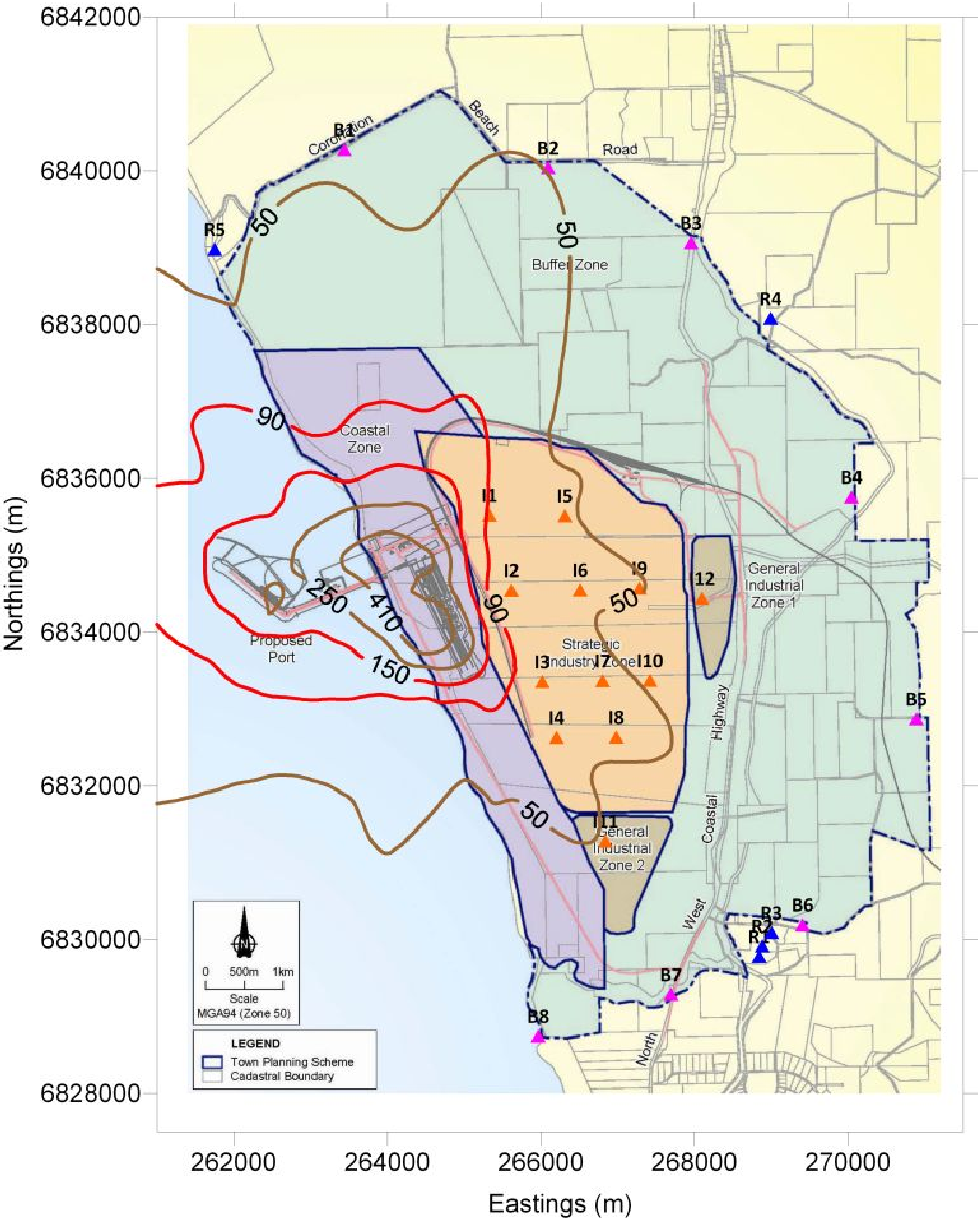

Figure 6-7 Predicted maximum 24-hr TSP ground level concentrations (µg/m^3) for Oakajee Port (with annual 70th percentile background)

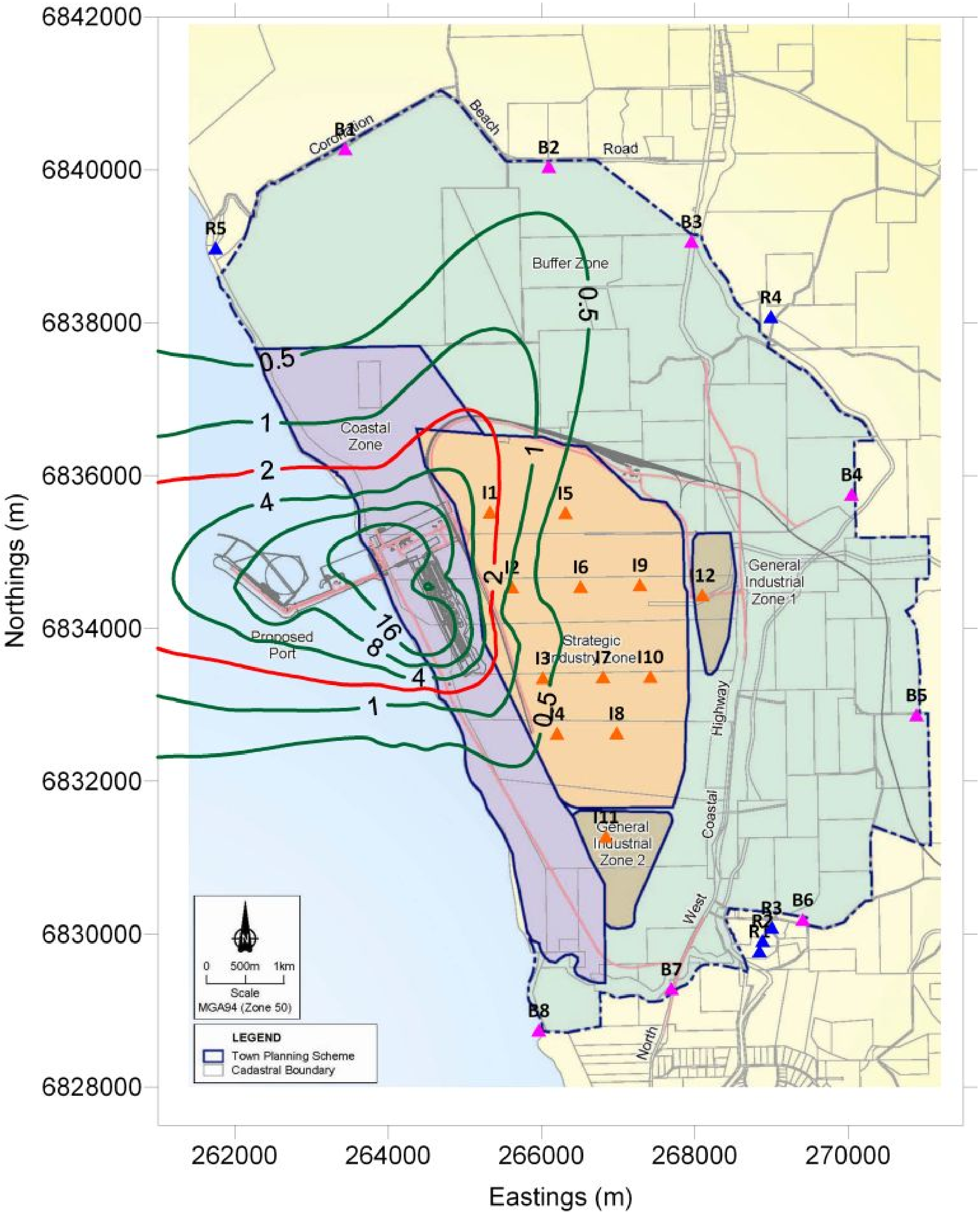

Figure 6-8 Predicted maximum monthly deposition levels (g/m^2) for Oakajee Port

7. DISCUSSION AND RECOMMENDATION

The model results show existing dust concentrations across the region are large compared to any predicted impact from Port operations.

The data presented in **Figure 6-1** and **Figure 6-2** show the small contribution expected from operations at points distant (greater than 4 km) to the Port. Locations closer to operations will experience a higher impact, though these points are shown to still be dominated by existing dust concentrations (**Figure 6-3**). Quantification of dust from operations (in monitoring programs for example) will need to take background dust concentrations into account when determining dust contributions from Port emissions across the region.

24-hour average concentrations meet the specified criteria, with the exception of small zones in the industrial estate and buffer zone. However, the background data shows periods where the 1-hour (or smaller) concentrations are high, especially during high winds. For this reason, it is recommended that application of temporary controls for sources susceptible to wind erosion sources be ready at all times (such as chemical suppressants and extra water trucks), especially during summer and autumn months.

Further emission reduction protocols that could be considered include:

- Minimising and re-vegetation of unused open areas. As well as preventing surface erosion, re-vegetation helps to reduce surface wind speed and thus erosion of surrounding areas.
- Open areas such as lay-down and machinery maintenance areas should be packed with lump or gravel material to reduce wind erosion. This has the effect of reducing exposure of particulates that are susceptible to eroding winds and wheel movements. Depending on availability and suitability, lump material of a suitable size is used on some sites.
- Use advanced meteorological forecasting to develop a proactive approach to dust management and reduction.
- Ongoing education and awareness of all site personnel in regards to responsibilities for control and reporting of dust emissions. Appropriate reporting and response procedures should be established and deployed.

8. REFERENCES

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APPENDIX A OAKAJEE INDUSTRIAL ESTATE BUFFER ASSESSMENT EXTRACTS – METEOROLOGY AND MODEL SETUP (AIR ASSESSMENTS 2009)

3 Meteorological and Ambient Monitoring in the Region

3.1 Available Data

Meteorological and ambient data that are known to be collected in the Geraldton region are listed in **Table 3-1**.

Table 3-1 Meteorological and Particulate Monitoring Undertaken in the Geraldton Region

Site	Easting GDA94 (m)	Northing GDA94 (m)	Period	Averaging Time	Parameters Measured
Oakajee - LandCorp	264,041	6,838,791	8/6/1990 to 14/2/1994	10 min	WS, WD, Sig and GU @ 10m using a Climatronics F460 wind sesnor AT and RH at 10m; DT between 10m and 1.6m (naturally ventilated shields not aspirated); SR and NR at 1.6m; RN at ground.
Oakajee - Kingstream					
North site	267,390	6838530	December 1997 to October 2000	1 in 6 days 10 min	TSP (HVAS) PM_{10} (TEOM)
East Site	268,630	6833,300		10 min	PM_{10} (TEOM), WS, WD, AT and RH
South Site	267,230	6828,480		10 min	PM_{10} (TEOM)
Oakajee - Crosslands	265,680	6,833,510	26/6/2007 to present	1 min	WS, WD, Sig and GU @10m AT @ 2m and 9.8m RH @ 2m, BP,RN and SR
Geraldton Airport AWS Bureau of Meteorology	275,260	6,812,520	1994 to present-	10 min on the hour	WS, WD @ 10m AT, RH at ~1.4 m RN
Geraldton - DEC Bowling Club 8th Street	268,835	6,815,245	Sept 2005 to present	10-min	WS, WD @ 10m PM_{10} (TEOM)
Geraldton Port Authority	NK	NK	NK	NK	WS and WD @ 30m at the port WS and WD at Beacon 2 over water
Narngulu - Iluka	Approx 272,700	Approx 6,808,800	1994 to 2005	10 min	WS, WD, Sig and GU @ 10m using a Climatronics F460 wind sesnor AT and RH at 10m; DT between 10m and 1.6m (naturally ventilated shields not aspirated); SR and NR at 1.6m; RN at ground.

1) WS wind speed; WD wind direction; SIG standard deviation in wind direction, GU gust speed, AT air temperature; DT Differential temperature between two levels, RH relative humidity; BP barometric pressure; SR solar radiation.
2) GDA94 is used throughout the report.
3) NK – Not Known.

At Oakajee there have been three monitoring campaigns since 1990 with:

- Monitoring of meteorological data from 1990 to 1994 at the Northern end of Oakajee (termed Oakajee North in this report) as commissioned by LandCorp. This monitoring utilised air quality grade sensors with a good data return of 96.1% over the 3.75 years This data was utilised in the 1993 Buffer definition study and in the Kingstream modelling in 1997;

- Particulate and meteorological monitoring conducted for Kingstream for the period 1997 to 2000. This monitoring was primarily undertaken to assess dust levels on site before and during site works. The siting for the wind station was in a slight gulley area near the North West coastal highway, with trees and vegetation within 60m. As such, though a reasonable site for determining the directions for particulate, it does not meet the requirements for air quality modelling; and
- Current meteorological monitoring undertaken by Oakajee Port & Rail. This monitoring uses air quality grade sensors located on the Oakajee plateau, near the western boundary of the proposed industrial area, and is a very well sited station with relatively flat areas for several hundred metres in all directions of the weather mast.

Other monitoring that has and is currently being undertaken in the Geraldton region include:

- Bureau of Meteorology (BoM) monitoring at Geraldton airport. The wind sensor used (a Synchrotac 760) is not sensitive for low wind speeds and the wind directions are only resolved to 10 degrees and, as such, is not particularly suitable for air quality modelling;
- DEC monitoring at the Geraldton bowling club. Wind measurements at this site are considered to be slightly compromised by nearby buildings and trees, with this site's main purpose being to provide good ongoing particulate (PM_{10}) measurements;
- Weather monitoring by the Geraldton port at two locations. The quality of this data is not known; and
- Meteorological monitoring conducted by Iluka at Narngulu just SW of the airport with air quality grade instrumentation. The tower and instrumentation were those used at Oakajee from 1990 to 1994.

