Appendix J

Photochemical Smog Assessment for the Proposed International Minerals Iron Ore Mine and Associated Infrastructure at Cape Preston

REPORT

PHOTOCHEMICAL SMOG ASSESSMENT FOR THE PROPOSED INTERNATIONAL MINERALS IRON ORE MINE AND ASSOCIATED INFRASTRUCTURE AT CAPE PRESTON

Maunsell Australia Pty Ltd

29 May 2008 Job 2455c

PACIFIC AIR & ENVIRONMENT

A PEL Company

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1 INTRODUCTION

Maunsell Australia Pty Ltd (Maunsell) appointed Pacific Air & Environment (PAE) to conduct a photochemical smog assessment for the proposed pellet and power plant forming part of the Balmoral South (BS) project near Cape Preston, Western Australia.

1.1 Background

Maunsell appointed Air Assessments to undertake a preliminary air quality assessment of SO_x, NO_x, and dust from the pellet plant, HBI and power station. The AERMOD dispersion model was used to predict ground level impacts.

A recommendation arising from this study was to undertake a regional smog assessment to account for the larger emissions of NO_X and to incorporate more accurate VOC estimates from the plant and regional emissions inventory.

PAE was then appointed to conduct screening photochemical modelling to assess the likely impact on photochemical smog in the region (including the Woodside LNG plants on the Burrup Peninsula). As part of the assessment, PAE conducted a photochemical modelling assessment of current emissions in the area, using TAPM with the GRS scheme as per the setup of CSIRO (2004). This run confirmed the results presented in the CSIRO report, giving a sound basis for the use of this model in subsequent assessments in the region.

Since commissioning PAE to do the screening assessment, Maunsell informed PAE that there are revisions to the BS project footprint. Specifically, the DRI/HBI plant has been scrapped, and the plant capacity has been increased from 12 Mtpa to 24 Mtpa. In addition, Maunsell instructed that the cumulative effect of approved and proposed projects needs be assessed.

1.2 Scope of Work

The Scope of Work is to conduct a photochemical modelling study for the following scenarios:

- Approved projects:
  - This includes current sources in the region plus emissions from the approved Mineralogy Central Block (CB) project.
- Proposed projects:
  - This includes emissions from the existing and approved CB Project sources as well as the proposed Balmoral South (BS) project.

1.3 General Approach to the Assessment

This air quality impact assessment has involved gathering, processing and presenting information on emissions in the region from previous work undertaken, and:

- using TAPM to predict photochemical smog in areas around the proposed power station and over the region as a whole;

- assessing predicted nitrogen dioxide (NO_2) and ozone (O_3) against relevant WA air quality guidelines; and
- presenting and discussing the input data, methodology and results in a report.

For this study, the impact of emissions from the site is based on current best practice modelling technology. The assessment of impacts is also based on stringent criteria that provide for a high level of environmental and human health protection.

1.4 Units Used in the Report

Two systems for expressing the concentrations of air pollution are now in common use. Firstly, concentrations may be expressed in parts per million (ppm) or as parts per billion (ppb).

The second option is to use either mg/m^3, or $\mu g/m^3$. These units are consistent with the System International. In order to convert between ppb and $\mu g/m^3$, a conversion factor is used that contains the molecular weight of the pollutant.

Some authorities use only one system (the European Union and World Health Organisation use $\mu g/m^3$), while others use both systems of units for standards. Conversion from one system to another can generate awkward numbers, and authorities using both systems often round off converted numbers for the sake of simplicity. The modelling output for this study is in ppb for all pollutants.

2 PROJECT DESCRIPTION

The proposed Balmoral South (BS) project is to be located at Cape Preston in the Pilbara, Western Australia. It is a proposed iron ore mine with associated concentrator, pellet plant and power station. The facility is to have a capacity of 24 Mtpa. The location of the project (and adjacent CB project) is shown in Figure 2.1.

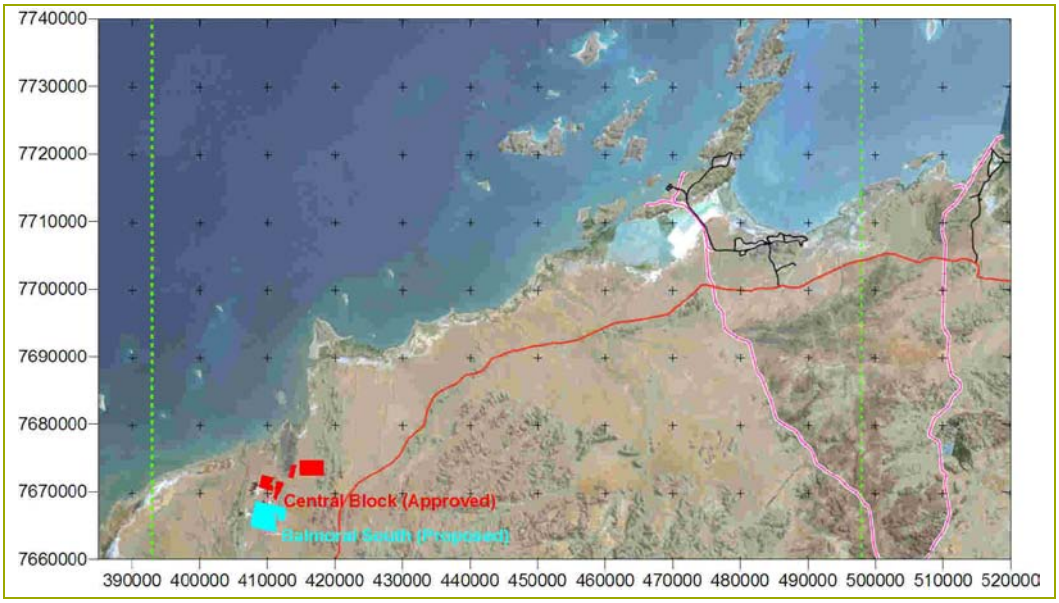


Figure 2.1: Location of the approved Central Block (indicated by red) and proposed Balmoral South (indicated by blue) projects.

3 CLIMATE OF THE AREA

Cape Preston is a peninsula on the Pilbara coast. Rainfall is low throughout the region and quite variable. Annual totals vary from 200 to 450mm, and many years without significant rainfall. The lower totals are typical of the south where tropical cyclone effects are less frequent. Most of the summer rain comes from scattered thunderstorms and the occasional tropical cyclone. A secondary peak in the monthly rainfall occurs in May/June as a result of rainfall caused by tropical cloud bands which intermittently affect the area, mostly in these months. These events can also produce low maximum temperatures particularly away from the coast. The number of thunderstorms average 20-30 per annum over most of the area but 15-20 is more common near the coast. Almost all storms occur in the summer.

This region contains some of Australia's consistently hottest places. The coast is 2-3°C cooler but usually more humid due to the sea breezes. Winter maximum temperatures are mild/warm with temperatures in the 23-27°C range in the south. Minimum temperatures range from 25C in midsummer to 12°C in July near the coast.

Climate averages for Mardie (approximately 25 km to the south-west of the BS project) are presented in Table 3.1. January and February are the warmest months with average maximum temperatures of approximately 31°C. Winters are warm with average minimum temperatures of 12°C and maximum temperatures of 27.7°C in July. Annual average rainfall is 237 mm, with February, March, May and June producing the highest monthly totals on average (Table 3.1). The average number of rain days for each of these months is still below 3. The wind speed at 9 am averages 14 km/h (3.9 m/s) for the year, with August to November being the windiest months on average (Table 3.1). Wind speed at 3 pm averages 23.7 km/h (6.6 m/s) with October to January being the windiest months in the afternoon.

Average (1956 - 2007) wind roses for Mardie at 9 am and 3 pm are shown in Figure 3.1. The morning (9 am) wind directions are predominantly from the east to south (57% of the time), while afternoon winds (3 pm) are predominantly from the west to north (73% of the time). The afternoon winds most likely represent sea breeze conditions, especially during the summer months.

Table 3.1: Climate averages for Mardie – 1956 to 2007 (source: Bureau of Meteorology).

Month	Average Minimum Temperature (°C)	Average Maximum Temperature (°C)	Median Rainfall (mm)	Rain Days (>1mm)	Average 9 AM Wind Speed (km/h)	Average 3 PM Wind Speed (km/h)
January	24.8	38.0	7.5	2.0	13.9	27.7
February	25.2	37.7	25.3	3.0	12.9	24.9
March	24.1	37.6	17.2	2.3	13.0	23.4
April	21.0	35.9	1.0	1.1	12.3	20.4
May	16.9	31.5	13.7	2.0	13.2	18.2
June	13.8	28.1	18.7	2.1	13.1	16.6
July	11.7	27.7	5.1	1.2	12.8	17.6
August	12.3	29.5	0.0	0.8	14.0	21.1
September	14.3	32.2	0.0	0.2	15.6	25.4
October	17.2	34.9	0.0	0.1	16.8	29.1
November	20.0	36.4	0.0	0.2	15.9	30.0
December	22.9	37.7	0.0	0.5	14.9	29.4
Annual	18.7	33.9	236.9	15.5	14.0	23.7

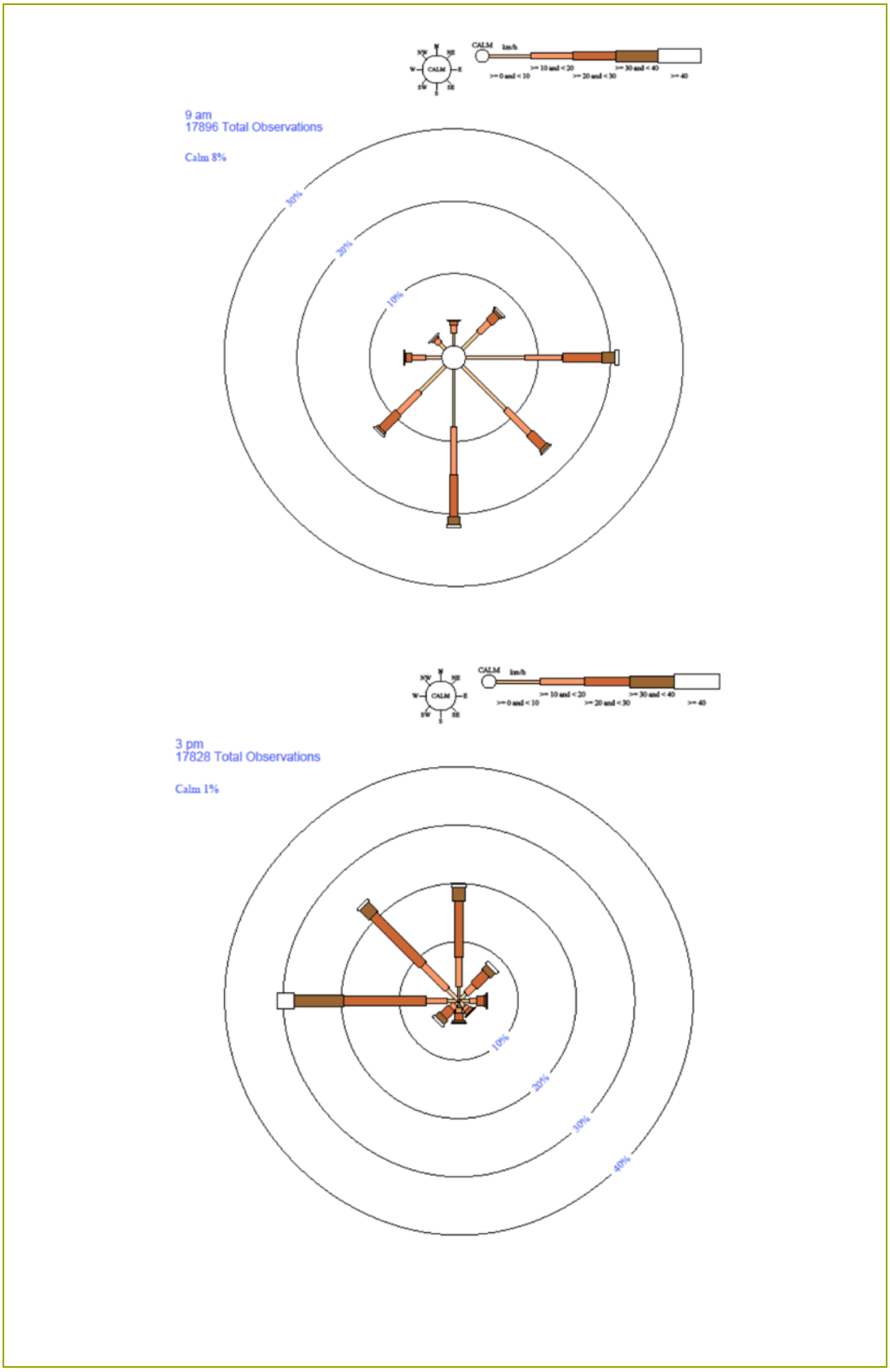


Figure 3.1: Climate wind roses for Mardie for 9 am (upper) and 3 pm (lower) – 1956 to 2007 (source: Bureau of Meteorology).

4 AMBIENT AIR QUALITY GUIDELINES

Many regulatory authorities publish guidance documents on air quality assessment and management. These guidelines usually include ground level concentration values for specific contaminants that should normally not be exceeded in the receiving environment. Guidelines typically specify how often the quoted concentration values can be exceeded without causing unreasonable levels of impact. Typically, the impacts of concern are related to human health or amenity. In some cases, the relevant impacts relate to other environmental values such as the protection of vegetation. Most guidelines aim to provide a very high level of protection against environmental harm.

4.1 NEPM for Ambient Air Quality

The National Environment Protection Council (NEPC), now incorporated into the Environment Protection and Heritage Council (EPHC), developed the Ambient Air Quality NEPM in 1998. The Ambient Air Quality NEPM refers to the so-called criteria or common air contaminants that have for many years been the core set of pollutants for air quality regulation and monitoring. The Ambient Air Quality NEPM comprises a monitoring-based set of standards, and was not designed to be applied to 'beyond the boundary' regulation of specific industrial facilities. Compliance with the Ambient Air Quality NEPM is a state and territory responsibility, and is to be demonstrated by monitoring programs that represent the exposure of relatively large population groups to ambient levels of the nominated contaminants.

Despite this specific design, state and territory environmental authorities have to varying degrees adopted the Ambient Air Quality NEPM goals as assessment criteria that should be complied with in all receiving environments beyond industrial site boundaries. There are some issues arising from this approach, relating mainly to extractive industries with significant dust emissions. In 2000, the Western Australia Department of Environmental Protection (DEP) adopted the Ambient Air Quality NEPM standards for general application to air quality management (WA EPA, 2001). Consequently, predicted ambient ground-level concentrations will be assessed against these standards. The relevant Air NEPM standards are listed in Table 4.1.

Table 4.1: Ambient Air Quality NEPM Goals

Pollutant	Averaging Period	Maximum Concentration (ppb)	Goal Within 10 Years - Maximum Allowable Exceedances
Nitrogen dioxide (NO_2)	1 hour	120	1 day a year
	1 year	30	None
Photochemical oxidants (as O_3)	1 hour	100	1 day a year
	4 hours	80	1 day a year

Source: NEPC 1998

5 STUDY APPROACH AND METHODOLOGY

5.1 Photochemical Modelling

The Air Pollution Model, or TAPM, is a three dimensional meteorological and air pollution model produced by the CSIRO Division of Atmospheric Research (Hurley, 2002a, 2002b).

TAPM incorporates the following databases for input to its computations:

- Gridded database of terrain heights on a longitude/latitude grid of 30 second grid spacing, (approximately 1 km). This default dataset is supplemented by finer resolution data at 9 second spacing for this study.
- Australian vegetation and soil type data at 3 minute grid spacing, (approximately 5 km).
- Rand's global long term monthly mean sea-surface temperatures on a longitude/latitude grid at 1 degree grid spacing, (approximately 100 km).
- Six-hourly synoptic scale analyses on a longitude/latitude grid at 0.75-degree grid spacing, (approximately 75 km), derived from the LAPS analysis data from the Bureau of Meteorology.

The air pollution component of TAPM includes gas-phase photochemical reactions based on the Generic Reaction Set (GRS) of Azzi *et al*. (1992). There are ten reactions for thirteen species: smog reactivity (Rsmog), the radical pool (RP), hydrogen peroxide (H_2O_2), nitric oxide (NO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), stable non-gaseous organic carbon (SNGOC), stable gaseous nitrogen products (SGN), stable non-gaseous nitrogen products (SNGN), stable non-gaseous sulfur products (SNGS), plus airborne particulate matter (APM) and fine particulate matter (FPM) that include secondary particulate concentrations consisting of SNGOC, SNGN and SNGS.