3.2 Wind Speed and Direction in the Region

3.2.1 Annual Winds

Annual wind roses for the two Oakajee sites, Geraldton airport and as predicted by the model TAPM at Oakajee are presented in **Figure 3-1**.

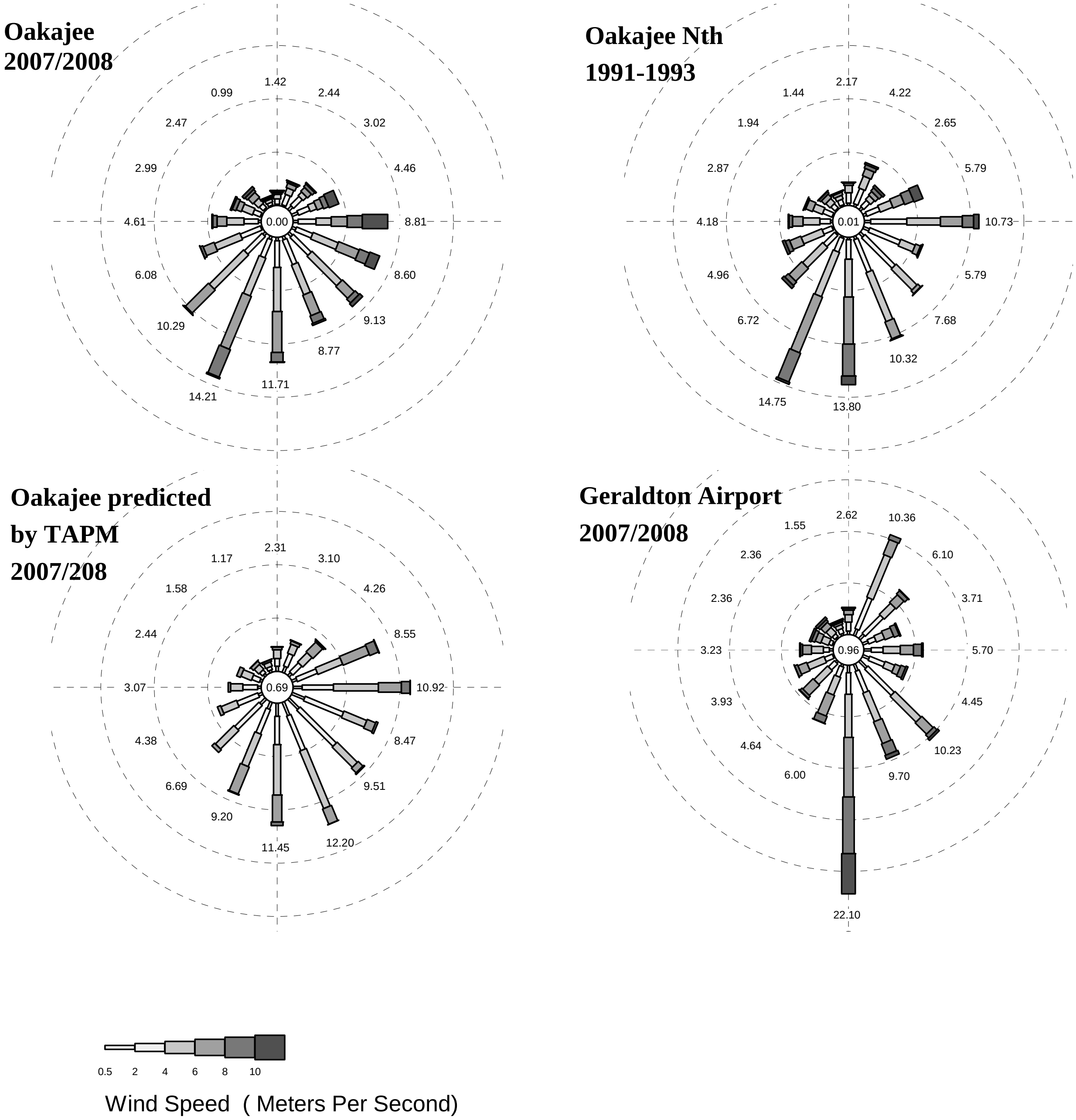

Figure 3-1 Annual Wind roses for Oakajee as Observed and Predicted by TAPM and Observed at Geraldton Airport

Figure 3-1 show that there are small differences between the two available Oakajee sites with the Oakajee Nth site tending to have slightly more southerly sea breezes than the current Oakajee site. Average annual wind speeds are similar with vector average wind speeds of 5.5 and 5.6 m/s respectively. Winds at both the Oakajee sites show a predominance of SW to Southerly winds with a moderate frequency of winds from the south to east quadrant, with a low percentage of winds from the N to NNE through to the WNW.

Comparing the Oakajee and Geraldton airport wind roses it is apparent that the Geraldton airport winds have a much higher frequency of southerly and NNE to NE winds than is recorded at Oakajee. Average wind speeds are however similar with the average 2007/2008 airport winds being 5.6 m/s. The variation in wind direction between the two Oakajee and Geraldton sites is also presented in **Figure 3-2**.

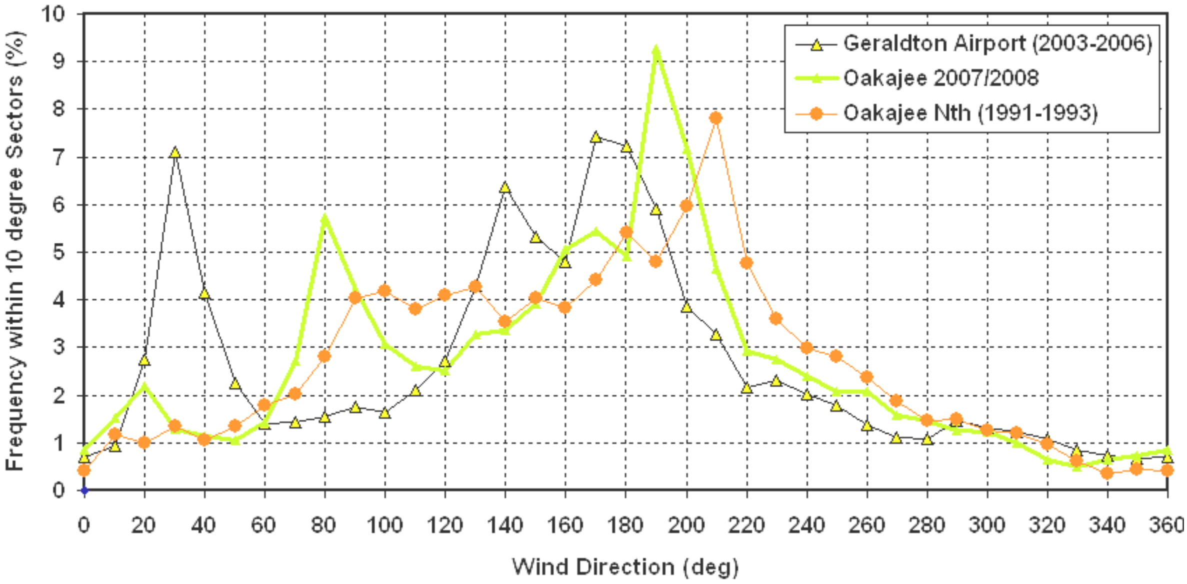

Figure 3-2 Annual Wind Direction Frequency for Oakajee and Geraldton Airport

Figure 3-2 also shows that the Oakajee sites show a higher frequency of winds from 70 to 120 degrees, whilst Geraldton airport show a much high frequency from 30 to 40 degrees. These NNE (30 to 40 degree) winds at Geraldton occur predominantly from midnight to mid morning. The high frequency of southerly winds at Geraldton airport evident in the wind rose is less evident in **Figure 3-2** and as such appears to be an artefact that the airport winds are resolved to ten degrees intervals and that three intervals are resolved (170, 180 and 190 degrees) into the south wind petal, whilst the neighbouring direction petals have only two ten degree intervals (e.g. the 157.5 degree petal contains only 150 and 160 degrees). Though the frequency of “southerly” winds is similar there is a clear shift in the winds between the three sites with maximum at Oakajee Nth at 210 degrees, Oakajee at 190 degrees and Geraldton airport at 170 to 180 degrees. For other directions such as from 270 degrees through North to 10 degrees the wind frequencies are very similar, being generally low.

The variation in the winds especially the easterly component highlights that there are significant differences between the Oakajee and Geraldton airport winds which are likely to be a function of the siting of the two sites. The airport being located on a flat plain about 8km from the coast, whilst the Oakajee sites are only about 1km from the coast.

Comparison of the Oakajee winds observed and predicted by TAPM (see later for a more full description) is also presented showing that TAPM winds show are lower percentage of SW and a higher percentage of SE to E winds. The TAPM average wind speed is also lower with an annual average wind speed of 4.4 m/s compared to the 5.5 to 5.6 m/s at the Oakajee sites

3.2.2 Wind Variation by Time of Day at Oakajee

The wind variation by time of day at Oakajee is presented in **Figure 3-3**.

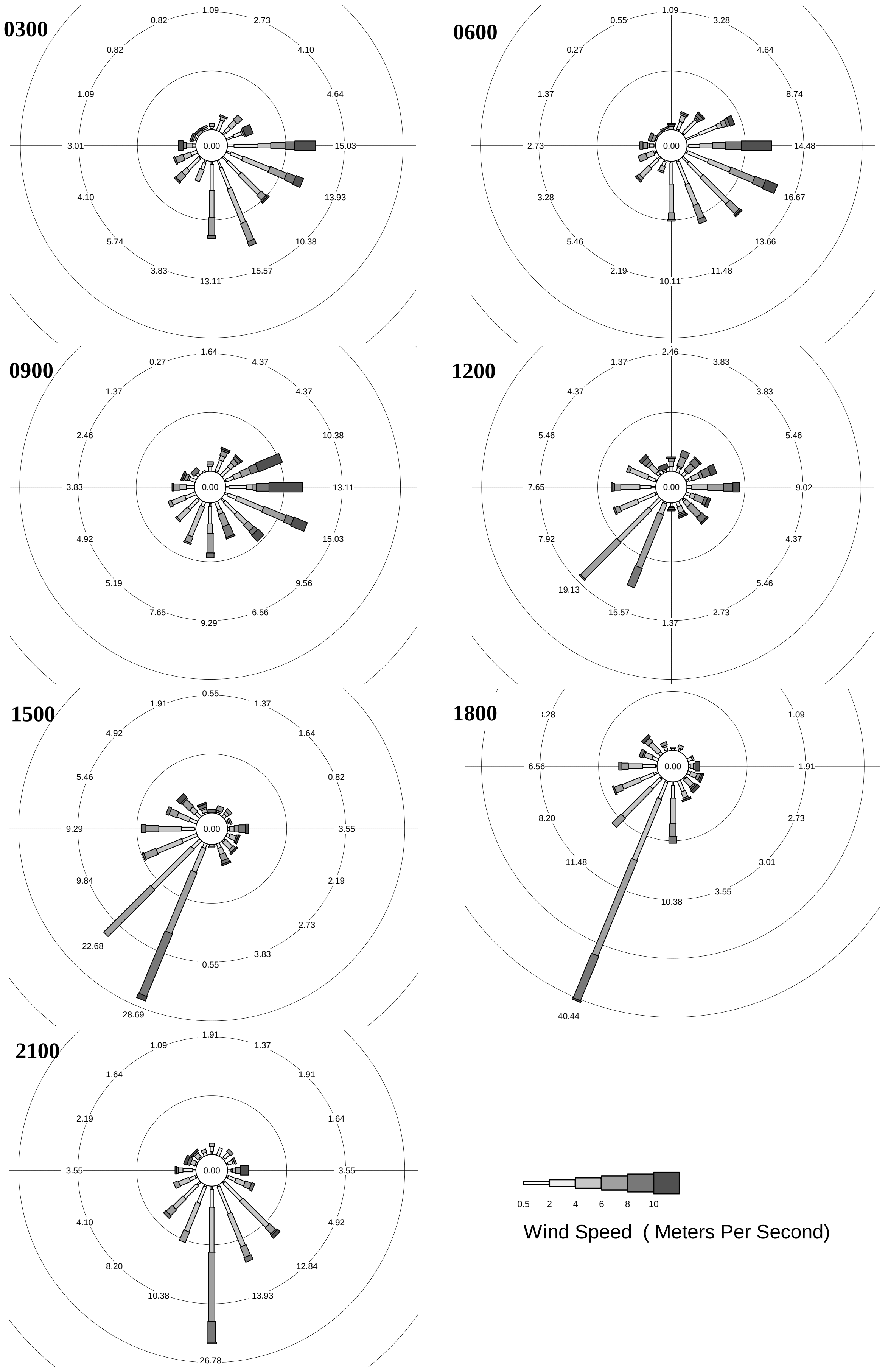

Figure 3-3 Wind Roses by Time of Day at Oakajee in 2007/2008

Figure 3-3 shows that:

- At 0300 to 0600 WST, the winds are generally light Easterly to Southerly. Note, Geraldton airports winds are predominantly NNE at this time;
- By 1200 WST, the winds are predominantly SW to SSW with the frequency of these winds increasing throughout the afternoon;
- By 1800 WST, the winds have a very high frequency of SSW winds; and
- By 2100 WST, the winds have turned more southerly.

This variation is primarily determined by the strong sea breezes that develop in the region, particularly on the coast with the afternoons dominated by the SW to SSW sea breeze which turns southerly around sunset.