The GRS is a much more simplified version of complex atmospheric chemistry than either CB-IV or SAPRC. The GRS offers smog formation modelling with low data requirements and low computational overheads, but without a detailed understanding of atmospheric chemistry processes. It negates the need for lumped speciated VOC emissions. Instead, the mechanism describes emissions of smog reactivity (Rsmog), which is defined as a reactivity coefficient multiplied by VOC concentration. Rsmog is used to estimate the smog forming potential of the atmosphere.

5.1.1 TAPM Configuration

TAPM was used in a nested mode with 45 x 45 x 17 grid points and 15 km, 5 km and 2.5 km spaced grids for meteorology and for pollution[a]. The area covered by each pollution grid is slightly less than the area of the corresponding meteorological grid. In this way, the pollution grids avoid the boundary regions of the nested meteorological grids, where spurious vertical velocities can sometimes occur. TAPM was run for the period 1 January 1999 to 31 December 1999 for comparison to the CSIRO's *Summary of TAPM Verification for the Pilbara Region* (2004).

[a] The model configuration was identical to that used by CSIRO (2004).

To improve model accuracy, observed wind conditions from Cape Preston Mainland and Island were used to nudge[b] the TAPM solution.

5.2 Receptors

Receptors are the locations at which the model calculates concentration or deposition. The grid can be either spaced regularly to reflect the topography, population distribution patterns, and other site-specific factors or irregularly spaced as discrete receptors to represent sensitive locations not included by the receptor grid (e.g. schools, hospitals and houses). The model will calculate concentration or deposition for each point on the grid, and then use a suitable interpolation method to draw a continuous contour line.

Ground level concentrations were calculated over a grid of uniformly spaced receptor points 2.5 km apart over an area of approximately 12,656 km^2.

In addition to the gridded receptors, 3 sensitive receptors were identified, the locations of which are shown in Figure 5.1

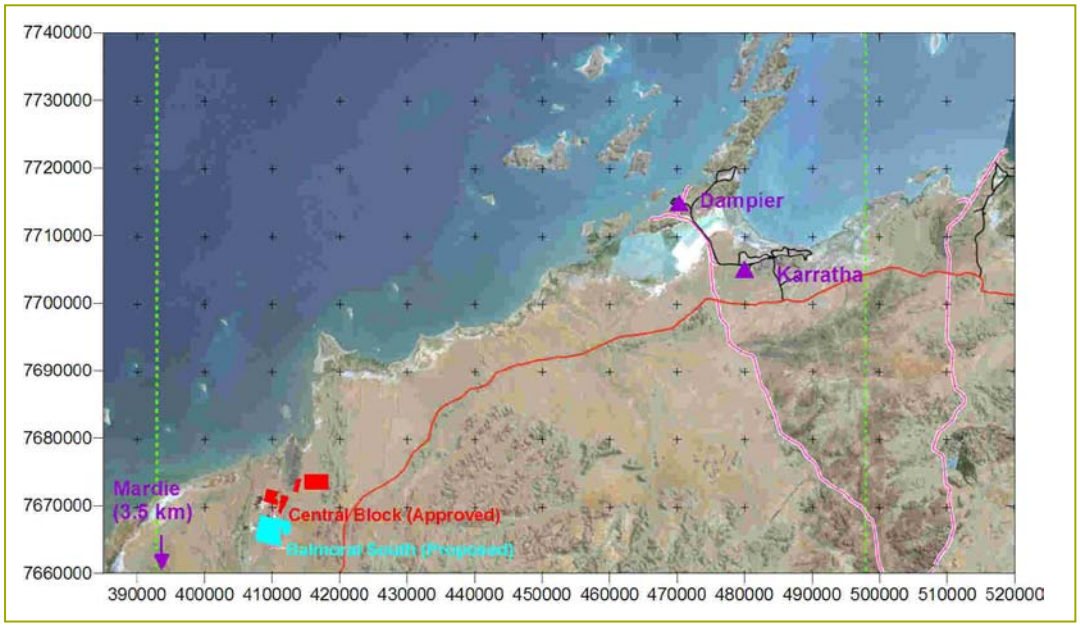


Figure 5.1: Location of the sensitive (discrete) receptors relevant to the BS Project.

[b] Nudging a model forces it towards the meteorological observations. The main benefit of nudging is to correct the possible drift of the large-scale winds calculated by model from the fields used for initialization and boundary conditions.

5.3 Discharges to Air

5.3.1 Existing Emissions

Existing point source emissions as at 1999 were sourced from the CSIRO's Summary of TAPM Verification for the Pilbara Region (2004). These sources and emissions are also used to validate TAPM for the present study (see Section 5.3.2).

Subsequent to the CSIRO study, a number of additional sources were added in the region (sourced from SKM, 2006). These include:

- the NWSV Karratha Gas Plant Train 4;
- the NWSV Karratha Gas Plant Train 5;
- the Burrup Fertilisers Ammonia Plant; and
- the Pluto LNG Development.

These additional sources are included in the modelling assessment to determine the current levels of photochemical pollutants in the region. A list of all the point source emissions utilised in the modelling is presented in Table 5.1.

Biogenic (NO_X and VOC) and gridded surface emissions have been supplied by the CSIRO for this study. This dataset is identical to that used by CSIRO in their 2004 modelling study.

Table 5.1: Air emissions data for existing point sources used in the modelling.

Src ID	Source	Easting m	Northing m	Height m	Stack Radius m	Velocity m/s	Temp K	PM_{10} g/s	NO_x g/s	SO_2 g/s	Rsmog g/s
OGP Plant	GT4001	476910	7722765	40	1.98	20.2	777	0	13.46	0.04	0
OGP Plant	GT4002	476910	7722800	40	1.98	20.2	777	0	13.46	0.04	0
OGP Plant	GT4003	476910	7722810	40	1.98	20.2	777	0	13.46	0.04	0
OGP Plant	GT4004	476910	7722845	40	1.98	20.2	777	0	13.46	0.04	0
OGP Plant	GT4005	476910	7722855	40	1.98	20.2	777	0	13.46	0.04	0
OGP Plant	GT4006	476910	7722890	40	1.98	20.2	777	0	13.46	0	0
OGP Plant	1KT1410	476540	7722965	40	1.94	23.9	790	0	15.77	0.05	0
OGP Plant	1KT1420	476590	7722965	40	1.94	23.9	790	0	15.6	0.05	0
OGP Plant	1KT1430	476610	7722965	40	1.87	25.8	790	0	15.26	0.05	0
OGP Plant	1KT1440+1V1104	476660	7722965	40	1.87	26.3	806	0	15.53	0.05	0.421
OGP Plant	1KT1450	476510	7722960	40	1.36	21.2	784	0	9.44	0.02	0
OGP Plant	2KT1410	476540	7722845	40	1.94	23.9	790	0	15.77	0.05	0
OGP Plant	2KT1420	476590	7722845	40	1.94	23.9	790	0	15.6	0.05	0
OGP Plant	2KT1430	476610	7722845	40	1.87	25.8	790	0	15.26	0.05	0
OGP Plant	2KT1440+2V1104	476660	7722845	40	1.87	26.3	806	0	15.53	0.05	0.421
OGP Plant	2KT1450	476510	7722840	40	1.36	21.2	784	0	9.44	0.02	0
OGP Plant	3KT1410	476540	7722610	40	1.94	23.9	790	0	15.77	0.05	0
OGP Plant	3KT1420	476590	7722610	40	1.94	23.9	790	0	15.6	0.05	0
OGP Plant	3KT1430	476610	7722610	40	1.87	25.8	790	0	15.26	0.05	0
OGP Plant	3KT1440+3V1104	476660	7722610	40	1.87	26.3	806	0	15.53	0.05	0.421
OGP Plant	3KT1450	476510	7722605	40	1.36	21.2	784	0	9.44	0.02	0
OGP Plant	1F2001	477152	7722915	33	0.73	6	700	0	0.3	0	0

Src ID	Source	Easting	Northing	Height	Stack Radius	Velocity	Temp	PM_{10}	NO_x	SO_2	Rsmog
OGP Plant	2F2001	477152	7722905	33	0.73	6	700	0	0.3	0	0
OGP Plant	3F2001	477152	7722895	33	0.73	6	700	0	0.3	0	0
OGP Plant	4F2001	476968	7722880	33	0.73	6	700	0	0.3	0	0
OGP Plant	5F2001	476968	7722870	33	0.73	6	700	0	0.3	0	0
OGP Plant	1KT2420	477035	7722698	24	1	40.7	816	0	9.44	0.02	0
OGP Plant	1KT2430	477050	7722698	24	1.45	30.6	620	0	20.26	0.04	0
OGP Plant	2KT2420	477065	7722698	24	1	40.7	816	0	9.44	0.02	0
OGP Plant	2KT2430	477080	7722698	24	1.45	30.6	620	0	20.26	0.04	0
OGP Plant	Seal Oil	476500	7722500	20	1	0	400	0	0	0	0.12
Hammersley Power Station	HAM_Stack1	471500	7717000	60	1.3	Time Varying					
Hammersley Power Station	HAM_Stack2	471500	7717000	60	1.3						
NWSV Karratha Gas Plant Train 4	4KT1430a	476664	7722465	40	1.45	28.2	490	0.000	5.000	0.300	0.000
NWSV Karratha Gas Plant Train 4	4KT1430b	476664	7722461	40	1.45	28.2	490	0.000	5.000	0.300	0.000
NWSV Karratha Gas Plant Train 4	4KT1410	476650	7722461	40	3.05	23.4	814	0.000	10.600	0.600	0.000
NWSV Karratha Gas Plant Train 4	1F1251	476933	7722944	40	1.46	21.3	1373	0.000	0.800	2.800	0.000
NWSV Karratha Gas Plant Train 4	GT4007	476972	7722702	40	1.65	23	694	0.000	3.300	0.200	0.000
NWSV Karratha Gas Plant Train 4	GT4008	476972	7722668	40	1.65	23	694	0.000	3.300	0.200	0.000
NWSV Karratha Gas Plant Train 5	GT4009	476972	7722626	40	1.65	23	694	0.000	3.300	0.200	0.000
NWSV Karratha Gas Plant Train 5	GT4010	476972	7722592	40	1.65	23	694	0.000	3.300	0.200	0.000
NWSV Karratha Gas Plant Train 5	5KT1430a	476664	7722335	40	1.45	28.2	490	0.000	5.000	0.300	0.000
NWSV Karratha Gas Plant Train 5	5KT1430b	476664	7722331	40	1.45	28.2	490	0.000	5.000	0.300	0.000
NWSV Karratha Gas Plant Train 5	5KT1410	476560	7722331	40	3.05	23.4	814	0.000	10.600	0.600	0.000
NWSV Karratha Gas Plant Train 5	2F1251	476953	7722944	40	1.46	21.3	1373	0.000	0.800	2.800	0.000
Burrup Fertilizers Ammonia Plant	BF1	476915	7718833	36	1.78	12.7	413	0.300	15.400	0.000	0.000
Burrup Fertilizers Ammonia Plant	BF2	477060	7718820	15	0.85	5	450	0.000	1.300	0.000	0.000

Src ID	Source	Easting	Northing	Height	Stack Radius	Velocity	Temp	PM_{10}	NO_x	SO_2	Rsmog
Pluto LNG Train 1	PR Compressor Frame 7 Turbine	475609	7720460	40	1.75	23.5	493	0.000	3.850	0.300	0.000
Pluto LNG Train 1	PR Compressor Frame 7 Turbine	475621	7720466	40	1.75	23.5	493	0.000	3.850	0.300	0.000
Pluto LNG Train 1	MR Compressor Frame 7 Turbine	475509	7720422	40	2.5	23	816	0.000	7.700	0.600	0.000
Pluto LNG Train 1	Frame 6 Power Generator	475528	7720311	40	1.65	16.5	438	0.000	2.700	0.450	0.000
Pluto LNG Train 1	Frame 6 Power Generator	475565	7720329	40	1.65	16.5	438	0.000	2.700	0.450	0.000
Pluto LNG Train 1	Frame 6 Power Generator	475602	7720342	40	1.65	16.5	438	0.000	2.700	0.450	0.000
Pluto LNG Train 1	Frame 6 Power Generator	475646	7720360	40	2.25	16.6	821	0.000	2.700	0.450	0.000
Pluto LNG Train 1	Frame 6 Power Generator	475683	7720379	40	2.25	16.6	821	0.000	2.700	0.450	0.000
Pluto LNG Train 1	Frame 5 Liquefaction	475963	7720205	40	1.9	25	791	0.000	3.000	0.300	0.000
Pluto LNG Train 1	Thermal Oxidiser	475826	7720671	40	1.45	20	873	0.000	1.600	1.000	0.000
Pluto LNG Train 1	Fired Heater	475590	7720677	33	0.75	11	761	0.000	0.800	0.100	0.000
Pluto LNG Train 2	PR Compressor Frame 7 Turbine	475720	7720177	40	1.75	23.5	493	0.000	3.850	0.300	0.000
Pluto LNG Train 2	PR Compressor Frame 7 Turbine	475733	7720183	40	1.75	23.5	493	0.000	3.850	0.300	0.000
Pluto LNG Train 2	MR Compressor Frame 7 Turbine	475615	7720137	40	2.5	23	816	0.000	7.700	0.600	0.000
Pluto LNG Train 2	Frame 6 Power Generator	475547	7720280	40	1.65	16.5	438	0.000	2.700	0.450	0.000

Src ID	Source	Easting	Northing	Height	Stack Radius	Velocity	Temp	PM_{10}	NO_x	SO_2	Rsmog
Pluto LNG Train 2	Frame 6 Power Generator	475578	7720298	40	1.65	16.5	438	0.000	2.700	0.450	0.000
Pluto LNG Train 2	Frame 6 Power Generator	475621	7720317	40	1.65	16.5	438	0.000	2.700	0.450	0.000
Pluto LNG Train 2	Frame 6 Power Generator	475665	7720329	40	2.25	16.6	821	0.000	2.700	0.450	0.000
Pluto LNG Train 2	Frame 6 Power Generator	475702	7720348	40	2.25	16.6	821	0.000	2.700	0.450	0.000
Pluto LNG Train 2	Frame 5 Liquefaction	475851	7720106	40	1.9	25	791	0.000	3.000	0.300	0.000
Pluto LNG Train 2	Thermal Oxidiser	475975	7720301	40	1.45	20	873	0.000	1.600	1.000	0.000
Pluto LNG Train 2	Fired Heater	475739	7720727	33	0.75	11	761	0.000	0.800	0.100	0.000
Flares	Cold Dry Flare	475286	7720329	160	0.7	20	773	0.048	0.300	0.000	0.006
Flares	Warm Wet Flare	475311	7720329	160	0.7	20	773	0.048	0.300	0.000	0.006
Flares	Marine Flare	475106	7720966	36.6	1.525	20	1273	3.260	20.000	0.016	0.410

5.3.2 Approved Emissions

Emission sources from the Central Block (formerly Austeel) project include the Pellet Plant, DRI Plant and a power station. Source details and emissions data were obtained from the *Austeel Project - Air Quality Assessment* (SKM, 2005). These are presented in Table 5.2.

5.3.3 Proposed Emissions

Emission sources from the proposed 24 Mtpa BS plant consist of the Pellet Plant and power station[c]. Source details and emissions data were obtained from International Minerals. These are presented in Table 5.2.

Under normal operating conditions the Pellet plant will emit from the main stack only. The pre-heat and tempered pre-heat stacks operate during start up. Start up duration is given as 8 hours. For modelling, the first 8 hours was assumed to be start up with the plant operating normally for the remainder of the year.

[c] Based on Alstom gas turbines.

Table 5.2: Air emissions data for approved and proposed point sources used in the modelling.