3.2.3 Inter-Annual Variation in Winds

To determine the representativeness of the winds for 2007/2008, the annual average wind speeds for Geraldton airport have been presented for the year 2000 onwards (see **Figure 3-4**).

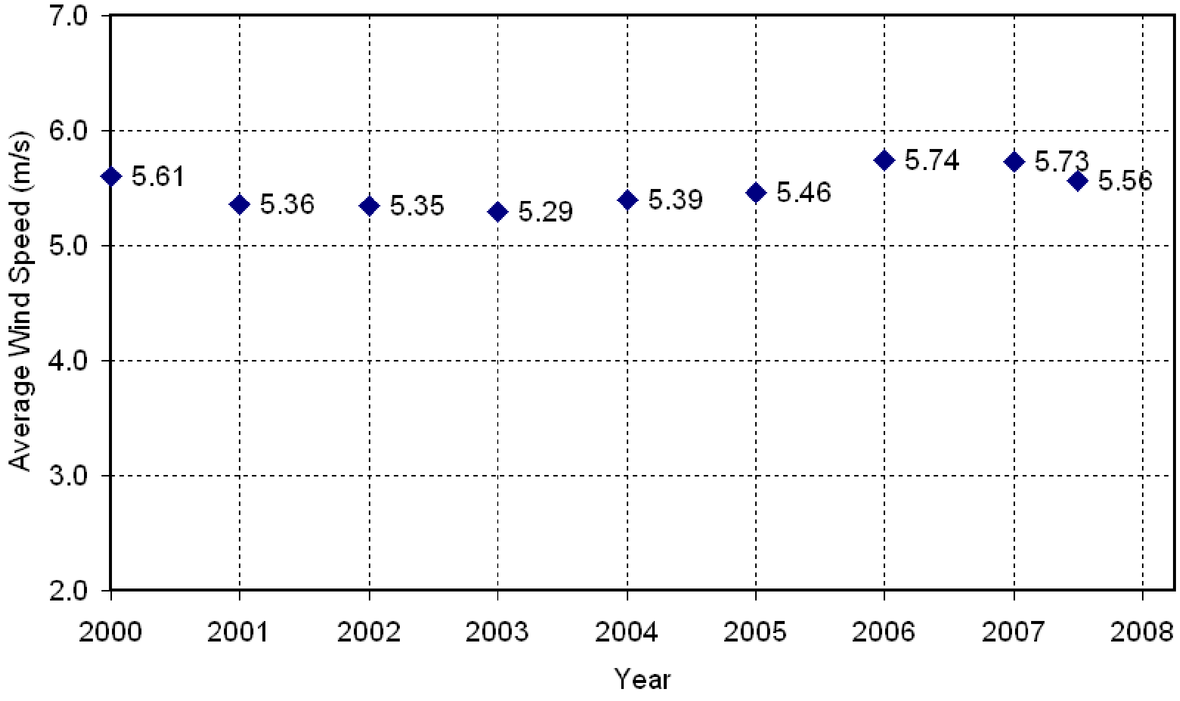

Figure 3-4 Annual Average Wind Speed at Geraldton Airport

Figure 3-4 shows that the annual wind speed varies between 5.29 and 5.74 m/s with the period 2007/2008 having wind speed average of 5.56 m/s which is above average, but not an extreme year. Therefore, based on the average wind speed, 2007/2008 appears to be reasonably representative.

3.3 Air Temperature

The annual distribution of air temperature at 1.5 to 2m above ground level at Oakajee and Geraldton Airport is presented in **Figure 3-5**. This illustrates that Oakajee has more moderate temperatures with less “low” (< 10 degrees) and less high temperatures, and instead has a higher frequency of temperatures in the 16 to 22 degree range. This more moderate temperature range is due to the greater frequency of onshore winds at this site than at the airport as discussed in **Section 3.2.1**.

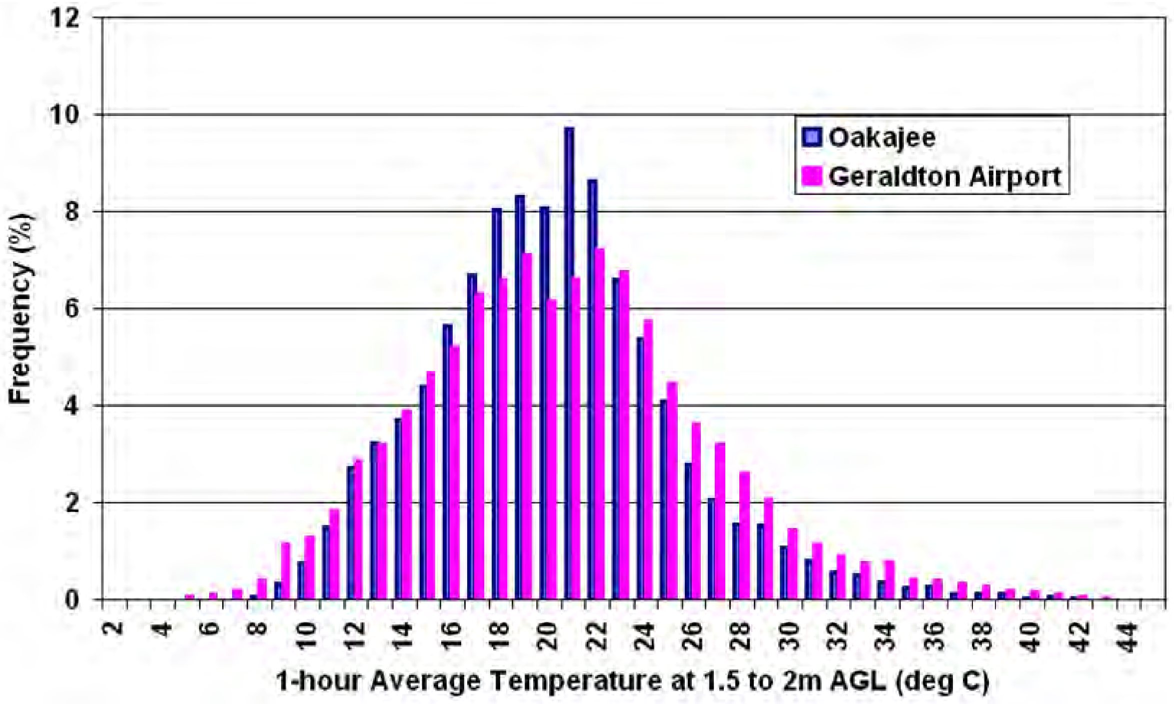

Figure 3-5 Air Temperature Distribution at Oakajee and Geraldton Airport for 2007/2008

3.3.1 Summary of Oakajee Data and Recommended data for Modelling

Based on the comparison of data between the various Oakajee data sets and by year, the following is concluded:

- The two wind sets available at Oakajee are similar though the data from the new site tends to record more southerly winds than the earlier data. Both data sets have good quality data which are suitable for air quality modelling. In this report the later data set is used for modelling primarily because data for TAPM is readily available for this period; and
- There are significant differences between the Oakajee and Geraldton airport winds, with Geraldton airport tending to have more southerly sea breezes and also a much higher frequency of NNE winds.

3.4 Existing Ambient Concentrations in the Geraldton Region

Monitoring of pollutants in the Geraldton region is known to have only occurred for particulate with no gaseous monitoring undertaken to date.

For gaseous pollutants such as volatile organic compounds (VOCs), the concentrations are expected to be low based on monitoring from other regional centres such as Albany (DEC, 2009) with Geraldton expected to have lower concentrations than Albany due to lower wood heater usage and less frequent calm conditions. For pollutants such as NO_X, NO_2 and ozone, the levels would also be expected to be low due to the lack of sources, except for occasional elevated levels from bushfires and/or burning off.

Particulate monitoring in the Geraldton region is known to have been undertaken by:

- Kingstream from 1997 to 2000 with three sites surrounding the Oakajee industrial area. This data could be used to determine background by taking the subtracting the concentrations measured from the upwind monitor. This data however was not available for this study; and
- The DEC from their PM_{10} monitoring station at the Geraldton Bowling Club at 8th street, Geraldton. This monitoring site has operated from September 2005 onwards.

The available data from the DEC Geraldton site (to the end of 2007) is summarised in **Table 3-2** and **Table 3-3**.

Table 3-2 Summary of PM_{10} Sampling at Geraldton

	Year Data Recovery	**Number of Days > 50 µg/m^3)**	**Maximum 24-hour (µg/m^3)**	**Performance against NEPM Standard and Goal**
Sept 2005 Onwards	27.7	2	Not Known	Not Demonstrated
2006	99.4	4	78	Met
2007	Not known	10	116	Exceeded

Table 3-3 24-hour average PM_{10} Statistics at Geraldton

Statistic	**2006 (µg/m^3)**	**2007 (µg/m^3)**
Maximum	78	116
6th Highest	46.6	77
90th percentile	35.4	Not known
75th percentile	27.8	Not known
50th percentile	20.4	Not known

Table 3-2 shows a reasonable degree of variation in the number of exceedances of the 50 µg/m^3 level ranging from 4 to 10 for the two complete years. As the NEPM goal is for no more than 5 exceedances of the 50 µg/m^3 standard, the site was just in compliance in 2006 and was significantly out of compliance in 2007.

Of the days which exceeded the standard, the majority are considered to be due to dust storms. An example of this is the 6th June 2007 as recorded on the ABC (http://202.6.74.88/news/stories/2007/06/06/1944208.htm) as:

Farmers in Western Australia's Mid West have suffered another setback with strong winds blowing away valuable top soil from their properties. Winds of up to 70 kilometres an hour hit Geraldton today, whipping up dust storms. Farmers in the region have little or no ground cover because of a lack of rain and now the winds have ripped though their paddocks, removing precious top soil and damaging crops.

The fiscal year 2007 is considered to be a reasonably atypical year, having relatively poor winter growth during the preceding year. As reported by Findlater (2008), *in 2006 the winter rains did not come until July and the winter growth that year was minimal. As such, with normal stocking, the ground was fairly bare by late winter with dust storms observed from August until the new growth in the 2007 winter*. As such, in 2007, nine of the ten exceedances of the standard occurred before the end of June before the ground cover improved. The Bureau's Geraldton airport observer reported over 10 days with dust clouds or haze evident with the 9th March 2007 and the 22nd June 2007 being two extreme events. On the 9th March, the airport observer recorded weather code 33 (severe dust storm or sandstorm) from 1200 to 1700 (when observations finish) with visibility for periods down to 200m.

5 Modelling Methodology

5.1 Selection of Appropriate Model

For the range of sources from low level to tall /buoyant point sources (see **Section 4**) and for the Oakajee location, the following important processes are required to be modelled:

- Dispersion within the Thermal Internal Boundary Layer (TIBL) that occurs with onshore winds that flow over hot land surfaces. The TIBL is important for tall stacks and/or very buoyant plumes and can lead to a process of fumigation of the plume at distances of several to tens of kilometres downwind, leading to higher concentrations that would otherwise occur;
- Dispersion over the range of atmospheric conditions, from highly convective through to highly stable conditions;
- Airflow and dispersion of plumes around elevated terrain such as the Moresby Range to the east;
- Particle settling and deposition onto surfaces; and
- Dispersion and wind flow under near calm conditions as occurs in the winter months where the winds are light and variable and plumes may meander and stagnate. This is important especially for surface and low level releases.

To model the range of dispersion processes and the range of source, two models, TAPM and CALPUFF have been selected. For tall stacks and buoyant plumes TAPM (The Air Pollution Model) was selected as it is considered the most applicable in terms of modelling plume dispersion within the TIBL, is very good for modelling convective dispersion and is shown to be reasonably accurate in modelling the airflow and dispersion around elevated terrain.

For low level sources, as there are concerns to TAPM’s ability to model correctly the near calm winds and also winds greater than 10 m/s, CALPUFF was selected. CALPUFF (and its meteorological pre-processor CALMET) is the US Environmental Protection Agency (U.S. EPA) preferred model for assessing the long range transport of pollutants. It can also be used for near-field applications involving complex meteorological conditions such as when there is dispersion over land and sea.

Other models, such as AUSPLUME were not selected as AUSPLUME cannot model accurately convective conditions for stacks less than 100m high and its treatment of plume dispersion on elevated terrain is too simplistic. Also, as a Gaussian plume model, it is not theoretically able to model dispersion below wind speeds of about 1 m/s and under these conditions is likely to over-predict concentrations at distances of greater than several kilometres

5.2 TAPM Set Up

TAPM was configured for this using study using the following:

- TAPM v4.01 (the latest available version);

- Modelling of the meteorology on a 33 by 33 grid with 30, 10, 3, 1 and 0.5 km grid spacing that covered the Oakajee area. A 0.5km grid was selected as this was considered fine enough to resolve the majority of the terrain features;
- Concentrations were predicted on a 250m grid over the area using the Lagrangian/Eulerian approach;
- 30 grid levels in the vertical;
- Modelling was undertaken for the 12 month period from July 2007 to June 2008 to be consistent with the available on-site data from the new Oakajee weather station. This was used in preference to the older 1990 to February 1994 data as the TAPM synoptic input files for this period were not as readily available and are not considered as good;
- Land use was defined from aerial photography to better reflect the area rather than the default TAPM land use data bases;
- Use of the TAPM v4 surface schemes without rain processes. This provided a better comparison to the observed winds than using rain processes. This is considered to occur as TAPM over-predicts the rainfall by a factor of 3 and if using rain processes the soil remained too wet, resulting in too high latent heat flux and therefore less frequent sea breezes;
- A monthly variation in soil wetness was applied, varying from 0.11 in the months December to February to 0.15 for August;
- Sea surface temperatures from TAPM data bases; and
- No data assimilation of surface observations to nudge the model predictions. Data assimilation is considered to lead to sharp wind shears in the vertical at night when the winds above the number of layers used to define surface layer return to that derived by TAPM.

5.3 CALMET Set Up and Meteorological File Development

Three dimensional meteorological data were developed for CALPUFF using CALMET (version 6.325). The files were developed with the aim of modelling low level or surface releases and for the important area up to 5 km from the source where the winds would be more or less consistent. As such, the following model set-up options and input data were used:

- A meteorological grid of 33 by 33 grid points with grid spacing of 0.5km as per the TAPM set up;
- Land uses were derived from that used in TAPM with land use categories given in **Table 5-1** with the distribution of the categories presented in **Figure 5-1**;

Table 5-1 CALMET Land Use Characteristics

Land Use	CALMET Land Use Category	Surface Roughness (m)	Bowen Ratio			
			July Aug	Sept	Oct May	Nov to Apr
Sea	54	<0.005	0.0	0.0	0.0	0.0
Moderate Roughness – Low trees and shrubland	20	0.25	1.0	1.5	2.5	4.0
Low Roughness – Open grasslands isolated small trees	30	0.05	1.0	1.5	2.5	4.0

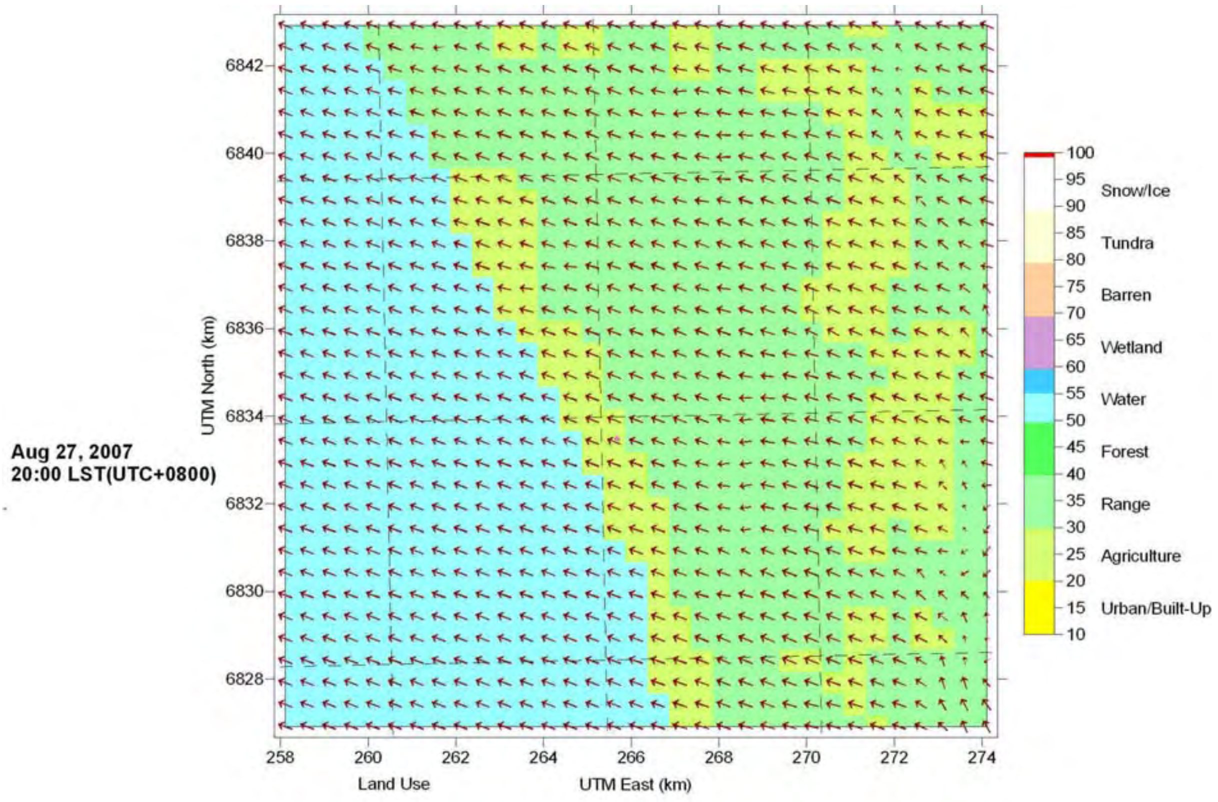

Figure 5-1 Land Use Categories for the Model Grid with Wind vectors for 2000 WST 28 August 2007

- Bowen ratios (the ratio of the sensible to latent heat fluxes) were varied by time of the year according to **Table 5-1**. A ratio of 4 specified for “summer” indicating that most of the heat is sensible heating of the air with little evaporation and transpiration occurring;
- Eleven vertical layers were specified with cell face heights of 20, 50, 100, 150, 200, 300, 500, 1000, 1500, 2500 and 3500m to allow for different wind directions with height. For the layers, biases of -1, -1, -1, -0.8, -0.6, -0.4, -0.2, 0.0, 0.2, 0.5, 1.0 were used such that the winds in the lowest 200m (where the plumes disperse) in the initial guess wind field developed in CALMET are based primarily on the surface winds;
- Rmax1 and Rmax2 used to weight the radius of influence of the wind data in the data assimilation step were set to 3km, with Rmin to 1 km and the relative weighting of the step 1 to observation data to 2km.

5.3.1 Surface and Upper Meteorological Data used in CALMET

Surface winds, air temperature, relative humidity and rainfall in the model domain were available for three sites for three different non overlapping periods as discussed in **Section 3.1**. For modelling, the 2007/2008 Oakajee data was used as it is a very well sited station and corresponds to the period with good upper air data from TAPM (see below). For the period July 2007 to June 2008, there was an excellent data return of 99.84% from the Oakajee site with the missing data (14 hours) substituted from Geraldton airport to make a complete year of data.

Cloud cover for the period was obtained from Geraldton airport which records the cloud type, amount and cloud base for 12 hours per day from 0600 to 1700 WST. Cloud at night was linearly interpolated between the last record in the afternoon/evening and the first record in the morning. This was considered to be preferable to using TAPM predictions as TAPM over-predicts the rainfall and therefore likely cloud amount.

Upper winds and temperatures were obtained from TAPM for the location of the Oakajee meteorological station. This was required as the Geraldton Bureau site generally has only one morning flight at 0700 WST with a wind only flight at 1300 WST, whilst CALMET requires at least two radiosonde flights per day. The upper wind and temperature data derived from TAPM were obtained for the location of the Oakajee meteorological station though as input into CALMET they were specified as a location 40 km north of this such that in the step 2 winds they would not be used with the step 1 winds derived by CALMET retained. This was undertaken such that the surface winds essentially reproduced the observations with the only wind variation due to what CALMET developed due to its drainage flows and topographical blocking. Examples of the surface wind patterns for light winds of about 1 m/s are presented in **Figure 5-1** and **Figure 5-2**.

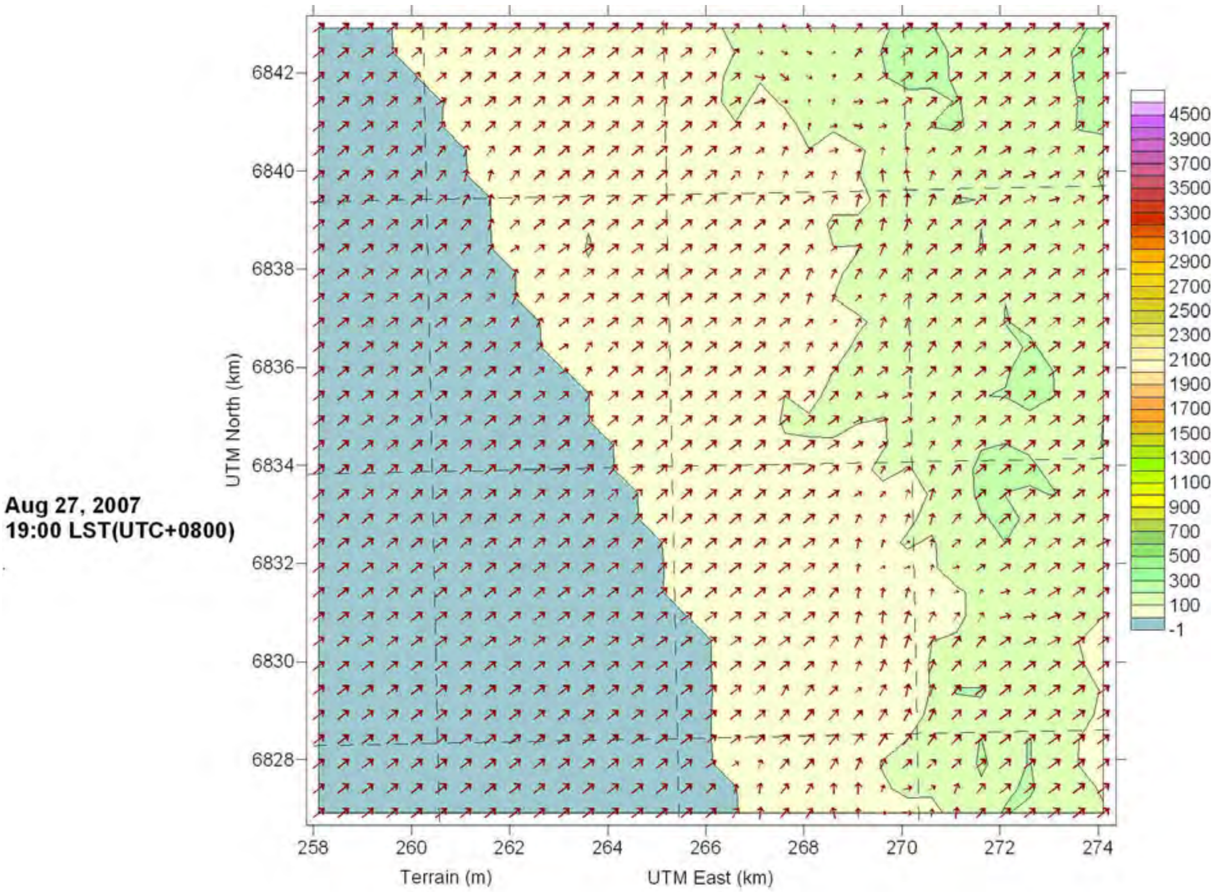

Figure 5-2 Meteorological grid showing the terrain and wind vectors for 1900 WST 27th August 2007

5.4 Predicted Stability Classes

The distribution of Pasquill Gifford stability classes predicted by CALMET at the Oakajee weather site using the Turner method and using Golder's method (based on the estimated Monin Obukhov length and surface roughness) are presented in **Table 5-2**. Stability wind roses are also presented in **Figure 5-3**.

Table 5-2 Distribution of Stability Classes at Oakajee from CALMET

Period	**Stability Class (%)**					
	A	**B**	**C**	**D**	**E**	**F**
This study (Turner Method)	0.13	4.4	15.1	53.2	17.0	10.1
This Study (Golders method)	0.72	2.4	12.2	65.8	13.4	5.4
SSE (1992/1993)	1.9	5.4	17.0	55.6	12.1	8.0

Notes: Stability classes range from A, highly dispersive conditions that occur for low wind speeds with strong solar insolation, to neutral conditions (D class) which occur for overcast and/or cloudy conditions to F class which corresponds to very low dispersion rates (stable atmosphere). These conditions occur for nights with clear skies and low wind speeds.

Table 5-2 indicates there is a high proportion of neutral stabilities at Oakajee with a low percentage of very unstable or stable conditions. A comparison to the stability class distribution determined by Steedman Science & Engineering in 1993 show a similar distribution. The high percentage of neutral classes is considered to result from the high frequency of moderate to strong wind speeds which tend to produce neutral conditions. Low wind speeds which result in the very unstable A class and stable F class conditions are not that common at Oakajee unlike most other sites in Australia. The stability wind roses in **Figure 5-3** indicate that the unstable conditions tend to be associated with westerly winds whilst the stable conditions are associated with southerly to easterly winds at night.