Src ID	Source	Easting m	Northing m	Height m	Stack Radius m	Velocity m/s	Temp K	PM_{10} g/s	NO_x g/s	SO_2 g/s	Rsmog g/s
Central Block Project (Approved)											
73	A1 Main Stack A	412761	7670800	60	4.125	18	413.15	28.92	231.34	23.13	0
74	A2 Feed dedusting	412825	7670782	20	0.5	20	331.15	0.59	0	0	0
75	A3 Discharge dedusting A	412837	7670955	20	0.69	20	313.15	1.18	0	0	0
76	A3 Discharge dedusting B	412837	7670955	20	0.69	20	313.15	1.18	0	0	0
77	A4 Screen dedusting	412867	7670971	20	0.69	20	313.15	1.18	0	0	0
78	B1 Main Stack B	412761	7670800	60	4.125	18	413.15	28.92	231.34	23.13	0
79	B2 Feed dedusting	412825	7670782	20	0.5	20	331.15	0.59	0	0	0
80	B3 Discharge dedusting A	412837	7670955	20	0.69	20	313.15	1.18	0	0	0
81	B3 Discharge dedusting B	412837	7670955	20	0.69	20	313.15	1.18	0	0	0
82	B4 Screen dedusting	412867	7670971	20	0.69	20	313.15	1.18	0	0	0
83	5.1 Main Stack	412768	7671120	60	2.92	16	613.15	3.48	28.7	1.22	0
84	5.2 Main Stack	412845	7671103	60	2.92	16	613.15	3.48	28.7	1.22	0
85	5.3 Main Stack	412952	7670079	60	2.92	16	613.15	3.48	28.7	1.22	0
86	6.1 Hot DRI dedusting	412771	7671264	65	0.79	20	323.15	1.21	0	0	0
87	6.2 Hot DRI dedusting	412849	7671146	65	0.79	20	323.15	1.21	0	0	0
88	6.3 Hot DRI dedusting	412955	7671223	65	0.79	20	323.15	1.21	0	0	0
89	7 Oxide handling dedusting	412879	7671223	65	0.51	20	323.15	0.51	0	0	0
90	8 Briquetting dedusting	412992	7671200	65	0.51	20	323.15	0.51	0	0	0
91	9 Passivation bin dedusting	412966	7670992	25	0.51	20	323.15	0.51	0	0	0
92	1 Unit 1	412420	7671700	40	2.9	46.12	813.15	0	19.47	0	0
93	2 Unit 2	412420	7671700	40	2.9	46.12	813.15	0	19.47	0	0

Src ID	Source	Easting m	Northing m	Height m	Stack Radius m	Velocity m/s	Temp K	PM_{10} g/s	NO_x g/s	SO_2 g/s	Rsmog g/s
Balmoral South Project (Proposed)											
88	Unit 1 – 240MW	411855.000	7664248.000	35	3	23	379.15	0.00	21.2	0.845	0
89	Unit 1 – 240MW	411804.000	7664259.000	35	3	23	379.15	0.00	21.2	0.845	0
90	Pellet Plant Stack A1[1]	411741.629	7665864.104	50	2.75	35	383.15	27	234	21.6	0
91	Pellet Plant Stack A2[2]	411765.291	7665790.752	50	2.25	33	373.15	0.09	99.5	0.4	0
92	Pellet Plant Stack A3[3]	411756.09	7665792.451	50	1	20.6	373.15	0.01	12.5	0.1	0
93	Pellet Plant Stack B1[1]	411699.87	7665670.264	50	2.75	35	383.15	27	234	21.6	0
94	Pellet Plant Stack B2[2]	411752.095	7665726.723	50	2.25	33	373.15	0.09	99.5	0.4	0
95	Pellet Plant Stack B3[3]	411741.744	7665729.076	50	1	20.6	373.15	0.01	12.5	0.1	0

1. Main Stack
2. Preheat Stack
3. Tempered Preheat Stack

6 MODEL VALIDATION

If modelling results are to be used as support for regulatory decision, it is essential to provide a measure of the model uncertainty. This information about uncertainties associated with modelling results can be as important as the modelling results in some cases. In this section the statistics of modelled and measured NO_2 and O_3 data at Dampier during 1999 are compared[d]. In addition, model predictions from the CSIRO study are also presented in order to ascertain whether TAPM model improvements (from TAPM V2.5 in the CSIRO study to TAPM V3 in the present study) affect the model results.

The statistics of modelled and measured NO_2 and O_3 are shown in Figure 6.1. With respect to NO_2, modelling with the newest version of TAPM produces a significant improvement in model performance compared to the modelling undertaken by CSIRO (Figure 6.1, upper). Model predictions of NO_2 approximate measurements for most averaging periods.

With respect to O_3, modelling with the newest version of TAPM produces some deterioration in model prediction when compared against the CSIRO results (Figure 6.1, lower). However, model results still compare favourably against measured values, and over predict maximum values by only 11%.

Based on the validation study, the model results presented in this assessment can be viewed with a fairly high degree of confidence.

[d] The only period for which monitoring data are available

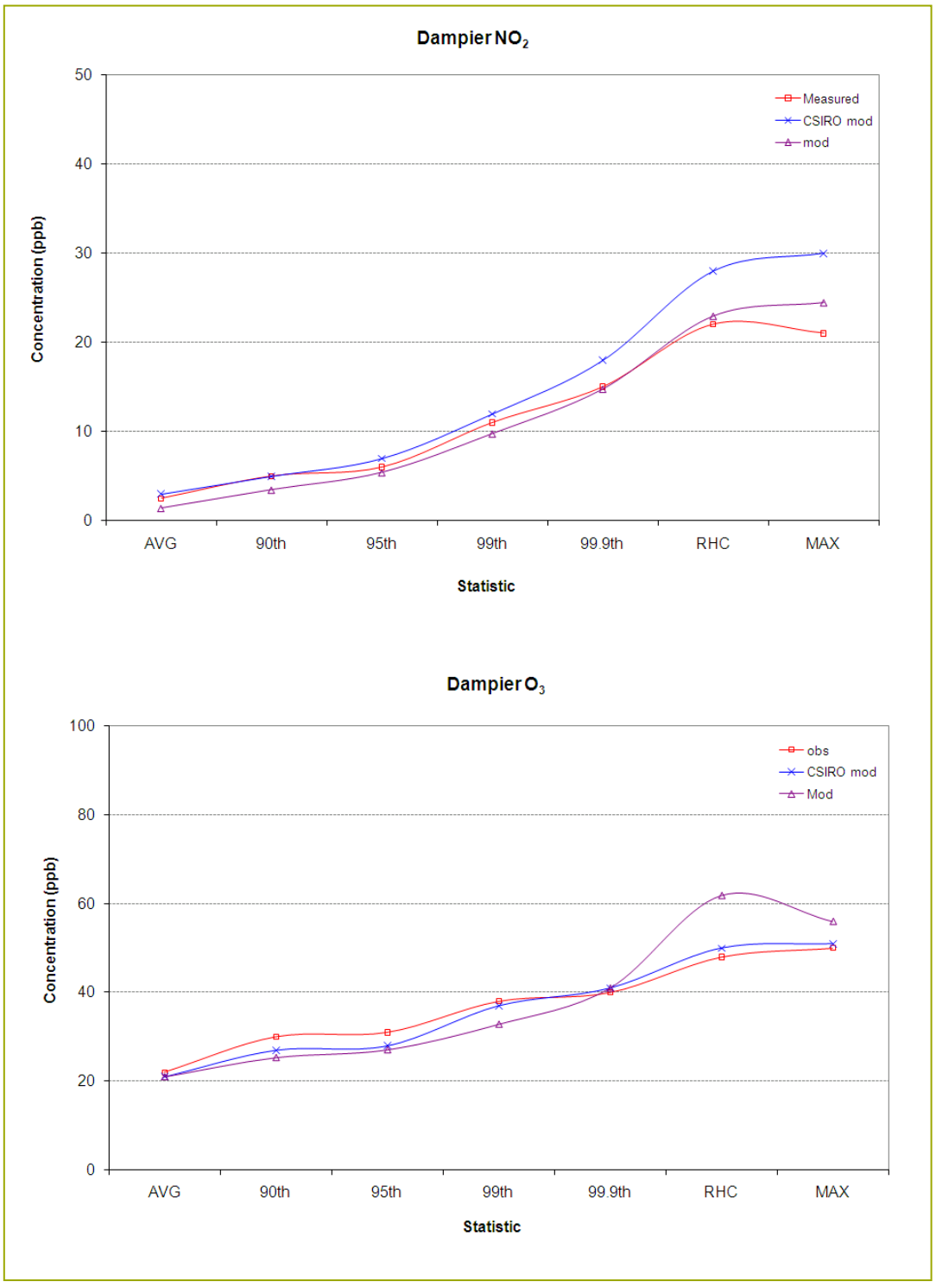


Figure 6.1: Statistics of predicted versus measured NO_2 (upper) and O_3 (lower) concentration at Dampier during 1999.

7 MODELLING RESULTS

The results from dispersion modelling are presented in the form of contour plots for the following pollutants and averaging periods[e]:

- annual average NO_2;
- maximum 1-hour NO_2;
- maximum 1-hour O_3.

7.1 Existing and Approved Projects

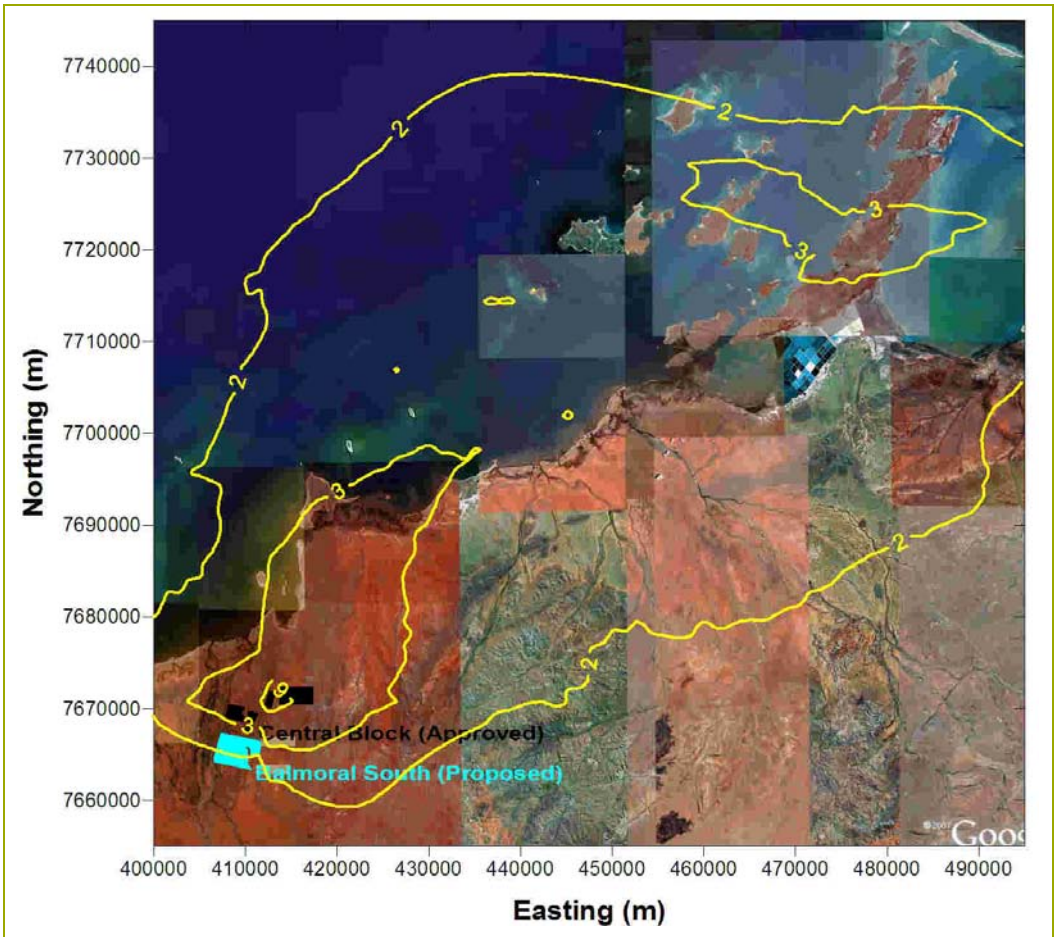
7.1.1 Nitrogen Dioxide

The predicted annual average ground-level NO_2 concentration contours are presented in Figure 7.1. Highest concentrations of 6 ppb are predicted to occur over the CB Project. Areas of concentrations exceeding 3 ppb include parts of the Burrup Peninsula. Concentrations are well within the relevant air quality guideline.

Predicted 2nd highest 1-hour NO_2 concentrations are shown in Figure 7.2. Modelling indicates that the 2nd highest 1-hour concentration of 90 ppb occurs over the CB Project. Over parts of the Burrup Peninsula, predicted 1-hour concentration is approximately 50 ppb. The NEP guideline of 120 ppb is not exceeded at any location in the study domain.

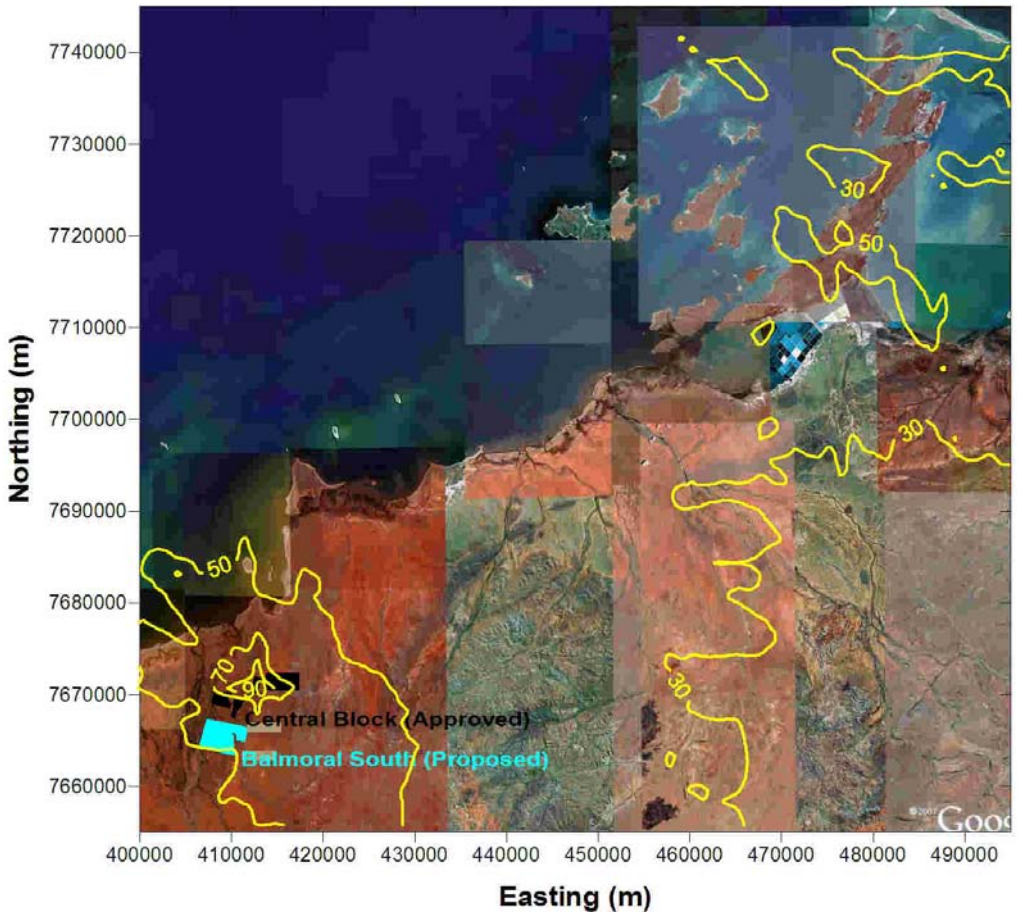
Statistics of predicted NO2 concentration at the sensitive (discrete) receptors in the region are shown in Figure 7.3. Dampier has the highest annual average concentration (3 ppb) and the highest short-term (1-hour) concentration of 42 ppb. The concentrations at the sensitive receptors are within the relevant air quality guidelines.

[e] These are based on the averaging periods as specified by the NEPM Guidelines



Species:	Location:	Scenario:	Percentile:	Averaging Time:
NO_2	Pilbara	Existing	-	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
TAPM V3	ppb	NEPM =30 ppb	1999 TAPM-Generated	P D'Abreton

Figure 7.1: Predicted annual average NO_2 concentrations.



Species: NO_2	**Location:** Pilbara	**Scenario:** Existing	**Percentile:** 2nd Highest	**Averaging Time:** 1-hour
Model Used: TAPM V3	**Units:** ppb	**Guideline:** NEPM =120 ppb	**Met Data:** 1999 TAPM-Generated	**Plot:** P D'Abreton

Figure 7.2: Predicted 2nd highest 1-hour NO_2 concentrations.

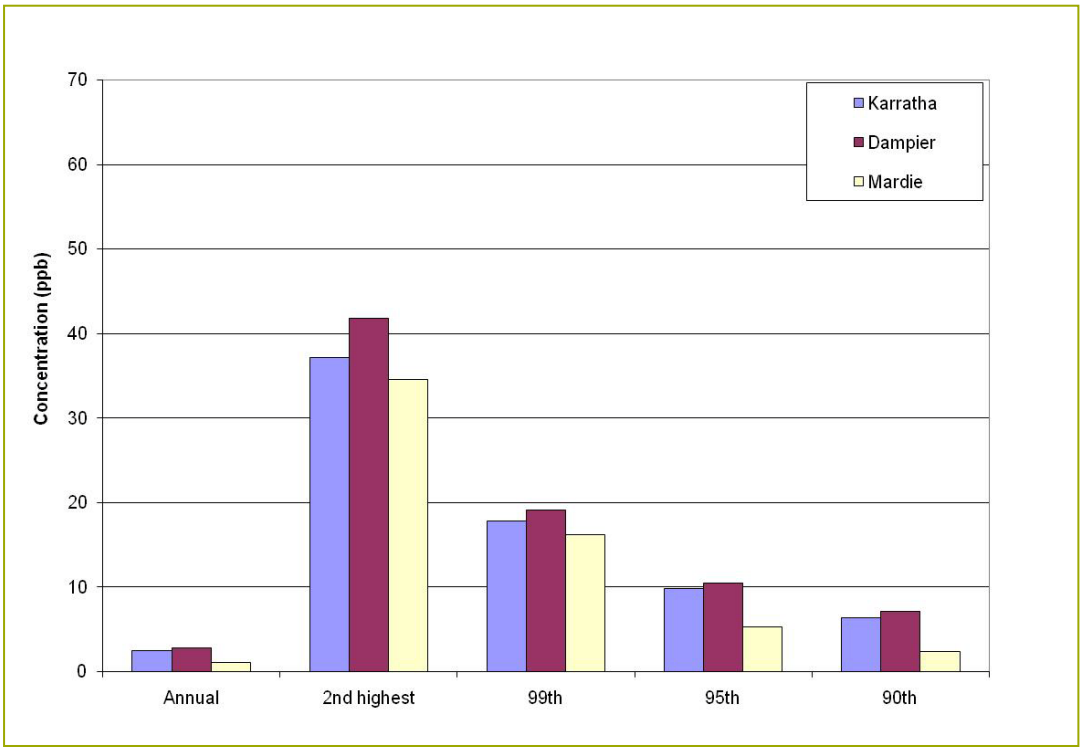
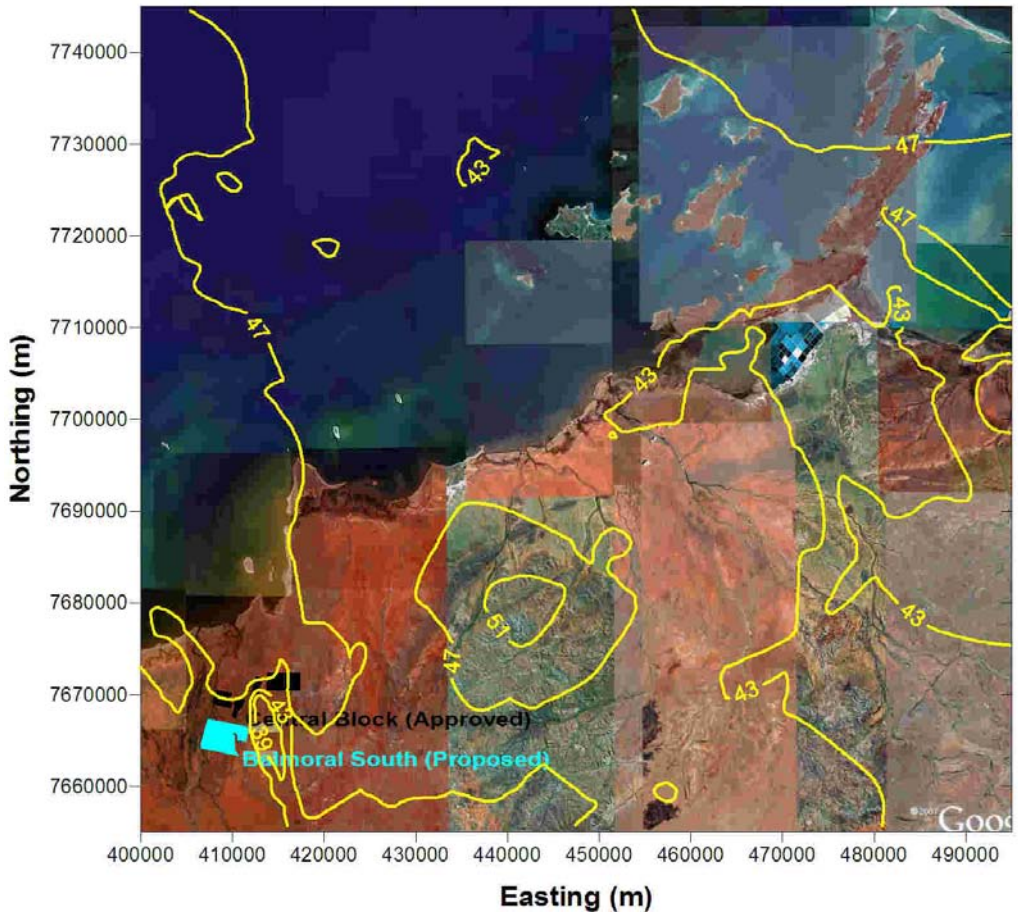


Figure 7.3: NO_2 concentration statistics at the discrete receptors.

7.1.2 Ozone

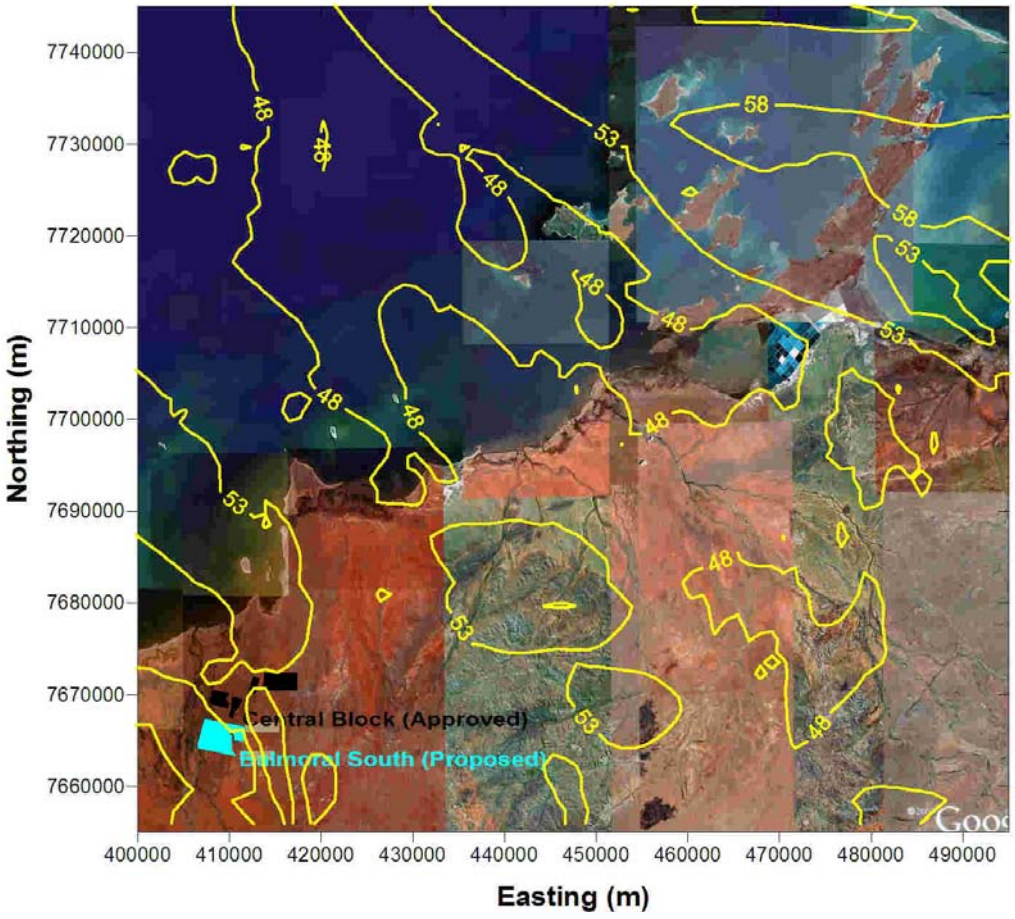
The predicted 2nd highest 4-hour O_3 concentrations are shown in Figure 7.4. Modelling indicates that the highest 4-hour concentration of 51 ppb occurs approximately 25 Km to the east of the CB Project. The NEP guideline of approximately 80 ppb is not exceeded at any location in the study domain.

Statistics of predicted O_3 concentration at the sensitive receptors in the region are shown in Figure 7.6. Annual average concentration of approximately 20 ppb occurs at all three receptors. Dampier has the highest short-term (1-hour) concentration of 55 ppb. The concentrations at the sensitive receptors are within the relevant air quality guidelines.



Species: O_3	**Location:** Pilbara	**Scenario:** Existing	**Percentile:** 2nd Highest	**Averaging Time:** 4-hour
Model Used: TAPM V3	**Units:** ppb	**Guideline:** NEPM =80 ppb	**Met Data:** 1999 TAPM-Generated	**Plot:** E Castiilo

Figure 7.4: Predicted 2nd highest 4-hour O_3 concentrations.



Species:	Location:	Scenario:	Percentile:	Averaging Time:
O_3	Pilbara	Existing	2nd Highest	1-hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
TAPM V3	ppb	NEPM =100 ppb	1999 TAPM-Generated	E Castiilo

Figure 7.5: Predicted 2nd highest 1-hour O_3 concentrations.

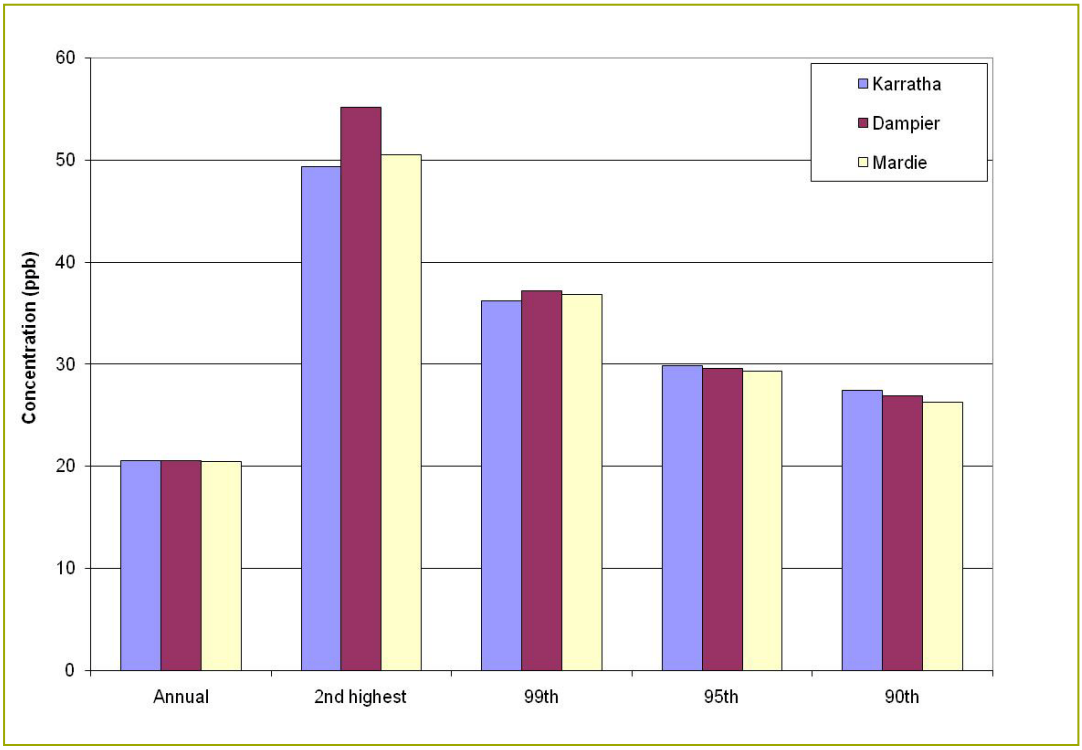


Figure 7.6: O_3 concentration statistics at the discrete receptors.

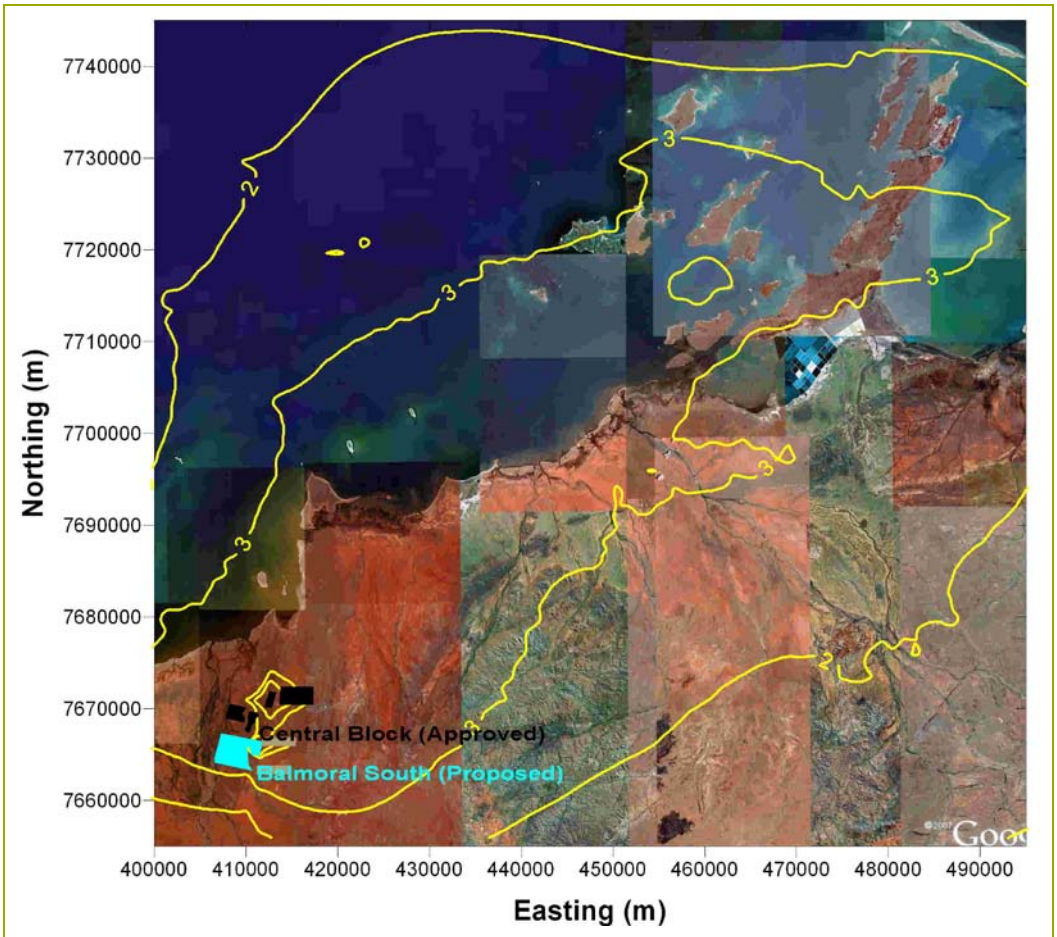
7.2 Existing, Approved and Proposed Projects

7.2.1 Nitrogen Dioxide

The predicted annual average ground-level NO_2 concentration contours are presented in Figure 7.7. Highest concentrations of 19 ppb are predicted to occur over the CB Project. Areas of concentrations exceeding 3 ppb increase to include a large part of the Burrup Peninsula. Concentrations are within the relevant air quality guideline over the CB and BS Project sites, and well within the guideline elsewhere.