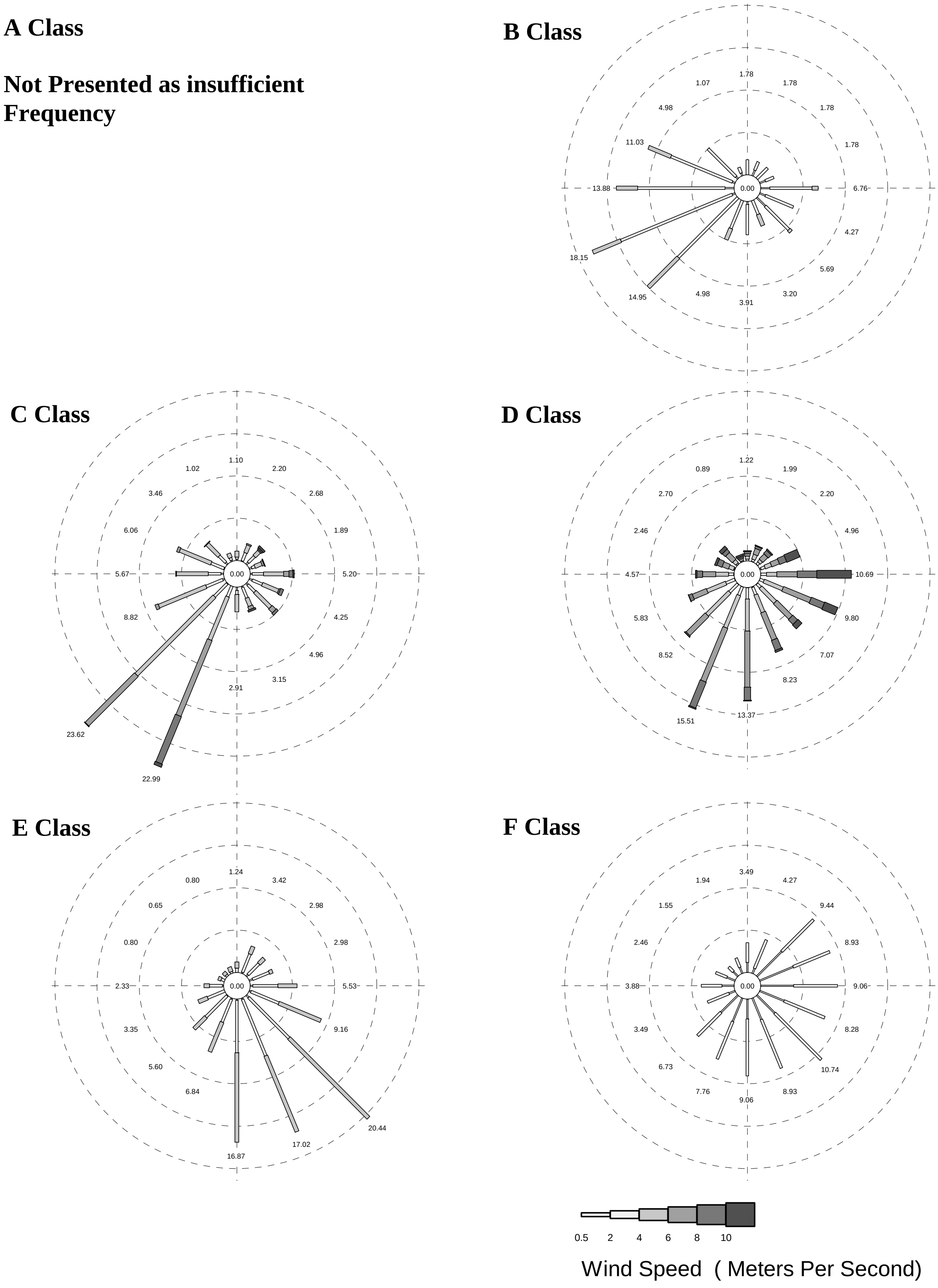

Figure 5-3 Stability Wind Roses at Oakajee in 2007/2008

5.5 CALPUFF Model Set Up

For dispersion modelling, CALPUFF version 6.252 (25 August 2008) was used with the following model options:

- Meteorological file using the 3 dimensional wind and turbulence fields generated by CALMET;
- Use of 1-hour wind data in the model. CALPUFF v6 can utilise sub 1-hour wind data, but this was not used in this assessment as it is not yet an accepted practice;
- Pollution predicted on a 250m subset of the meteorological grid;
- Dispersion estimates using the Pasquil Gifford dispersion curves. These curves were adjusted for the roughness length and the sampling time, with the variable TPG set to 10 minutes in line with the generally accepted practice that the Pasquill Gifford dispersion curves relate to 3 to 10 minute averages and that the horizontal dispersion should be increased when predicting 1-hour averages;
- Threshold for calms of 0.5 m/s;
- Minimum horizontal standard deviation overland of 0.5 m/s as per the CALPUFF defaults;
- Modelling of fugitive sources from a WWTP as a volume source option within CALMET. This requires coordinates of the centre of the volume source, source height and initial vertical and horizontal dispersion estimates. Modelling of fugitive dust emissions were predicted using an area source and modelled using the slug option; and
- Incorporation of terrain using the partial plume path adjustment.

5.6 Particle Size Distribution used in Modelling

For modelling particulate dispersion, the size distribution of the particulate is required such that the model can estimate the rate of settling and deposition of the various size fractions. This is more important for particulate greater than 10 μm as they tend to be deposited more quickly, whilst particulate less than 2.5 μm is not readily deposited within the domains of local models.

For modelling particulate, the USEPA particle size distributions for crustal sources are generally used as listed in **Table 5-3**. This indicates that crustal generated dust has a small percentage of particulate below 2.5 μm with the majority above 2.5 μm.

Table 5-3 Aerodynamic Particle Distribution used for Fugitive Dust

Size Range (μm)	Mid Range used in Modelling (μm)	Percentage in Range (%)
< 2.5	1	15
2.5 - 5.0	3	42
5.0 - 10.0	7	43

5.7 NO to NO_2 Conversion

At release from combustion sources, NO_X is predominantly in the form of NO with around 5 to 10% as NO_2. After release, the NO is converted to NO_2 by chemical reactions, primarily involving ozone in the presence of sunlight and to a lesser extent due to other reactive gases.

In the literature there are a number of models and empirical relationships for estimating the conversion of NO to NO_2 for plumes from stacks. In this study as a conservative measure a simple relationship that NO_X consists of 30% NO_2 is used as was proposed for the assessment of the 330 MW Newgen Perth power station (Katestone 2007). This relationship may under-predict the fraction of NO_2 at low concentrations, but at the higher NO_X concentrations will be conservative.

Using this estimate of NO_2, the actual NO_X concentrations at ground are then estimated as:

$$\begin{aligned} NO_X \text{ (actual glc in } \mu g/m^3) &= NO_2 + NO = 0.3\, NO_{X\ pred} + 0.7\,(30/46)\, NO_{X\ pred} \\ &= [0.3 + 0.7(30/46)]\, NO_{X\ pred} \\ &= 0.7565\, NO_{X\ pred} \qquad \textbf{(Equation 5.1)} \end{aligned}$$

These two relationships for estimating NO_2 and ground level NO_X were used for the 1-hour and 24-hour predictions, whilst for the annual predictions where the average conversion to NO_2 may be higher, a 100% conversion of NO to NO_2.was assumed as a conservative measure.

APPENDIX B 07/08 HIGH BACKGROUND DUST EVENTS

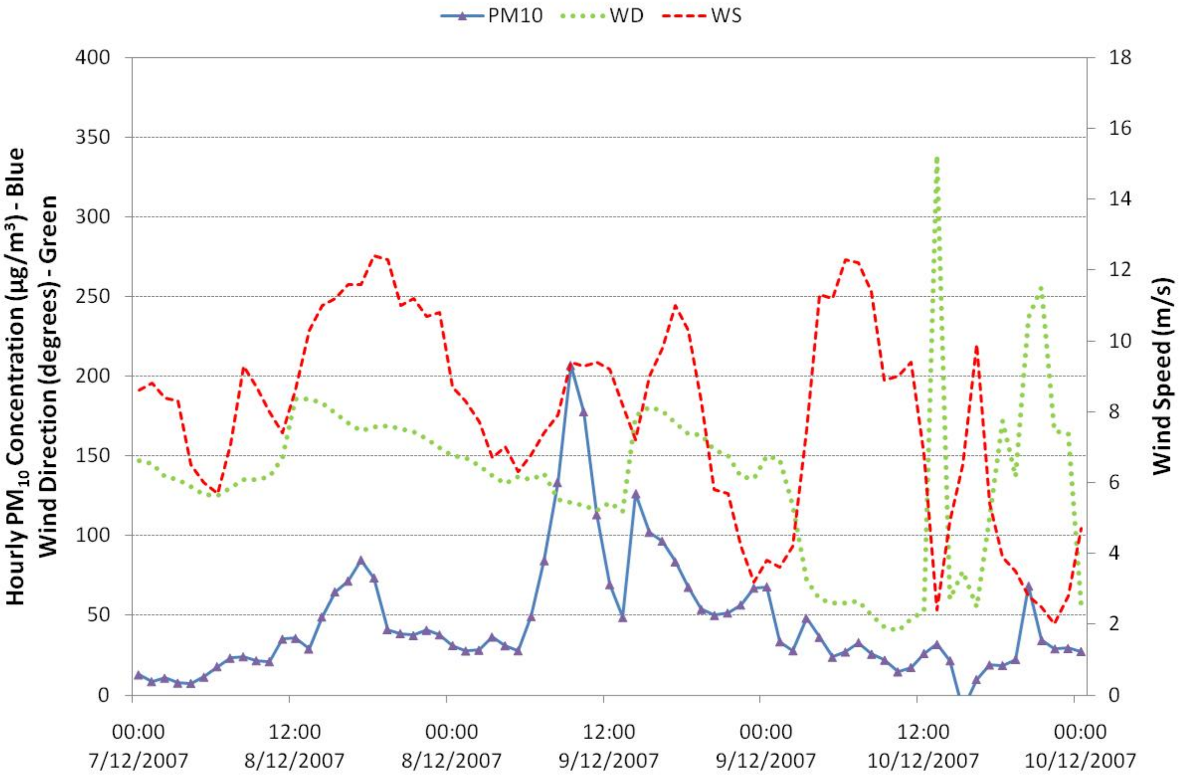

Figure A-1 Hourly PM$_{10}$ concentrations at DEC Geraldton station 8 – 10 December 2007

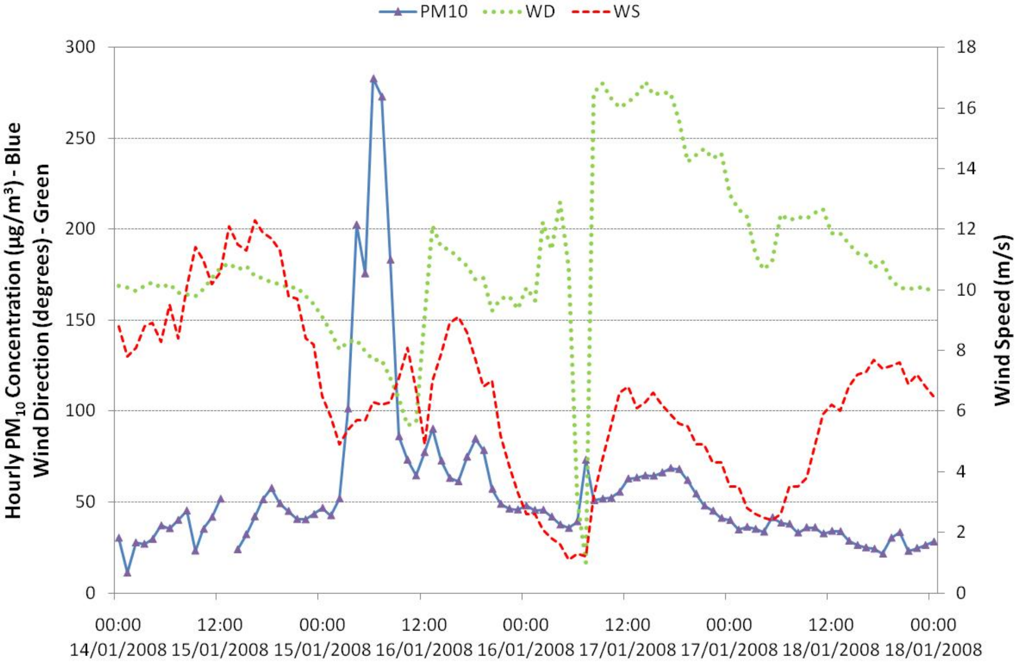

Figure A-2 Hourly PM$_{10}$ concentrations at DEC Geraldton station 15 – 18 January 2008

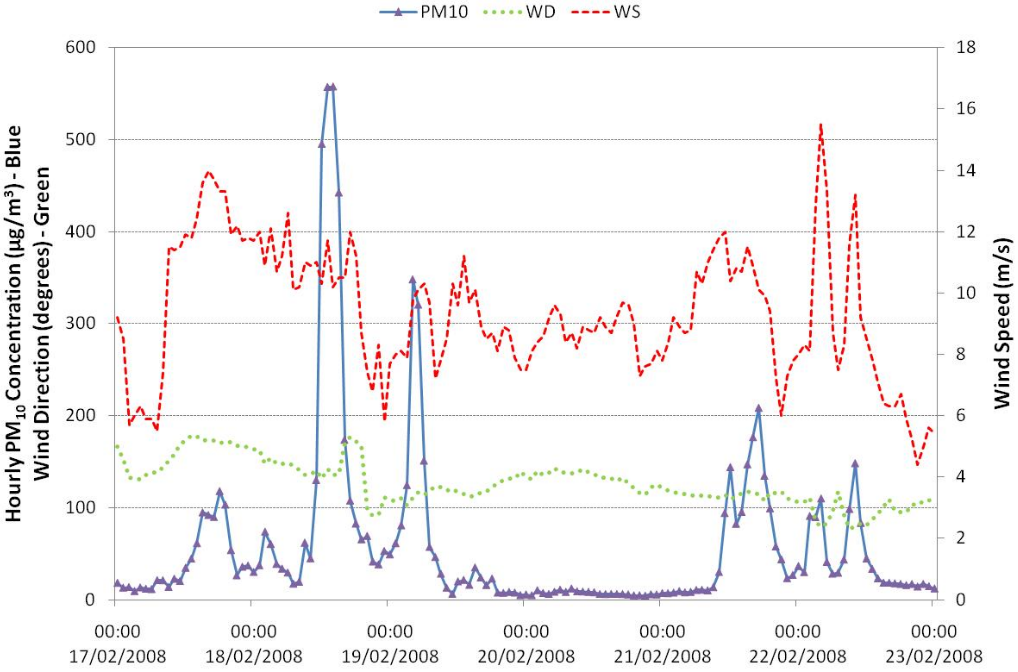

Figure A-3 Hourly PM$_{10}$ concentrations at DEC Geraldton station 15 – 23 February 2008