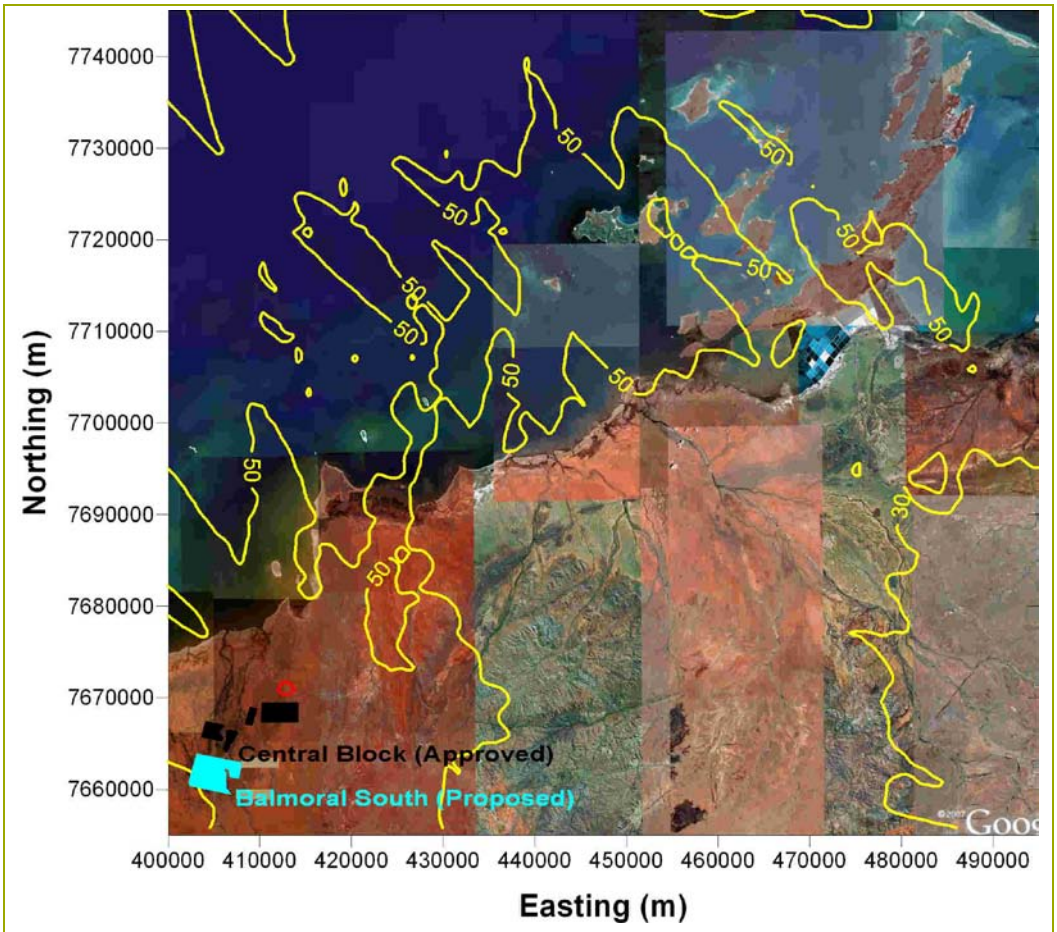
Predicted 2nd highest 1-hour NO_2 concentrations are shown in Figure 7.8. Modelling indicates that the 2nd highest 1-hour concentration of approximately 150 ppb occurs over the CB and BS Projects. The area predicted to experience 1-hour concentration exceeding 50 ppb increases to include most of the coastline between Cape Preston and the Burrup Peninsula. The air quality guideline of 120 ppb is exceeded over a very small area north of the Central Block.

Statistics of predicted NO_2 concentration at the sensitive (discrete) receptors in the region are shown in Figure 7.9. Mardie has the highest short-term (1-hour) concentration of 43 ppb, with Dampier having a concentration of 42 ppb. The concentrations at the sensitive receptors are all within the relevant air quality guidelines.



Species: NO_2	**Location:** Pilbara	**Scenario:** Existing, Approved, Proposed Project	**Percentile:** -	**Averaging Time:** Annual
Model Used: TAPM V3	**Units:** ppb	**Guideline:** NEPM =30 ppb	**Met Data:** 1999 TAPM-Generated	**Plot:** P D'Abreton

Figure 7.7: Predicted annual average NO_2 concentrations.



Species:	Location:	Scenario:	Percentile:	Averaging Time:
NO_2	Pilbara	Existing, Approved, Proposed Project	2nd Highest	1-hour
Model Used: TAPM V3	**Units:** ppb	**Guideline:** NEPM =120 ppb	**Met Data:** 1999 TAPM-Generated	**Plot:** P D'Abreton

Figure 7.8: Predicted 2nd highest 1-hour NO_2 concentrations.

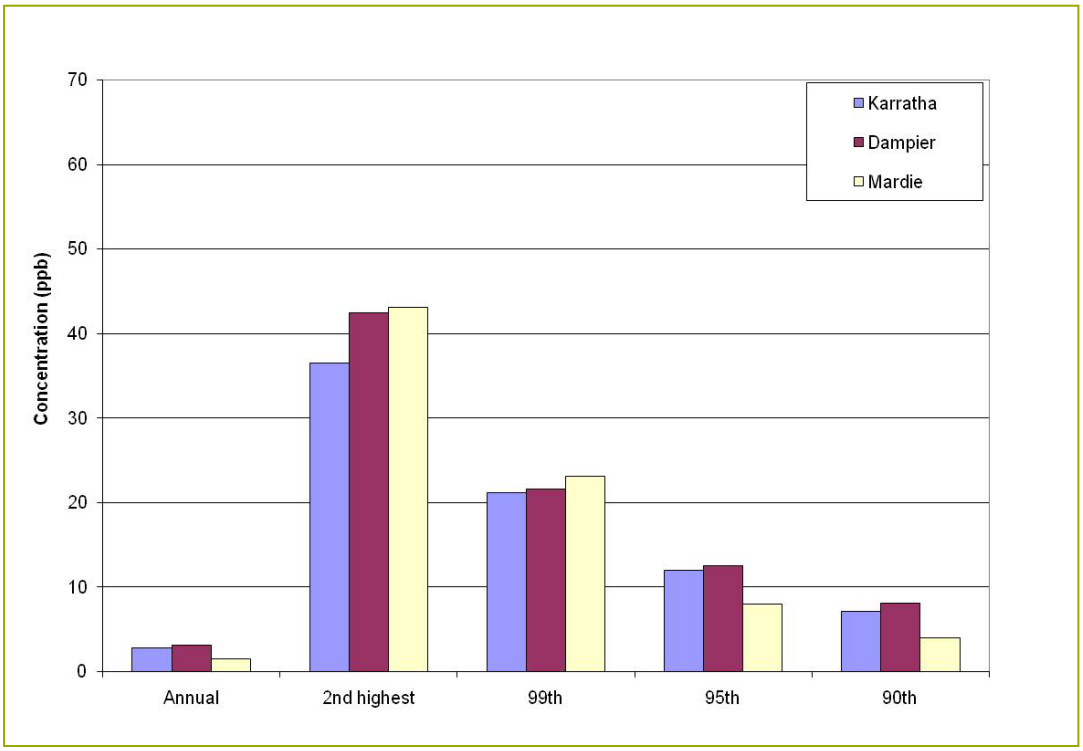
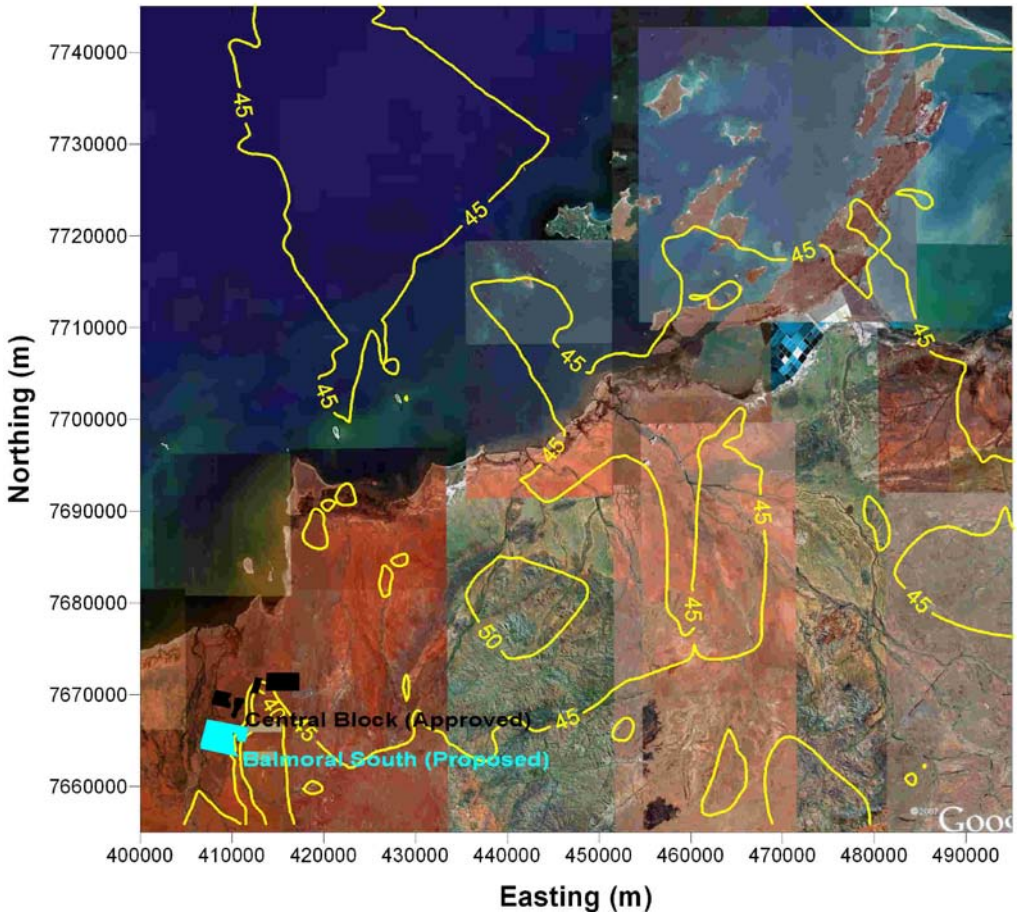


Figure 7.9: NO_2 concentration statistics at the discrete receptors.

7.2.2 Ozone

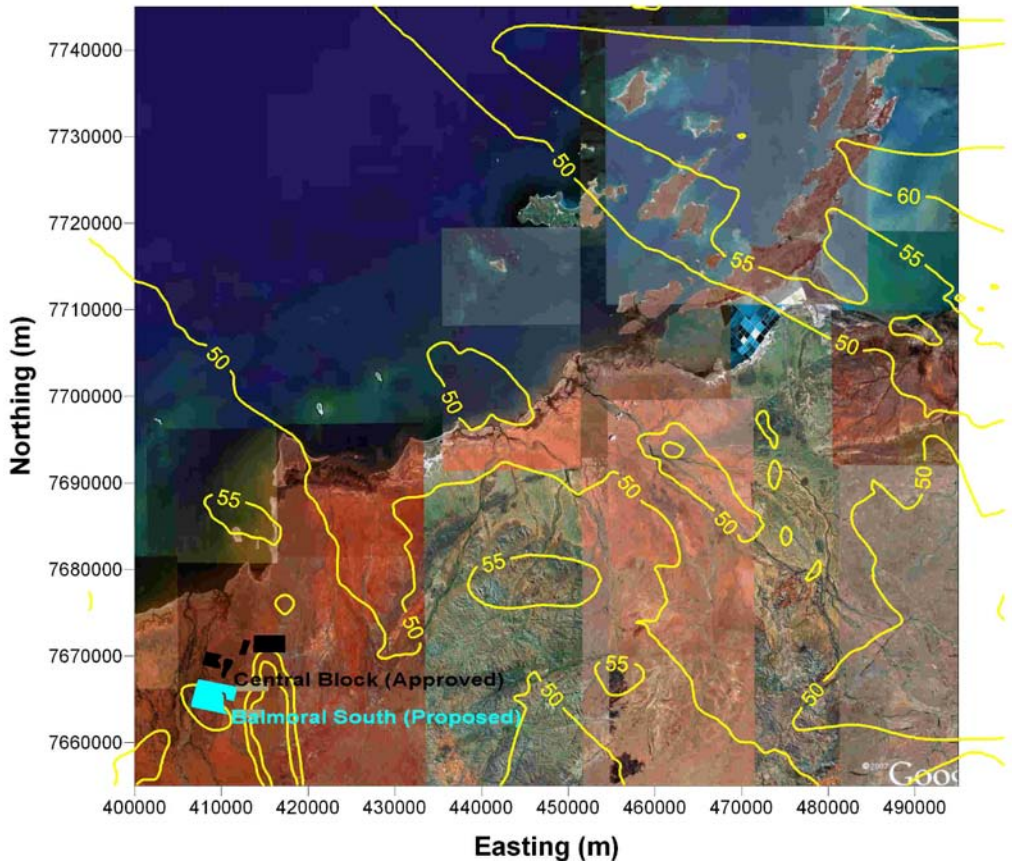
The predicted 2nd highest 4-hour O_3 concentrations are shown in Figure 7.10. Modelling indicates that the highest 4-hour concentration of 51 ppb occurs approximately 25 Km to the east of the CB Project. This is in a similar location and magnitude to the previous scenario maximum (see Section 7.1.2). Generally, there is a marginal increase in O_3 concentration over the domain. The NEPM guideline of approximately 80 ppb is not exceeded at any location in the study domain. Similarly, predicted one-hour O_3 concentrations are within the NEP guideline (Figure 7.11).

Statistics of predicted O_3 concentration at the sensitive receptors in the region are shown in Figure 7.12. Annual average concentration of approximately 20 ppb at all three receptor is relatively unchanged from the previous scenario (*c.f.* Section 7.1.2). The highest short-term (1-hour) concentration does not increase significantly from the previous scenario. The concentrations at the sensitive receptors are within the relevant air quality guidelines.



Species: O_3	**Location:** Pilbara	**Scenario:** Existing, Approved, Proposed Project	**Percentile:** 2nd Highest	**Averaging Time:** 4-hour
Model Used: TAPM V3	**Units:** ppb	**Guideline:** NEPM =80 ppb	**Met Data:** 1999 TAPM-Generated	**Plot:** E Castiilo

Figure 7.10: Predicted 2nd highest 4-hour O_3 concentrations.



Species:	Location:	Scenario:	Percentile:	Averaging Time:
O_3	Pilbara	Existing, Approved, Proposed Project	2nd Highest	1-hour
Model Used: TAPM V3	**Units:** ppb	**Guideline:** NEPM =100 ppb	**Met Data:** 1999 TAPM-Generated	**Plot:** E Castiilo

Figure 7.11: Predicted 2nd highest 1-hour O_3 concentrations.

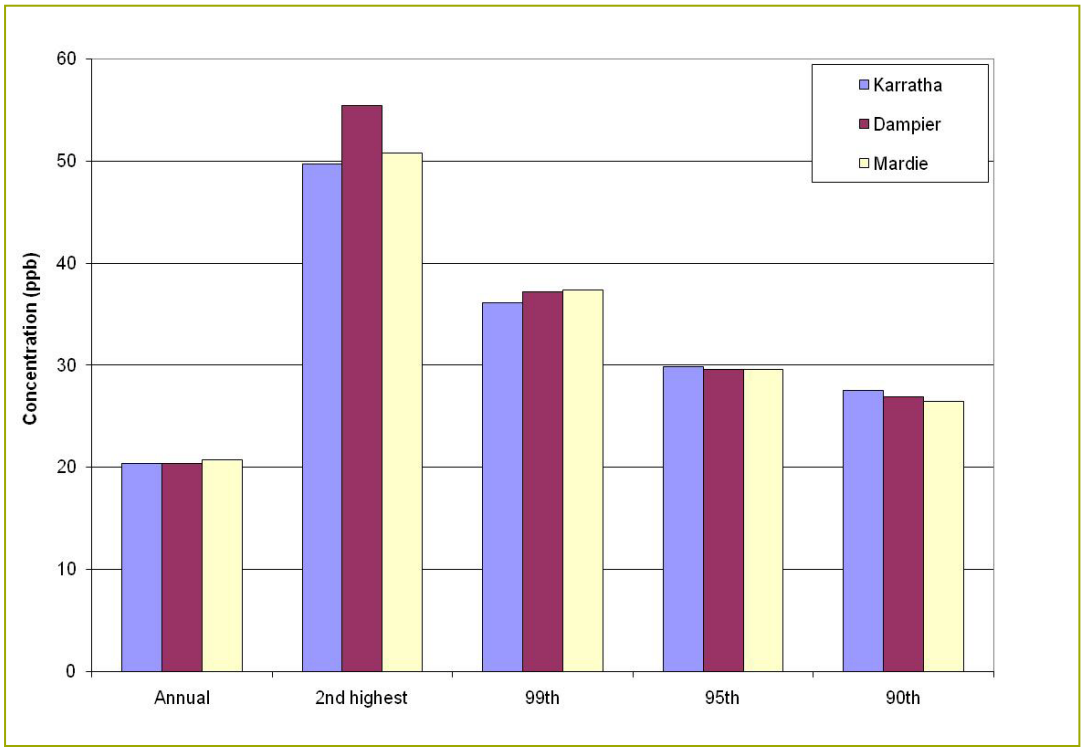


Figure 7.12: O_3 concentration statistics at the discrete receptors.

8 DISCUSSION

8.1 Meteorological Conditions

8.1.1 Ozone

The hourly meteorological conditions corresponding to predicted hourly ozone concentrations at the three sensitive receptors are shown in Figure 8.1 to Figure 8.3.

At Karratha and Dampier, higher ozone concentrations are generally associated with moderate to high temperatures and light (2-4 m/s) north-westerly to north-easterly winds (Figure 8.1 and Figure 8.2). At Mardie, to the south of the BS project, elevated ozone concentrations are predicted to occur with elevated temperatures and light to moderate (2-5 m/s) north-westerly to north-easterly winds (Figure 8.3). This suggests that ozone formation occurs over the ocean within an aged air mass before being advected overland with the afternoon sea breeze.

8.2

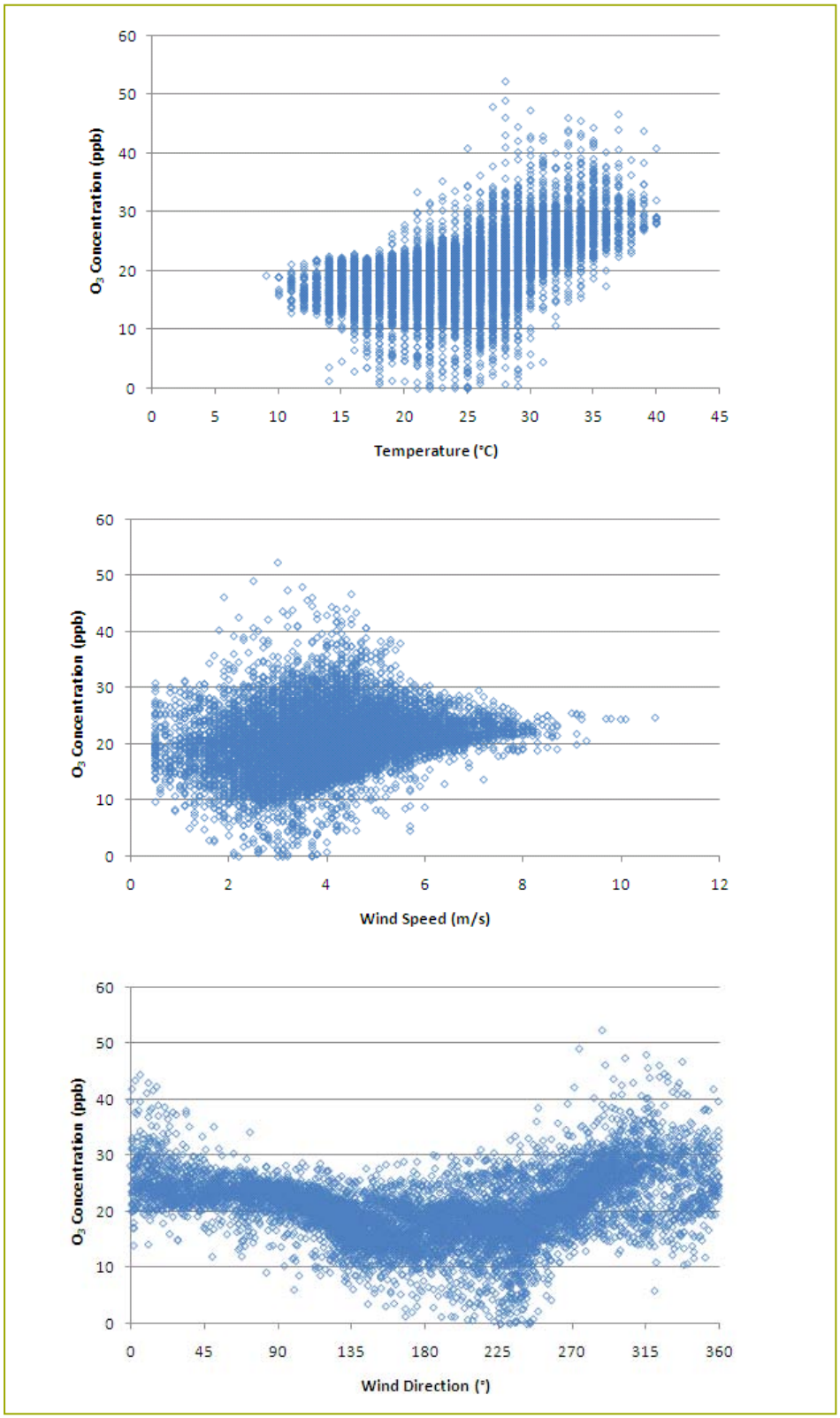


Figure 8.1: Relationship between temperature (upper), wind speed (centre) and wind direction (lower) with predicted ozone at Karratha.

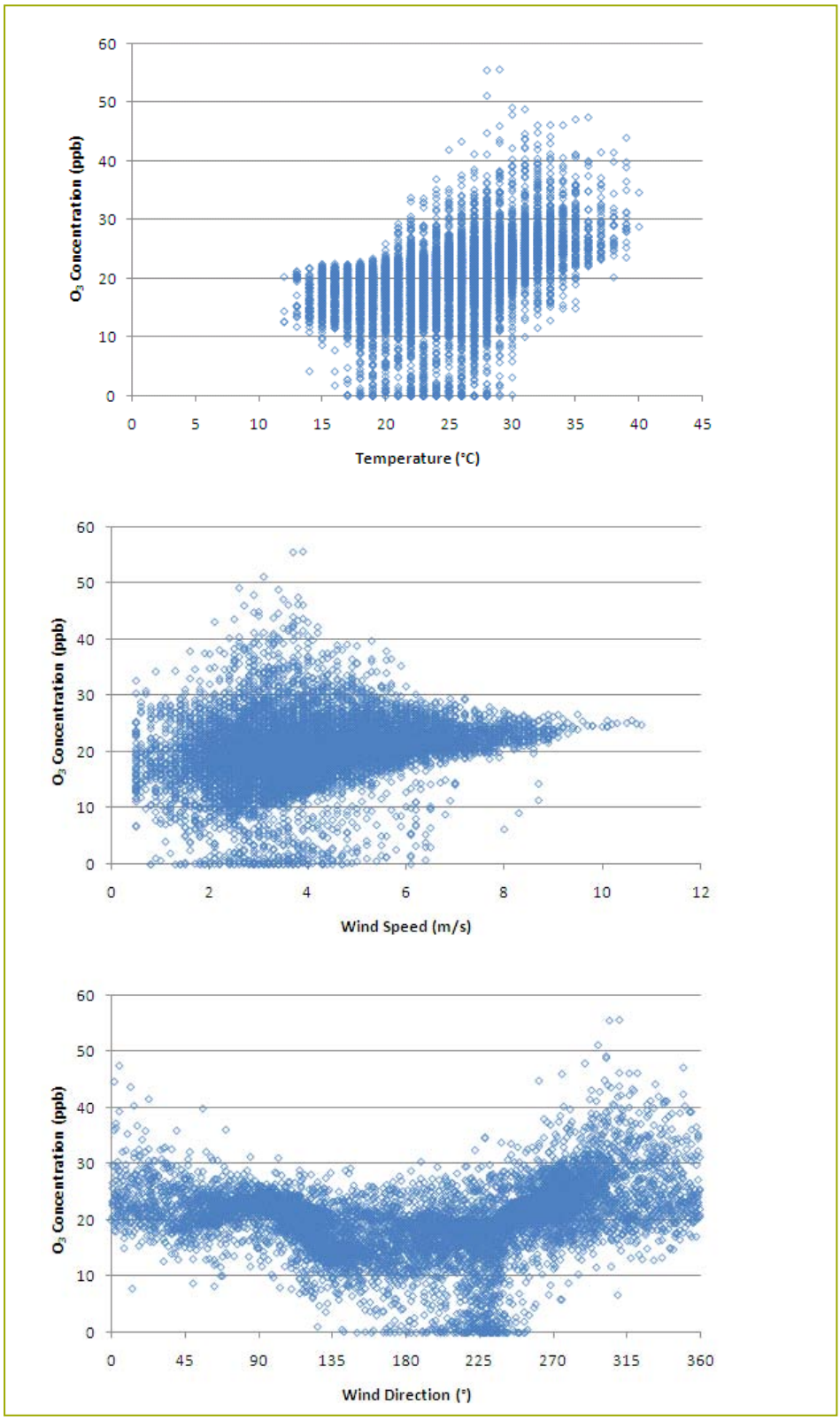


Figure 8.2: Relationship between temperature (upper), wind speed (centre) and wind direction (lower) with predicted ozone at Dampier.

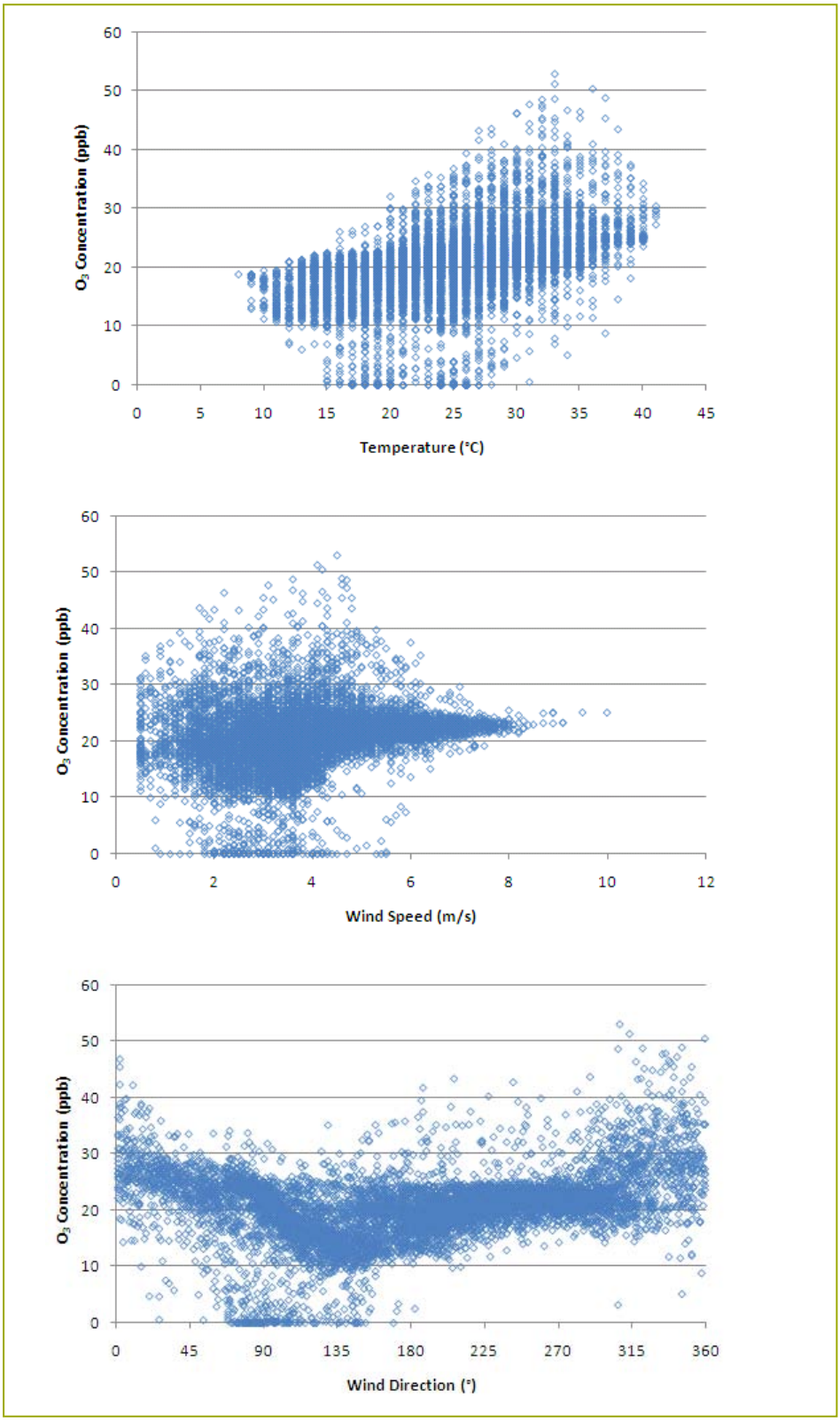


Figure 8.3: Relationship between temperature (upper), wind speed (centre) and wind direction (lower) with predicted ozone at Mardie.

Meteorological conditions during the ozone maximum at the three discrete receptors are shown in Figure 8.4 and Figure 8.5.

Predicted peak ozone events occur at Karratha and Dampier on 27 February 2007. As expected, ozone concentrations are low at both stations during pre-dawn hours when ozone production does not occur (Figure 8.4). Southerly to south-easterly winds dominate those hours, advecting all pollutants northwards over the ocean. By midday, a predicted secondary ozone peak of 30 ppb occurs at both locations. This peak occurs with maximum temperatures and north-north-easterly winds. The ozone impacting on the locations during this time appears to originate over the ocean, suggesting ozone production there within an aged air mass before being advected overland with the onset of the sea breeze. The predicted peak ozone concentration at both locations occurs at 20:00, with lower temperatures and north-westerly winds.

Peak predicted ozone concentration of 52 ppb at Mardie on 27 November 2007 is associated with relatively high temperatures and moderate north-westerly winds (Figure 8.5). This indicates that ozone formation occurs over the ocean within a relatively aged air mass before being advected overland with the afternoon sea breeze.

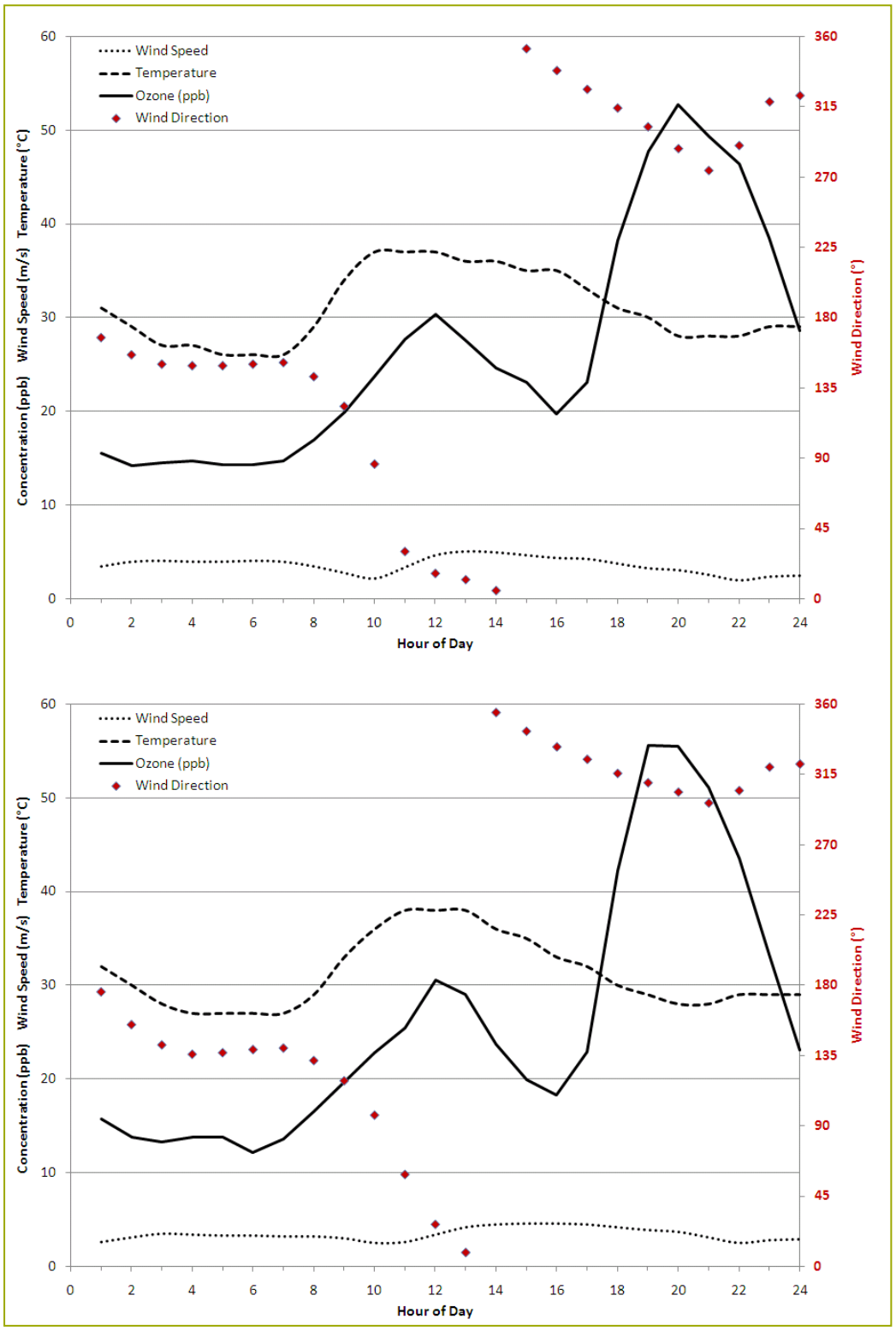


Figure 8.4: Meteorological conditions during the peak ozone event at Karratha (upper) and Dampier (lower) on 27 February 2007