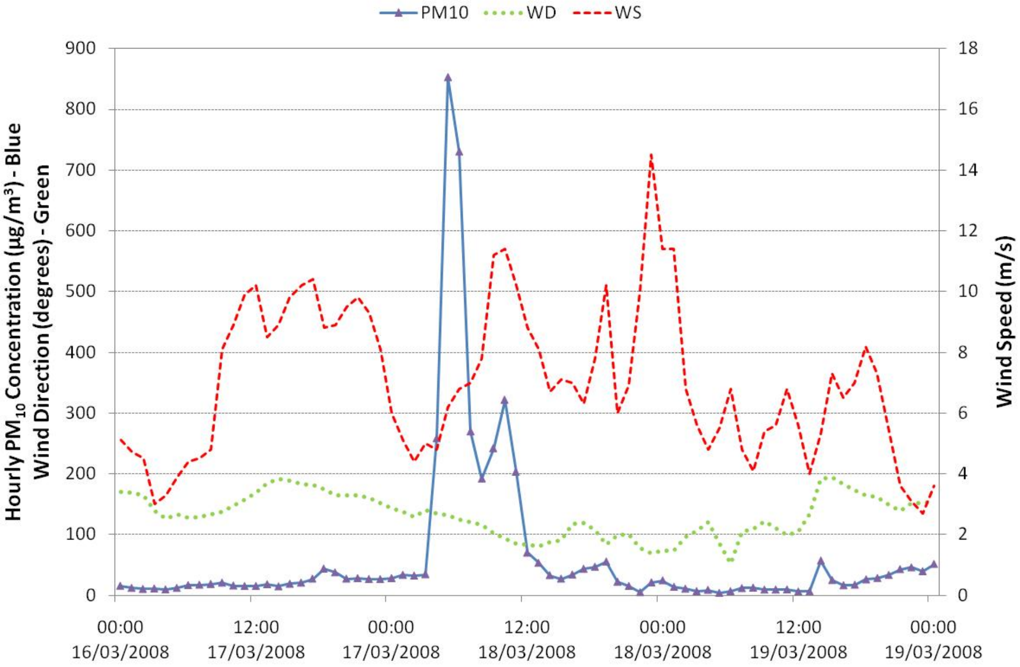

Figure A-4 Hourly PM_{10} concentrations at DEC Geraldton station 17 – 19 March 2008

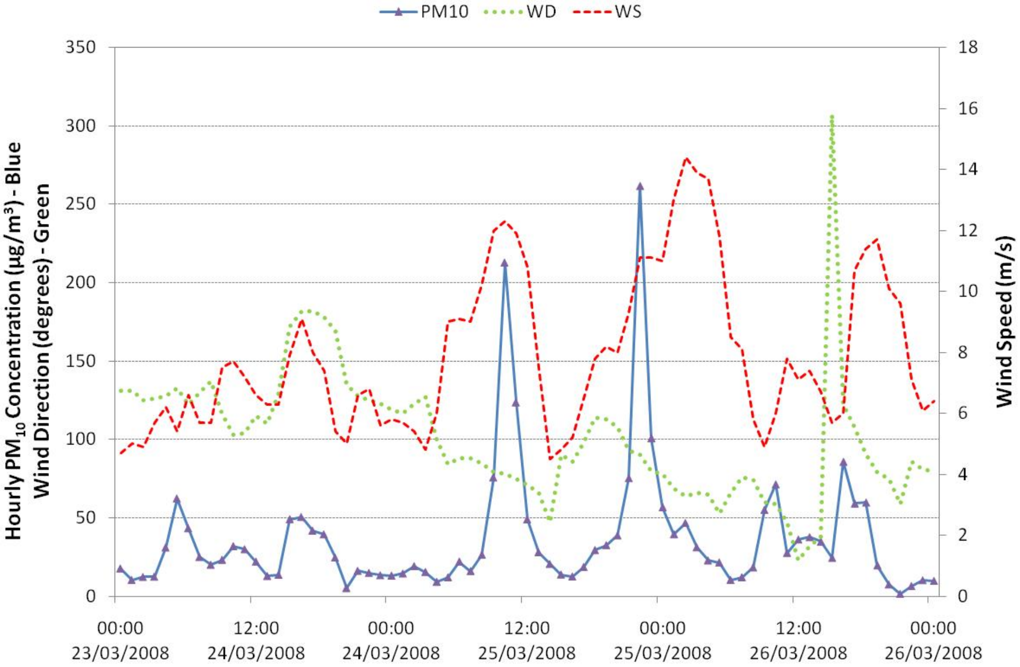

Figure A-5 Hourly PM_{10} concentrations at DEC Geraldton station 24 – 26 March 2008

SINCLAIR KNIGHT MERZ

APPENDIX C EXAMPLE SUMMARY METEOROLOGICAL DATA

```
    Stability Classes

              A      B      C      D      E      F  Total
 Number       5    281   1270   5080   1375    773  8784
 Percent   0.06   3.20  14.46  57.83  15.65   8.80

  Stability Class by Wind direction
       A    B    C    D    E    F
 N    0.0  3.4 11.3 49.4 17.0 18.9
 NE   0.0  1.7 11.6 48.1 15.1 23.6
 E    0.1  2.2  7.6 70.2 10.7  9.2
 SE   0.1  1.5  7.1 49.8 31.1 10.3
 S    0.0  1.1  5.1 66.2 20.6  7.1
 SW   0.1  3.9 31.5 52.2  7.5  4.9
 W    0.1  9.8 19.8 56.5  7.4  6.4
 NW   0.2  8.5 23.8 56.0  4.6  6.8

Stabilty Class by Hour of Day
Hour     A    B    C    D    E    F
 1       0    0    0  188  110   68
 2       0    0    0  196   98   72
 3       0    0    0  188  117   61
 4       0    0    0  199  104   63
 5       0    0    0  204  107   55
 6       0    0    1  230   88   47
 7       0    0    9  290   38   29
 8       0    2   42  322    0    0
 9       0   22   74  270    0    0
10       0   28   94  244    0    0
11       1   46  150  169    0    0
12       1   58  177  130    0    0
13       2   55  199  110    0    0
14       0   47  208  111    0    0
15       1   16  143  206    0    0
16       0    6   96  264    0    0
17       0    1   55  310    0    0
18       0    0   22  319   19    6
19       0    0    0  232   85   49
20       0    0    0  183  128   55
21       0    0    0  174  136   56
22       0    0    0  170  129   67
23       0    0    0  180  114   72
24       0    0    0  191  102   73
```

```
 Mixing heights            Time (hr)
                  1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24

 > 2000 m         3   4   3   4   3   4   5   3   0   2   4   7  10   8   9   7   6   0   2   1   1   3   3   4
1800 to 2000 m    0   1   3   2   5   3   1   1   0   1   7   7   6  10   2   2   1   1   2   2   4   1   0   0
```

```
  1600 to 1800 m    4   2   8   4   5   9   5   3   6   9   9  14  21  11   7   6   5   2   3   1   0   0   0   1
  1400 to 1600 m    2   5   5   9  11  10   4  11  12  13  21  42  46  36  32  17   8   8   4   2   2   2   3   3
  1200 to 1400 m    7   9   7  12   4   5  16  13  15  30  58  63  61  68  66  44  20  11   3   4   5   5   4   6
  1000 to 1200 m   10  14  10   9  13  11  23  27  57  70  81  88  85  81  79  79  56  34  17   8   5   2   8   7
   800 to 1000 m   13  13  12   7  15  21  35  39  75  92 100  75  73  86  88  91  90  52  31  20  18  17  12  13
   600 to  800 m   30  20  32  29  31  27  45  77  74  78  51  43  42  45  57  83  89  71  46  41  37  41  30  24
   400 to  600 m   68  62  52  60  63  64  63  72  73  57  33  26  22  20  26  35  69  78  59  60  61  61  76  76
   200 to  400 m  100 111 112 110  96  94  82  85  50  14   2   1   0   1   0   2  22  70 116 117 122 112 111 108
     0 to  200 m  129 125 122 120 120 118  87  35   4   0   0   0   0   0   0   0   0  39  83 110 111 122 119 124

                      Wind Occurence Matrix

                       Speed           N      NE      E       SE      S       SW      W      NW    Total
                        (m/s)

                     <0.5 (calm)                                                                5.44
                      0.5 -   1.9      0.26    0.97    1.62    1.34    1.78    1.42    0.54    0.48    8.40
                      2.0 -   3.9      1.02    1.97    2.49    4.06    4.09    3.61    2.30    0.94   20.49
                      4.0 -   5.9      0.75    1.12    2.56    6.03    6.52    7.32    3.04    1.30   28.64
                      6.0 -   7.9      0.39    0.93    2.60    3.10    5.99    6.68    1.70    0.83   22.21
                      8.0 -   9.9      0.24    0.40    2.25    1.18    2.03    1.96    0.57    0.54    9.16
                     10.0 - 11.9       0.13    0.30    2.02    0.71    0.14    0.09    0.16    0.33    3.86
                     12.0 - 13.9       0.01    0.07    1.06    0.09    0.00    0.00    0.01    0.05    1.29
                     14.0 - 15.9       0.00    0.01    0.33    0.09    0.00    0.00    0.00    0.00    0.43
                     16.0 - 17.9       0.00    0.00    0.05    0.02    0.00    0.00    0.00    0.00    0.07
                     >18.0             0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
                     Total             2.80    5.76   14.97   16.63   20.54   21.08    8.31    4.46  100.00

   Speed           N     NNE     NE    ENE     E     ESE    SE    SSE     S     SSW     SW    WSW     W     WNW     NW    NNW
Total
    (m/s)

<0.5 (calm)                                                                                                                   5.4
 0.5 -   1.9      0.1    0.2    0.5    0.6    0.8    0.8    0.8    0.6    0.9    1.3    0.6    0.3    0.3    0.2    0.3    0.1    8.4
 2.0 -   3.9      0.4    0.9    1.0    1.0    1.4    1.4    2.1    2.2    2.1    1.6    1.9    1.8    1.2    0.6    0.5    0.3   20.5
 4.0 -   5.9      0.4    0.6    0.4    0.6    1.3    2.2    3.5    2.8    3.6    3.4    4.1    2.4    1.5    1.0    0.6    0.3   28.6
 6.0 -   7.9      0.1    0.4    0.4    0.6    1.3    1.9    1.4    1.9    3.5    4.8    2.9    1.0    0.8    0.5    0.6    0.1   22.2
 8.0 -   9.9      0.1    0.1    0.3    0.5    1.3    0.9    0.5    0.7    0.8    2.6    0.1    0.2    0.4    0.3    0.2    0.1    9.2
10.0 - 11.9       0.1    0.0    0.1    0.6    1.3    0.5    0.3    0.2    0.0    0.1    0.0    0.0    0.1    0.1    0.2    0.1    3.9
12.0 - 13.9       0.0    0.0    0.0    0.3    0.7    0.1    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    1.3
14.0 - 15.9       0.0    0.0    0.0    0.0    0.3    0.1    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.4
16.0 - 17.9       0.0    0.0    0.0    0.0    0.0    0.1    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.1
>18.0             0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
Total             1.3    2.3    2.8    4.2    8.4    8.2    8.5    8.3   11.0   13.8    9.7    5.7    4.3    2.8    2.4    0.9  100.0

                      Ave wind speed =    5.20

                       Wind Speed    Count   Percentage
                       range (m/s)              (%)
                      0.00 -   0.99    859      9.78
                      1.00 -   1.99    357      4.06
                      2.00 -   2.99    745      8.48
```

```
  3.00 -  3.99  1055    12.01
  4.00 -  4.99  1211    13.79
  5.00 -  5.99  1305    14.86
  6.00 -  6.99  1083    12.33
  7.00 -  7.99   868     9.88
  8.00 -  8.99   499     5.68
  9.00 -  9.99   306     3.48
 10.00 - 10.99   197     2.24
 11.00 - 11.99   142     1.62
 12.00 - 12.99    69     0.79
 13.00 - 13.99    44     0.50
 14.00 - 14.99    23     0.26
 15.00 - 15.99    15     0.17
 16.00 - 16.99     4     0.05
 17.00 - 17.99     2     0.02
 18.00 - 18.99     0     0.00
 19.00 - 19.99     0     0.00
 20.00 - 20.99     0     0.00
 21.00 - 21.99     0     0.00
 22.00 - 22.99     0     0.00
 23.00 - 23.99     0     0.00
 24.00 - 24.99     0     0.00
 25.00 - 25.99     0     0.00
 26.00 - 26.99     0     0.00
 27.00 - 27.99     0     0.00
 28.00 - 28.99     0     0.00
 29.00 - 29.99     0     0.00
```

APPENDIX D SOURCE CHARACTERISTICS

Table C-1 Source modelling dimensions

Source	Source Acronym	Horizontal Spread (m)	Vertical Spread (m)	Height (m)	Easting (m)	Northing (m)
Car Dumper	CD	2.5	1.75	3	264889	6835123
Transfer Station 1	TS1	4	10	4	264422	6834911
Transfer Station 2	TS2	4	10	4	264277	6834845
Stacker 1	ST1	50	10	5	264552	6834599
Stacker 2	ST2	50	10	5	264567	6834205
Reclaimer	REC	30	4	5	264841	6833814
Transfer Station 3	TS3	4	10	4	264322	6834917
Lump Rescreening Plant	LRP	20	4	5	264136	6834833
Rescreened Fines - Transfer Station	RSF-TS	4	10	4	264422	6834911
Rescreened Fines - Stacker	RSF-ST	50	10	5	264552	6834599
Transfer Station 4	TS4	4	10	4	262645	6834225
Shiploader	SL	15	3	10	262360	6834426
Vehicles	VEH	150	0.25	1	264172	6834939
Wind Erosion 1	WE1	75	8.5	10	264898	6833693
Wind Erosion 2	WE2	75	8.5	10	264788	6833956
Wind Erosion 3	WE3	75	8.5	10	264666	6834201
Wind Erosion 4	WE4	75	8.5	10	264561	6834420
Wind Erosion 5	WE5	75	8.5	10	264426	6834682
Wind Erosion 6	WE6	75	8.5	10	264039	6834936
Wind Erosion 7	WE7	75	8.5	10	264316	6835044
Wind Erosion 8	WE8	75	8.5	10	264604	6835158
Conveyor 1A	CV1A	85	0.25	1	264708	6835046
Conveyor 1B	CV1B	85	0.25	1	264469	6834928
Conveyor 2A	CV2A	223	0.25	1	263965	6834771
Conveyor 2B	CV2B	223	0.25	1	263103	6834410