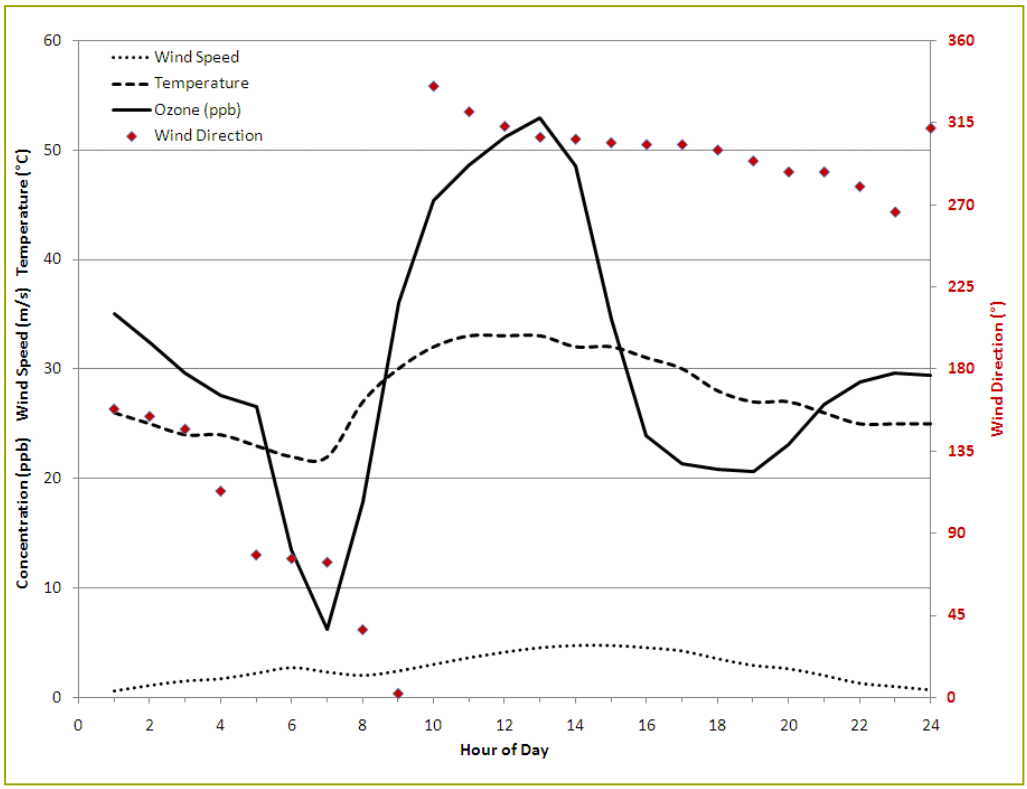


Figure 8.5: Meteorological conditions during the peak ozone event at Mardie on 27 November 2007

8.2.1 Nitrogen Dioxide

The hourly meteorological conditions corresponding to predicted hourly ozone concentrations at the three sensitive receptors are shown in Figure 8.6 to Figure 8.8.

At Karratha, higher nitrogen dioxide concentrations are associated with moderate to high temperatures, and light (2-4 m/s) north-westerly and south-westerly winds (Figure 8.6). The peak with north-westerly winds is most likely associated with emissions from industry on the Burrup Peninsula, whereas the peak with south-westerly wind is most likely associated with emissions from the CB and BS projects at Cape Preston.

At Dampier, elevated nitrogen dioxide concentrations are associated with moderate to high temperatures, and light (2 m/s) north-easterly and south-westerly winds (Figure 8.7). The peak with south-westerly wind is most likely associated with emissions from the CB and BS projects at Cape Preston.

At Mardie, elevated nitrogen dioxide concentrations are predicted to occur with temperatures above 25°C and light (2 m/s) north-easterly to south-easterly winds (Figure 8.8). A secondary maximum occurs with north-westerly winds. This indicates that while nitrogen dioxide peaks at this site are associated with direct impact of the emissions from the CB and BS projects, some evidence suggests that nitrogen dioxide formation occurs over the ocean within an aged air mass before being advected overland with the afternoon sea breeze.

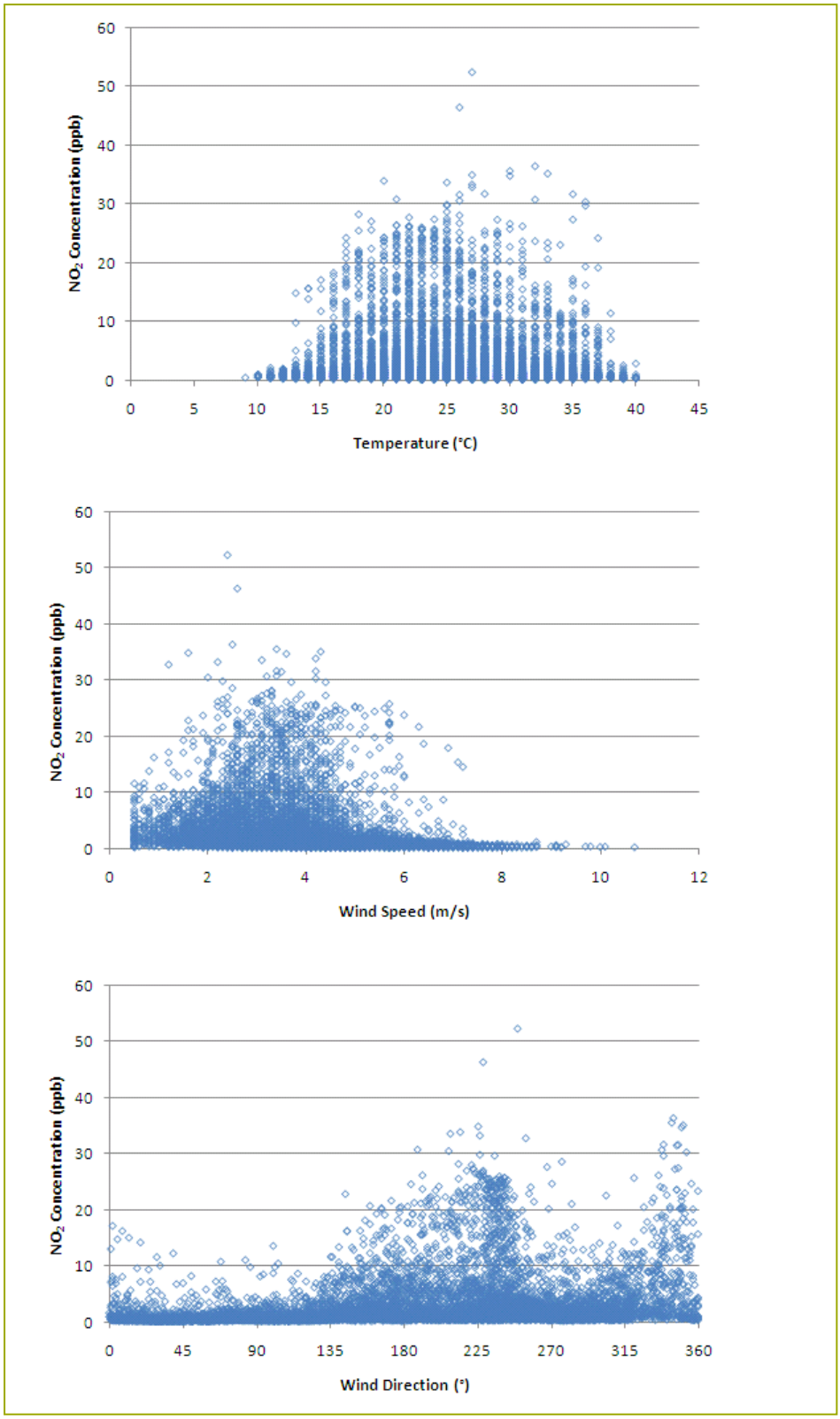


Figure 8.6: Relationship between temperature (upper), wind speed (centre) and wind direction (lower) with predicted nitrogen dioxide at Karratha

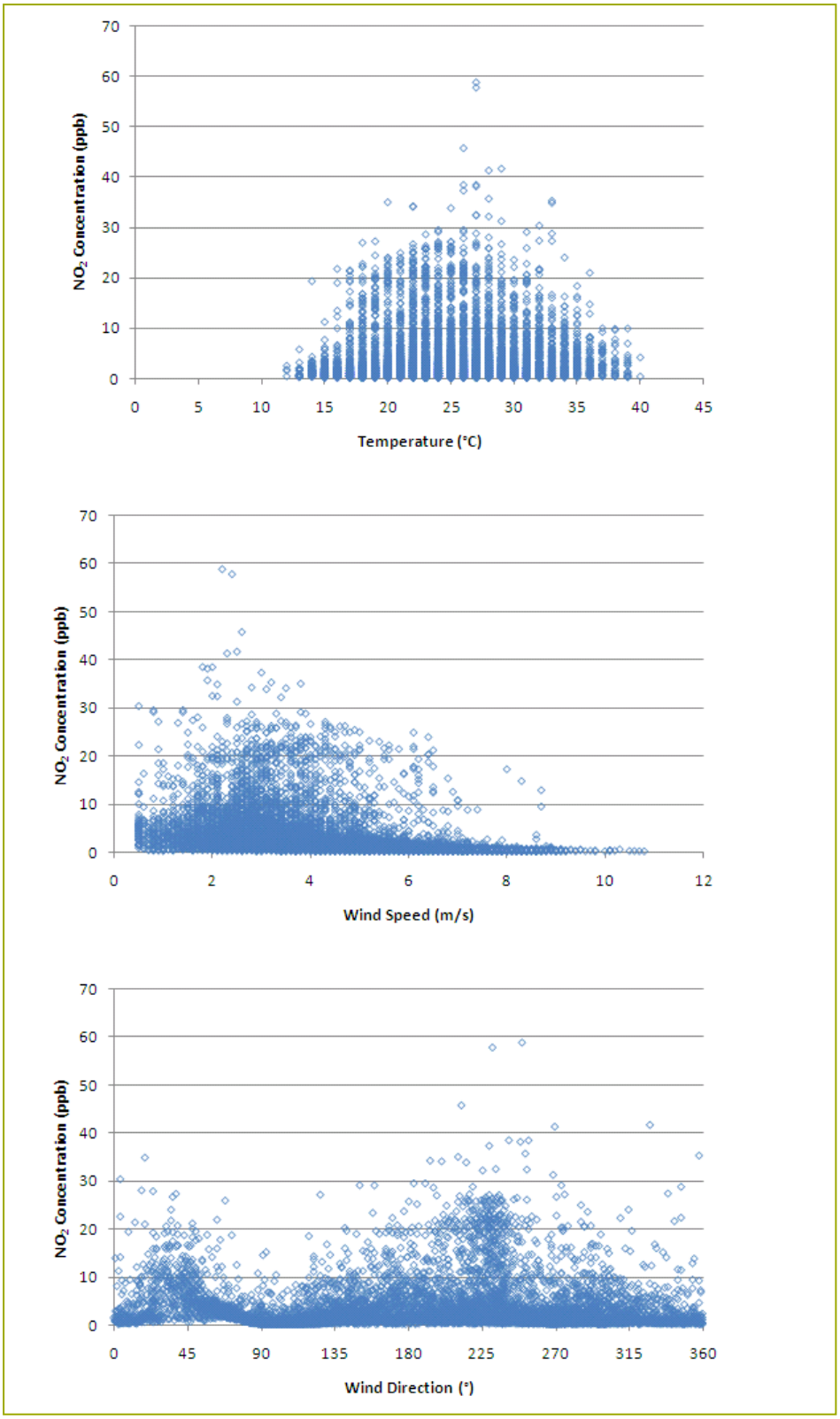


Figure 8.7: Relationship between temperature (upper), wind speed (centre) and wind direction (lower) with predicted nitrogen dioxide at Dampier

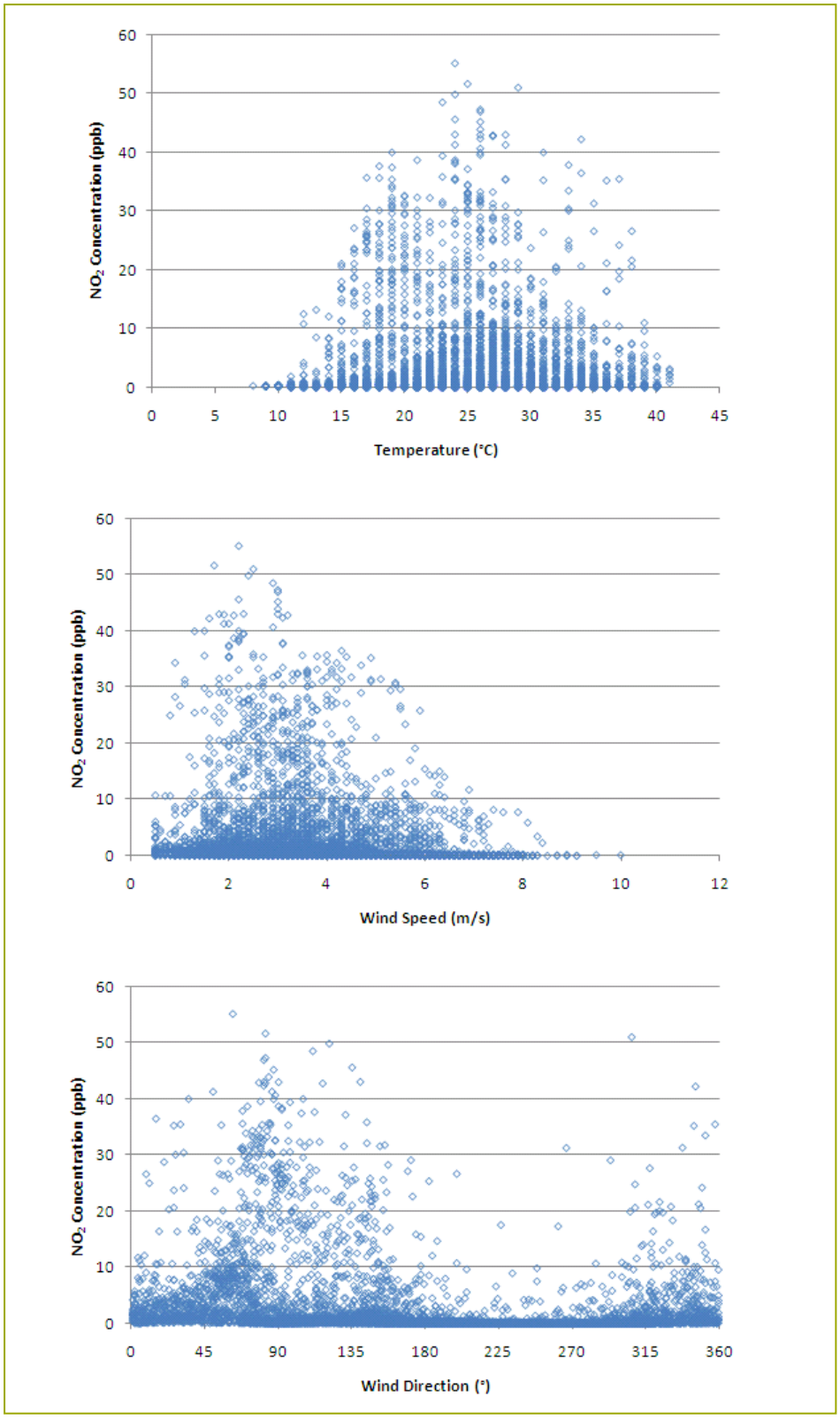


Figure 8.8: Relationship between temperature (upper), wind speed (centre) and wind direction (lower) with predicted nitrogen dioxide at Mardie

Meteorological conditions during the nitrogen dioxide maximum at the three discrete receptors are shown in Figure 8.9 and Figure 8.10.

Predicted peak nitrogen dioxide events occur at Karratha and Dampier on 13 April 2007. The predicted peak concentration at both locations occurs between 12:00 and 19:00, with elevated temperatures and north-westerly winds (Figure 8.9). North-westerly winds dominate those hours, suggesting direct influence on those receptors from emissions on the Burrup Peninsula. At 22:00, a predicted secondary ozone peak of 20 ppb occurs at both locations. This peak occurs with decreasing temperatures and light south-westerly winds. The nitrogen dioxide impacting on the locations during this time appears to originate from emissions at the CB and BS projects, suggesting NO_x to NO_2 conversion within an aged air mass.

Peak predicted nitrogen dioxide concentration of 33 ppb at Mardie on 17 April 2007 is associated with relatively high temperatures and moderate north-westerly winds (Figure 8.10). This indicates that nitrogen dioxide formation occurs over the ocean within a relatively aged air mass before being advected overland with the afternoon sea breeze.