APPENDIX E AUSPLUME CONFIGURATION FILE

```
1         ____________________________________________________________

            Oakajee 0708 Met WV05017 (01/05/2010) PM10 Contour Base

          ____________________________________________________________

 Concentration or deposition                          Concentration
 Emission rate units                                  grams/second
 Concentration units                                  microgram/m3
 Units conversion factor                              1.00E+06
 Constant background concentration                            0.00E+00
 Terrain effects                                      None
 Plume depletion due to dry removal mechanisms included.
 Smooth stability class changes?                      No
 Other stability class adjustments ("urban modes")    None
 Ignore building wake effects?                        Yes
 Decay coefficient (unless overridden by met. file)   0.000
 Anemometer height                                    10 m
 Roughness height at the wind vane site               0.030 m
 Use the convective PDF algorithm?                    No

                    DISPERSION CURVES
 Horizontal dispersion curves for sources <100m high  Pasquill-Gifford
 Vertical  dispersion  curves for sources <100m high  Pasquill-Gifford
 Horizontal dispersion curves for sources >100m high  Briggs Rural
 Vertical  dispersion  curves for sources >100m high  Briggs Rural
 Enhance horizontal plume spreads for buoyancy?       Yes
 Enhance  vertical  plume spreads for buoyancy?       Yes
 Adjust horizontal P-G formulae for roughness height? Yes
 Adjust  vertical  P-G formulae for roughness height? Yes
 Roughness height                                     0.100m
 Adjustment for wind directional shear                None

                     PLUME RISE OPTIONS
 Gradual plume rise?                                  Yes
 Stack-tip downwash included?                         Yes
 Building downwash algorithm:                        PRIME method.
 Entrainment coeff. for neutral & stable lapse rates 0.60,0.60
 Partial penetration of elevated inversions?          No
 Disregard temp. gradients in the hourly met. file?   No

 and in the absence of boundary-layer potential temperature gradients
 given by the hourly met. file, a value from the following table
 (in K/m) is used:

    Wind Speed                Stability Class
     Category       A      B      C      D      E      F
   ________________________________________________________

        1         0.000  0.000  0.000  0.000  0.020  0.035
```

```
       2         0.000  0.000  0.000  0.000  0.020  0.035
       3         0.000  0.000  0.000  0.000  0.020  0.035
       4         0.000  0.000  0.000  0.000  0.020  0.035
       5         0.000  0.000  0.000  0.000  0.020  0.035
       6         0.000  0.000  0.000  0.000  0.020  0.035

WIND SPEED CATEGORIES
Boundaries between categories (in m/s) are:  1.54,  3.09,  5.14,  8.23, 10.80

WIND PROFILE EXPONENTS: "Irwin Rural" values (unless overridden by met. file)

AVERAGING TIMES
24 hours

_____________________________________________________________________________

1         ____________________________________________________________

           Oakajee 0708 Met WV035017 (01/05/2010) PM10 Contour Base

                          SOURCE CHARACTERISTICS

          ____________________________________________________________


                  VOLUME SOURCE: CD

   X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
 264889  6835123            0m             3m         3m             2m

             (Constant) emission rate = 1.00E+00 grams/second

        Hourly multiplicative factors will be used with
        this emission factor.

                  Particle  Particle  Particle
                    Mass      Size    Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3100      1.0      1.00
                    0.2600      4.0      1.00
                    0.2300      7.0      1.00
                    0.2000      9.0      1.00


                  VOLUME SOURCE: TS1

   X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
 264422  6834911            0m             4m         4m            10m

             (Constant) emission rate = 1.00E+00 grams/second
```

```
       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size    Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3100      1.0       1.00
                    0.2600      4.0       1.00
                    0.2300      7.0       1.00
                    0.2000      9.0       1.00


                  VOLUME SOURCE: TS2

  X(m)     Y(m)      Ground Elevation    Height   Hor. spread   Vert. spread
264277  6834845             0m              4m         4m            10m

             (Constant) emission rate = 1.00E+00 grams/second

       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size    Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3100      1.0       1.00
                    0.2600      4.0       1.00
                    0.2300      7.0       1.00
                    0.2000      9.0       1.00


                  VOLUME SOURCE: ST1

  X(m)     Y(m)      Ground Elevation    Height   Hor. spread   Vert. spread
264552  6834599             0m              5m        50m            10m

             (Constant) emission rate = 1.00E+00 grams/second

       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size    Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3100      1.0       1.00
                    0.2600      4.0       1.00
                    0.2300      7.0       1.00
                    0.2000      9.0       1.00
```

```
                    VOLUME SOURCE: ST2

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
264567  6834205             0m            5m         50m            10m

               (Constant) emission rate = 1.00E+00 grams/second

         Hourly multiplicative factors will be used with
         this emission factor.

                    Particle  Particle  Particle
                      Mass      Size    Density
                    fraction  (micron)  (g/cm3)
                   _____________________________
                      0.3100      1.0      1.00
                      0.2600      4.0      1.00
                      0.2300      7.0      1.00
                      0.2000      9.0      1.00


                    VOLUME SOURCE: REC

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
264841  6833814             0m            5m         30m             4m

               (Constant) emission rate = 1.00E+00 grams/second

         Hourly multiplicative factors will be used with
         this emission factor.

                    Particle  Particle  Particle
                      Mass      Size    Density
                    fraction  (micron)  (g/cm3)
                   _____________________________
                      0.3100      1.0      1.00
                      0.2600      4.0      1.00
                      0.2300      7.0      1.00
                      0.2000      9.0      1.00


                    VOLUME SOURCE: TS3

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
264322  6834917             0m            4m          4m            10m

               (Constant) emission rate = 1.00E+00 grams/second

         Hourly multiplicative factors will be used with
         this emission factor.

                    Particle  Particle  Particle
```

```
                    Mass      Size     Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3100      1.0       1.00
                    0.2600      4.0       1.00
                    0.2300      7.0       1.00
                    0.2000      9.0       1.00


                  VOLUME SOURCE: LRP

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread    Vert. spread
264136  6834833            0m              5m         20m            4m

             (Constant) emission rate = 1.00E+00 grams/second

       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size     Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3100      1.0       1.00
                    0.2600      4.0       1.00
                    0.2300      7.0       1.00
                    0.2000      9.0       1.00


                  VOLUME SOURCE: RSF-TS

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread    Vert. spread
264422  6834911            0m              4m          4m           10m

             (Constant) emission rate = 1.00E+00 grams/second

       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size     Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3100      1.0       1.00
                    0.2600      4.0       1.00
                    0.2300      7.0       1.00
                    0.2000      9.0       1.00


                  VOLUME SOURCE: RSF-ST

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread    Vert. spread
```

```
 264552  6834599             0m             5m         50m           10m

              (Constant) emission rate = 1.00E+00 grams/second

        Hourly multiplicative factors will be used with
        this emission factor.

                     Particle  Particle  Particle
                       Mass      Size     Density
                     fraction  (micron)  (g/cm3)
                    _____________________________
                       0.3100      1.0      1.00
                       0.2600      4.0      1.00
                       0.2300      7.0      1.00
                       0.2000      9.0      1.00


                     VOLUME SOURCE: TS4

   X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
 262645  6834225             0m             4m          4m           10m

              (Constant) emission rate = 1.00E+00 grams/second

        Hourly multiplicative factors will be used with
        this emission factor.

                     Particle  Particle  Particle
                       Mass      Size     Density
                     fraction  (micron)  (g/cm3)
                    _____________________________
                       0.3100      1.0      1.00
                       0.2600      4.0      1.00
                       0.2300      7.0      1.00
                       0.2000      9.0      1.00


                     VOLUME SOURCE: SL

   X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
 262360  6834426             0m            10m         15m            3m

              (Constant) emission rate = 1.00E+00 grams/second

        Hourly multiplicative factors will be used with
        this emission factor.

                     Particle  Particle  Particle
                       Mass      Size     Density
                     fraction  (micron)  (g/cm3)
                    _____________________________
                       0.3100      1.0      1.00
```

```
                    0.2600      4.0      1.00
                    0.2300      7.0      1.00
                    0.2000      9.0      1.00


                  VOLUME SOURCE: VEH

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
264172  6834939             0m             1m        150m           0m

             (Constant) emission rate = 1.00E+00 grams/second

       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size    Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3100      1.0      1.00
                    0.2600      4.0      1.00
                    0.2300      7.0      1.00
                    0.2000      9.0      1.00


                  VOLUME SOURCE: WE1

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
264898  6833693             0m            10m         75m           9m

             (Constant) emission rate = 1.00E+00 grams/second

       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size    Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3100      1.0      1.00
                    0.2600      4.0      1.00
                    0.2300      7.0      1.00
                    0.2000      9.0      1.00


                  VOLUME SOURCE: WE2

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
264788  6833956             0m            10m         75m           9m

             (Constant) emission rate = 1.00E+00 grams/second
```

```
                Hourly multiplicative factors will be used with
                this emission factor.

                           Particle  Particle  Particle
                             Mass      Size    Density
                           fraction  (micron)  (g/cm3)
                          ----------------------------
                             0.3100      1.0      1.00
                             0.2600      4.0      1.00
                             0.2300      7.0      1.00
                             0.2000      9.0      1.00


                           VOLUME SOURCE: WE3

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
264666  6834201            0m             10m        75m            9m

                      (Constant) emission rate = 1.00E+00 grams/second

                Hourly multiplicative factors will be used with
                this emission factor.

                           Particle  Particle  Particle
                             Mass      Size    Density
                           fraction  (micron)  (g/cm3)
                          ----------------------------
                             0.3100      1.0      1.00
                             0.2600      4.0      1.00
                             0.2300      7.0      1.00
                             0.2000      9.0      1.00


                           VOLUME SOURCE: WE4

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
264561  6834420            0m             10m        75m            9m

                      (Constant) emission rate = 1.00E+00 grams/second

                Hourly multiplicative factors will be used with
                this emission factor.

                           Particle  Particle  Particle
                             Mass      Size    Density
                           fraction  (micron)  (g/cm3)
                          ----------------------------
                             0.3100      1.0      1.00
                             0.2600      4.0      1.00
                             0.2300      7.0      1.00
                             0.2000      9.0      1.00
```

```
                  VOLUME SOURCE: WE5

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
264426  6834682             0m            10m         75m            9m

             (Constant) emission rate = 1.00E+00 grams/second

       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size     Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3100      1.0      1.00
                    0.2600      4.0      1.00
                    0.2300      7.0      1.00
                    0.2000      9.0      1.00


                  VOLUME SOURCE: WE6

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
264039  6834936             0m            10m         75m            9m

             (Constant) emission rate = 1.00E+00 grams/second

       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size     Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3100      1.0      1.00
                    0.2600      4.0      1.00
                    0.2300      7.0      1.00
                    0.2000      9.0      1.00


                  VOLUME SOURCE: WE7

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
264316  6835044             0m            10m         75m            9m

             (Constant) emission rate = 1.00E+00 grams/second

       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
```

```
                    Mass      Size    Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3100      1.0      1.00
                    0.2600      4.0      1.00
                    0.2300      7.0      1.00
                    0.2000      9.0      1.00


                  VOLUME SOURCE: WE8

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
264604  6835158             0m            10m        75m            9m

             (Constant) emission rate = 1.00E+00 grams/second

       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size    Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3100      1.0      1.00
                    0.2600      4.0      1.00
                    0.2300      7.0      1.00
                    0.2000      9.0      1.00


                  VOLUME SOURCE: CV1A

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
264708  6835046             0m             1m        85m            0m

             (Constant) emission rate = 1.00E+00 grams/second

       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size    Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3100      1.0      1.00
                    0.2600      4.0      1.00
                    0.2300      7.0      1.00
                    0.2000      9.0      1.00


                  VOLUME SOURCE: CV1B

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
```

```
264469  6834928             0m             1m         85m            0m

             (Constant) emission rate = 1.00E+00 grams/second

       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size    Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3100      1.0      1.00
                    0.2600      4.0      1.00
                    0.2300      7.0      1.00
                    0.2000      9.0      1.00


                  VOLUME SOURCE: CV2A

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
263965  6834771             0m             1m        223m            0m

             (Constant) emission rate = 1.00E+00 grams/second

       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size    Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3100      1.0      1.00
                    0.2600      4.0      1.00
                    0.2300      7.0      1.00
                    0.2000      9.0      1.00


                  VOLUME SOURCE: CV2B

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
263103  6834410             0m             1m        223m            0m

             (Constant) emission rate = 1.00E+00 grams/second

       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size    Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3100      1.0      1.00
```

```
                      0.2600      4.0      1.00
                      0.2300      7.0      1.00
                      0.2000      9.0      1.00
```

```
1          ____________________________________________________________

            Oakajee 0708 Met WV035017 (01/05/2010) PM10 Contour Base

                              RECEPTOR LOCATIONS

           ____________________________________________________________

 The Cartesian receptor grid has the following x-values (or eastings):
 261000.m  261500.m  262000.m  262500.m  263000.m  263500.m  264000.m
 264500.m  265000.m  265350.m  265700.m  266050.m  266400.m  266750.m
 267100.m  267450.m  267800.m  268150.m  268500.m  269000.m  269500.m
 270000.m  270500.m  271000.m  271500.m

 and these y-values (or northings):
6827500.m 6828000.m 6828500.m 6829000.m 6829500.m 6830000.m 6830350.m
6830700.m 6831050.m 6831400.m 6831750.m 6832100.m 6832450.m 6832800.m
6833150.m 6833500.m 6833850.m 6834200.m 6834550.m 6834900.m 6835250.m
6835600.m 6835950.m 6836300.m 6836650.m 6837000.m 6837500.m 6838000.m
6838500.m 6839000.m 6839500.m 6840000.m 6840500.m 6841000.m 6841500.m
6842000.m
```

```
 METEOROLOGICAL DATA : Oakajee 07/08 .Stability based on CALMEts Turner sch
e

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             HOURLY VARIABLE EMISSION FACTOR INFORMATION
             -------------------------------------------

 The input emission rates specfied above will be multiplied by hourly varying
 factors entered via the input file:
 D:\Ausplume\WV05017\Modelling\Base\PM10\OakajeePM10Base.src
 For each stack source, hourly values within this file will be added to each
 declared exit velocity (m/sec) and temperature (K).

 Title of input hourly emission factor file is:
 Oakajee PM10 Emissions 02/05/2010

             HOURLY EMISSION FACTOR SOURCE TYPE ALLOCATION
             ---------------------------------------------

 Prefix CD     allocated: CD
 Prefix TS1    allocated: TS1
```

```
Prefix TS2    allocated: TS2
Prefix ST1    allocated: ST1
Prefix ST2    allocated: ST2
Prefix REC    allocated: REC
Prefix TS3    allocated: TS3
Prefix LRP    allocated: LRP
Prefix RSF-TS allocated: RSF-TS
Prefix RSF-ST allocated: RSF-ST
Prefix TS4    allocated: TS4
Prefix SL     allocated: SL
Prefix VEH    allocated: VEH
Prefix WE1    allocated: WE1
Prefix WE2    allocated: WE2
Prefix WE3    allocated: WE3
Prefix WE4    allocated: WE4
Prefix WE5    allocated: WE5
Prefix WE6    allocated: WE6
Prefix WE7    allocated: WE7
Prefix WE8    allocated: WE8
Prefix CV1A   allocated: CV1A
Prefix CV1B   allocated: CV1B
Prefix CV2A   allocated: CV2A
Prefix CV2B   allocated: CV2B
```

APPENDIX F RECEPTOR COORDINATES

Table E-1 Location of receptors within the locality of the port

Receptor number	Easting (m)	Northing (m)
R1 (Residence)	268840	6829780
R2 (Residence)	268880	6829920
R3 (Residence)	269000	6830090
R4 (Residence)	268990	6838080
R5 (Coronation Beach)	261750	6838980
B1 (Buffer Zone Boundary)	263437	6840277
B2 (Buffer Zone Boundary)	266093	6840042
B3 (Buffer Zone Boundary)	267954	6839066
B4 (Buffer Zone Boundary)	270042	6835758
B5 (Buffer Zone Boundary)	270889	6832871
B6 (Buffer Zone Boundary)	269406	6830191
B7 (Buffer Zone Boundary)	267692	6829288
B8 (Buffer Zone Boundary)	265963	6828746
I1 (Industrial)	265326	6835524
I2 (Industrial)	265615	6834544
I3 (Industrial)	266016	6833355
I4 (Industrial)	266200	6832631
I5 (Industrial)	266310	6835517
I6 (Industrial)	266509	6834547
I7 (Industrial)	266803	6833366
I8 (Industrial)	266980	6832634
I9 (Industrial)	267281	6834573
I10 (Industrial)	267419	6833371
I11 (Industrial)	266840	6831282
I12 (Industrial)	268096	6834440

APPENDIX G MODEL RESULTS AT RECEPTORS

Table F-1 PM_{10} statistics for predicted ground-level concentrations at receptors (no background)

Receptor	Maximum ($\mu g/m^3$)	99 Percentile ($\mu g/m^3$)	95 Percentile ($\mu g/m^3$)	90 Percentile ($\mu g/m^3$)	70 Percentile ($\mu g/m^3$)	Average ($\mu g/m^3$)	Days exceeding allowed limit. (50 $\mu g/m^3$)
R1	2.12	0.84	0.31	0.10	0.00	0.05	0
R2	1.92	0.87	0.33	0.11	0.00	0.05	0
R3	1.72	0.95	0.36	0.12	0.00	0.05	0
R4	2.05	1.85	0.97	0.54	0.10	0.18	0
R5	5.90	2.93	1.72	1.25	0.41	0.42	0
B1	6.44	2.42	1.55	1.05	0.40	0.36	0
B2	7.35	3.89	1.88	1.29	0.51	0.47	0
B3	2.57	2.05	1.29	0.74	0.36	0.30	0
B4	2.05	1.69	0.65	0.33	0.02	0.11	0
B5	1.24	0.92	0.44	0.13	0.00	0.06	0
B6	2.11	0.92	0.33	0.14	0.00	0.05	0
B7	3.33	1.12	0.22	0.07	0.00	0.05	0
B8	2.02	0.64	0.17	0.03	0.00	0.03	0
I1	22.70	14.78	8.66	6.85	3.10	2.54	0
I2	15.00	11.07	6.86	4.61	1.60	1.60	0
I3	18.40	6.79	2.92	1.29	0.01	0.44	0
I4	9.64	4.06	1.42	0.59	0.00	0.24	0
I5	7.09	4.58	3.13	2.09	0.69	0.71	0
I6	10.50	5.62	3.29	1.53	0.20	0.52	0
I7	9.79	3.92	1.68	0.72	0.01	0.27	0
I8	9.32	2.60	1.01	0.56	0.00	0.18	0
I9	7.95	4.44	2.14	0.87	0.08	0.31	0
I10	5.93	2.92	1.54	0.64	0.02	0.20	0
I11	6.72	1.69	0.54	0.17	0.00	0.10	0
I12	6.28	2.99	1.47	0.57	0.03	0.21	0

Table F-2 PM_{10} statistics for predicted ground-level concentrations at receptors (with 70th percentile background)

Receptor	Maximum (µg/m^3)	99 Percentile (µg/m^3)	95 Percentile (µg/m^3)	90 Percentile (µg/m^3)	70 Percentile (µg/m^3)	Average (µg/m^3)	Days exceeding allowed limit. (50 µg/m^3)
R1	27.70	26.36	25.87	25.62	25.50	25.55	0
R2	27.49	26.42	25.90	25.64	25.50	25.56	0
R3	27.35	26.49	25.92	25.65	25.50	25.56	0
R4	28.01	27.70	26.66	26.14	25.61	25.71	0
R5	31.62	28.84	27.54	26.98	26.01	25.99	0
B1	32.19	28.36	27.28	26.80	25.99	25.94	0
B2	33.07	29.66	27.60	26.99	26.12	26.04	0
B3	28.73	27.85	27.01	26.39	25.92	25.85	0
B4	28.02	27.71	26.28	25.89	25.53	25.63	0
B5	26.94	26.59	26.05	25.66	25.50	25.57	0
B6	27.76	26.45	25.90	25.66	25.50	25.56	0
B7	28.94	26.68	25.77	25.58	25.50	25.55	0
B8	27.52	26.21	25.70	25.54	25.50	25.54	0
I1	48.20	41.36	35.64	33.23	29.15	28.48	0
I2	42.00	38.04	33.37	30.54	27.13	27.25	0
I3	44.60	32.76	28.71	27.05	25.51	25.99	0
I4	35.50	29.71	27.02	26.18	25.50	25.76	0
I5	34.50	31.21	29.20	28.04	26.26	26.33	0
I6	37.60	31.67	29.50	27.14	25.75	26.10	0
I7	36.00	29.99	27.55	26.34	25.51	25.81	0
I8	35.23	28.35	26.78	26.12	25.50	25.71	0
I9	34.90	30.46	27.96	26.53	25.60	25.87	0
I10	31.93	28.81	27.26	26.22	25.52	25.74	0
I11	32.43	27.38	26.14	25.70	25.50	25.61	0
I12	32.76	28.97	27.21	26.15	25.53	25.75	0

Table F-3 TSP statistics for predicted ground-level concentrations at receptors (no background)

Receptor	Maximum ($\mu g/m^3$)	99 Percentile ($\mu g/m^3$)	95 Percentile ($\mu g/m^3$)	90 Percentile ($\mu g/m^3$)	70 Percentile ($\mu g/m^3$)	Average ($\mu g/m^3$)	Days exceeding allowed limit. (90$\mu g/m^3$)
R1	3.82	1.47	0.47	0.16	0.00	0.07	0
R2	3.47	1.54	0.50	0.17	0.00	0.08	0
R3	2.94	1.65	0.54	0.19	0.00	0.08	0
R4	3.04	2.68	1.31	0.78	0.16	0.26	0
R5	11.10	4.96	2.59	1.82	0.60	0.64	0
B1	11.50	3.60	2.53	1.55	0.57	0.55	0
B2	13.40	6.83	3.31	2.02	0.74	0.75	0
B3	3.71	2.78	1.96	1.27	0.56	0.47	0
B4	3.02	2.47	0.95	0.49	0.04	0.16	0
B5	1.85	1.40	0.65	0.21	0.01	0.09	0
B6	3.60	1.67	0.49	0.22	0.00	0.08	0
B7	6.02	1.62	0.36	0.10	0.00	0.08	0
B8	3.69	1.06	0.25	0.05	0.00	0.05	0
I1	48.60	30.98	16.93	12.60	5.76	4.85	0
I2	26.80	21.21	12.98	8.71	3.17	3.08	0
I3	37.80	13.74	5.33	2.29	0.02	0.84	0
I4	19.80	7.79	2.38	0.93	0.00	0.44	0
I5	11.80	7.92	5.32	3.58	1.32	1.25	0
I6	17.20	9.88	5.81	2.67	0.36	0.91	0
I7	19.00	7.30	2.95	1.27	0.02	0.47	0
I8	17.80	4.96	1.76	0.91	0.00	0.32	0
I9	12.40	7.34	3.66	1.41	0.13	0.52	0
I10	11.20	5.16	2.49	1.07	0.03	0.35	0
I11	13.00	2.84	0.89	0.26	0.00	0.17	0
I12	9.48	4.82	2.43	0.86	0.05	0.34	0

Table F-4 TSP statistics for predicted ground-level concentrations at receptors (with 70th percentile background)

Receptor	Maximum ($\mu g/m^3$)	99 Percentile ($\mu g/m^3$)	95 Percentile ($\mu g/m^3$)	90 Percentile ($\mu g/m^3$)	70 Percentile ($\mu g/m^3$)	Average ($\mu g/m^3$)	Days exceeding allowed limit. ($90\mu g/m^3$)
R1	39.96	37.50	36.54	36.18	35.99	36.08	0
R2	39.60	37.55	36.58	36.19	35.99	36.08	0
R3	39.16	37.73	36.61	36.21	35.99	36.08	0
R4	39.73	39.17	37.61	36.94	36.17	36.31	0
R5	47.49	41.31	39.05	38.19	36.75	36.76	0
B1	47.89	40.31	38.80	37.85	36.70	36.65	0
B2	49.79	43.33	39.56	38.33	36.91	36.85	0
B3	40.67	39.24	38.31	37.42	36.66	36.54	0
B4	39.76	39.18	37.20	36.60	36.04	36.19	0
B5	38.14	37.68	36.82	36.25	36.00	36.10	0
B6	39.85	37.71	36.58	36.24	35.99	36.08	0
B7	42.21	37.75	36.43	36.12	35.99	36.08	0
B8	39.68	37.18	36.29	36.05	35.99	36.05	0
I1	84.69	68.09	55.37	51.19	42.95	41.71	0
I2	65.49	60.19	50.79	45.26	39.26	39.37	0
I3	75.09	50.70	41.88	38.67	36.01	36.91	0
I4	56.49	44.15	38.67	37.11	35.99	36.47	0
I5	51.09	45.64	42.70	40.26	37.42	37.47	0
I6	55.79	46.77	42.91	38.92	36.45	37.04	0
I7	56.39	44.33	39.74	37.48	36.02	36.53	0
I8	54.59	41.27	38.19	37.00	35.99	36.36	0
I9	50.69	44.05	40.28	37.72	36.17	36.61	0
I10	48.09	41.69	38.85	37.25	36.02	36.39	0
I11	49.39	39.14	37.08	36.31	35.99	36.18	0
I12	46.99	41.59	38.69	37.01	36.04	36.39	0

Table F-5 Maximum predicted increase in monthly deposition at receptors

Receptor	Maximum (g/m^2)	Months exceeding allowed increase (2 g/m^2)
R1	0.06	0
R2	0.06	0
R3	0.05	0
R4	0.04	0
R5	0.21	0
B1	0.17	0
B2	0.40	0
B3	0.16	0
B4	0.04	0
B5	0.04	0
B6	0.05	0
B7	0.09	0
B8	0.06	0
I1	2.39	1
I2	0.78	0
I3	0.57	0
I4	0.39	0
I5	0.29	0
I6	0.34	0
I7	0.27	0
I8	0.22	0
I9	0.21	0
I10	0.18	0
I11	0.20	0
I12	0.14	0