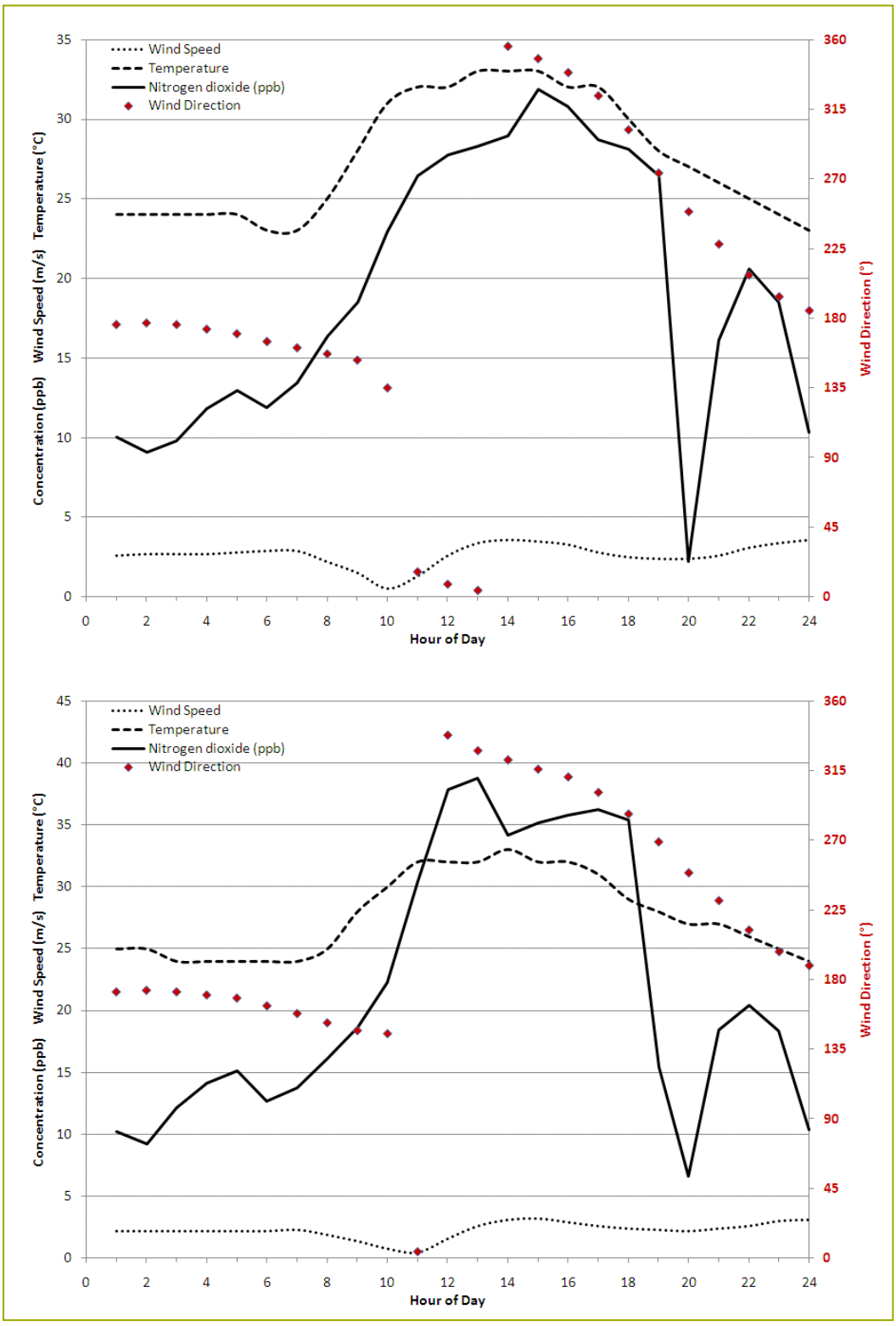


Figure 8.9: Meteorological conditions during the peak nitrogen dioxide event at Karratha (upper) and Dampier (lower) on 13 April 2007

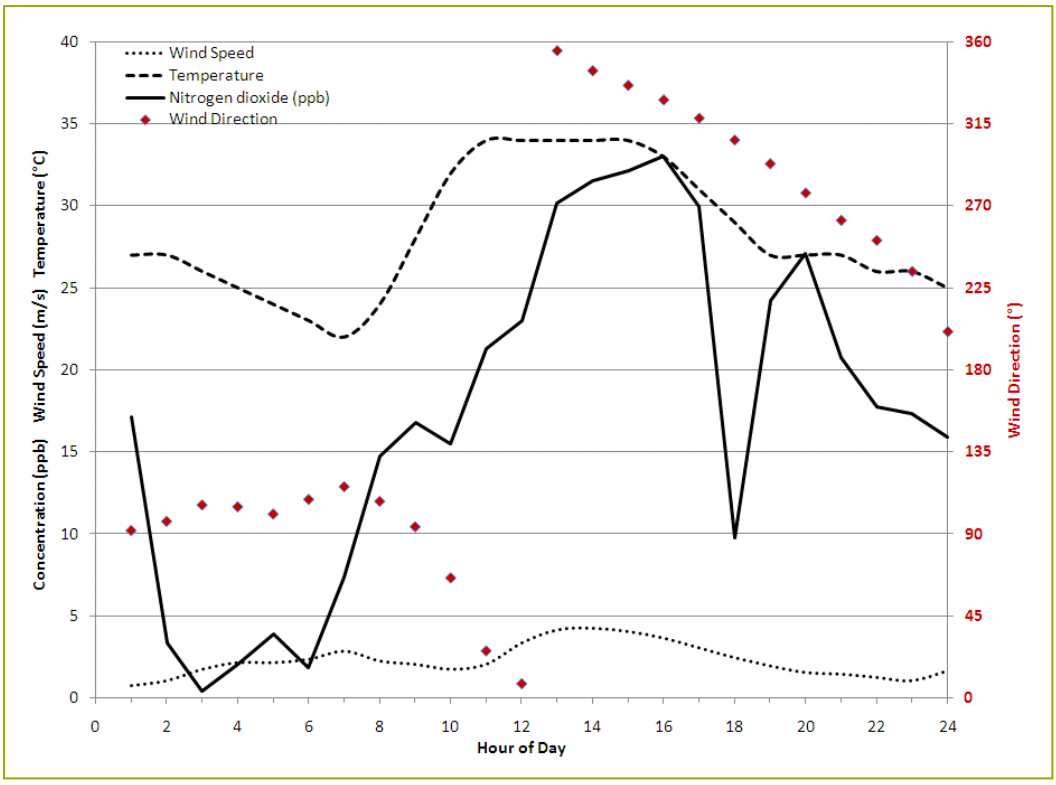


Figure 8.10: Meteorological conditions during the peak nitrogen dioxide event at Mardie on 17 April 2007

8.3 Photochemical Smog Formation

Photochemical smog involves the formation of a wide range of gaseous and particulate compounds. Ozone forms in a series of reactions involving precursor emissions (oxides of nitrogen and reactive organic gases) in the presence of sunlight. These photochemical reactions are complex, but the basic reactions can be simplified as follows:

Sunlight provides the energy for the reaction:

$$NO_2 + O_2 \rightarrow NO + O_3$$

Nitrogen dioxide (NO_2) is produced by the oxidation of NO. Most of the oxidation occurs by the reactions:

$$NO + O3 \rightarrow NO_2 + O_2$$

and

$$NO + RP \rightarrow NO_2 + RP$$

In the latter case, RP denotes the free radical pool, which provides “spare” oxygen atoms for the reaction. The free radical pool is influenced by the presence of reactive organic gases, which are a subset of total volatile organic compounds (VOC). The availability of free radicals is essentially determined by VOC concentrations, the amount of energy from sunlight, and temperature. As these increase, RP increases and facilitates the formation of additional NO_2 to drive ozone formation.

In a situation where all of the available NO_x has been consumed, there is no more conversion of NO_x possible and the amount of smog produced is limited by the amount of NO_x in the air. This regime is known as 'NO_x-limited'. Similarly, when the concentration of VOCs is substantially less than that of NO_x, ozone formation is limited by the amount of VOC available and the regime is said to be 'VOC-limited'.

If ozone production is limited by NO_x, reducing emissions of VOCs may have little or no effect in reducing the level of ozone. Naturally occurring VOCs from trees and other vegetation causes the formation of ozone to be NO_x-limited in many regions. As a general rule, the formation of ozone tends to be 'VOC-limited' in urban areas but as urban air moves over rural areas, it typically becomes more 'NOx-limited'. It is therefore important in the present study to ascertain whether the air shed is 'NO_x-' or 'VOC-limited', as this will determine whether the additional NO_x emissions from the Balmoral South project would increase or decrease photochemical smog (i.e. O_3 concentration) in the area.

Scatter plots of predicted NO2 and O3 at Karratha, Dampier and Mardie (for both scenarios modelled) are shown in Figure 8.11 and Figure 8.12. The figures suggest that at the air shed is 'VOC-limited' (indicated by the negative relationship between NO_2 and O_3).

The 'VOC-limited' nature of the air shed suggests that increased NO_2 emissions over Cape Preston will not result in significant increase in O_3 concentration over the air shed.

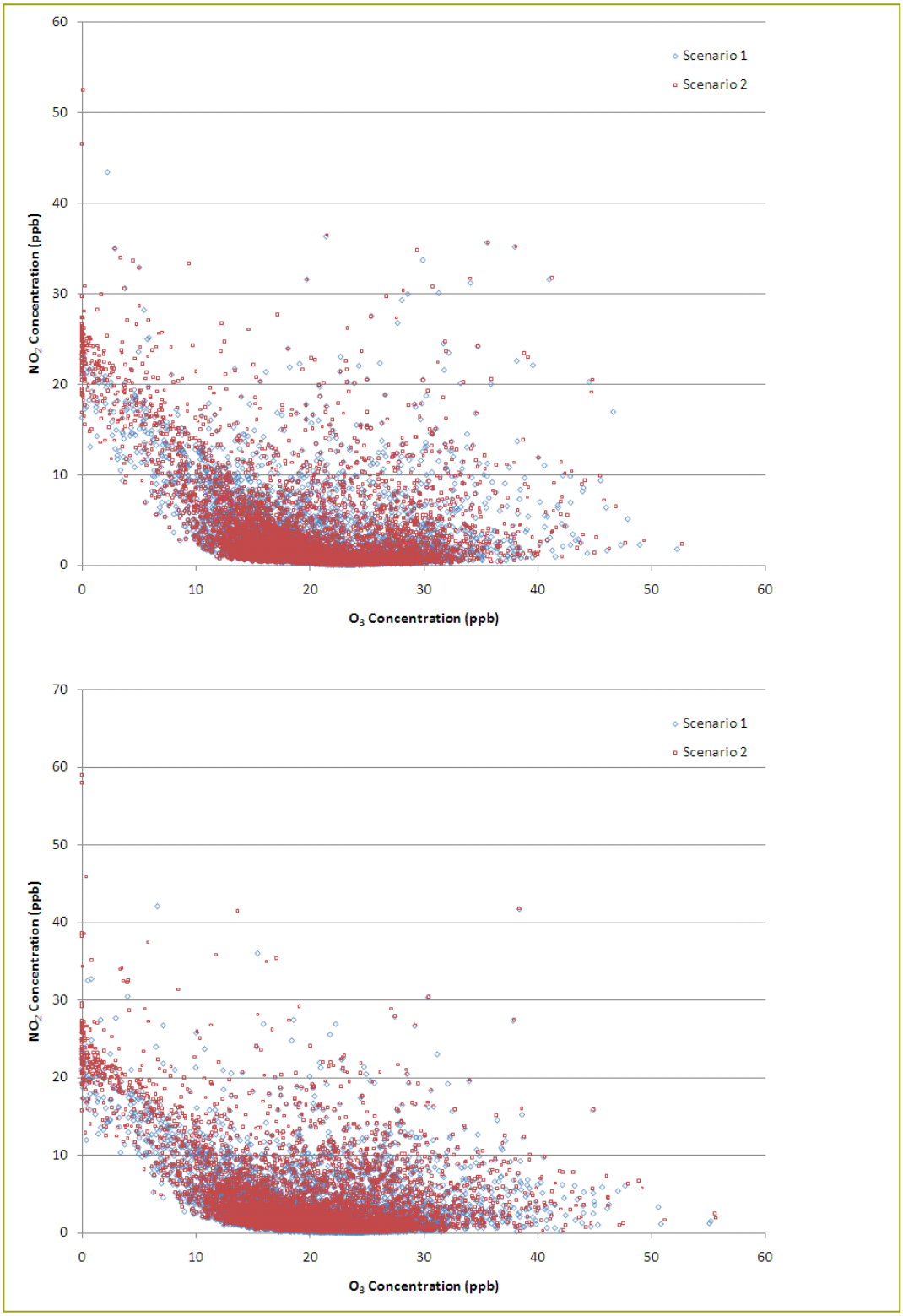


Figure 8.11: Scatter plot of predicted NO_2 and O_3 concentration at Karratha (upper) and Dampier (lower).

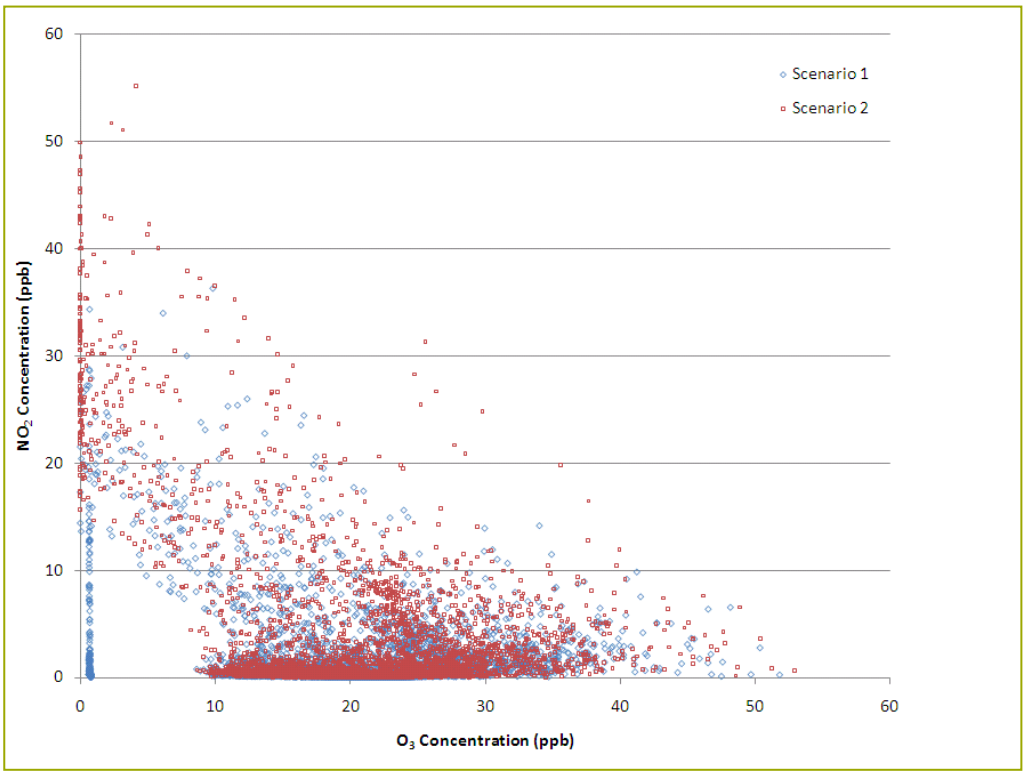


Figure 8.12: Scatter plot of predicted NO_x and O_3 concentration at Mardie.

9 CONCLUSIONS

Photochemistry modelling of the air shed over the Burrup Peninsula has been performed to assess the likely impact on the regional air quality from the proposed pellet and power plant forming part of the Balmoral South (BS) project near Cape Preston.

Use was made of the TAPM model. Emissions from current sources in the region, from the approved Mineralogy Central Block (CB) project, and the proposed Balmoral South (BS) project were utilised in the modelling.

The results of the modelling (for existing, approved and proposed developments) indicate the following:

- The highest annual average NO_2 concentration of 19 ppb occurs over the CB and BS projects. The predictions are within the air quality guideline.
- Thehighest 1-hour NO_2 concentration of 120 ppb over the CB and BS projects is shown to exceed over a very small area north of Central Block.
- The highest 1-hour O_3 concentration of 62 ppb occurring between Cape Preston and Karratha is within the air quality guideline.
- Predicted 4-hour O_3 concentration is within the guideline value.
- Further, the following are evident at the sensitive receptors:
    - NO_2 increase with the proposed project is very minimal, with the only observable change in Mardie from 35 ppb to 43 ppb).
    - Predicted NO_2 concentrations are within the air quality guideline at all three receptors.
    - O_3 increase with the proposed project is minimal at all three sensitive receptors.
    - Highest predicted 1-hour O_3 concentrations at the three sensitive receptors are within the air quality guideline.

Investigation of the relationship between meteorological conditions and O_3 concentration shows that:

- elevated concentrations occurs with moderate to high temperatures, with light north-westerly winds at the three receptors; and
- peak ozone occurs with north-westerly winds at the three receptors.
- This suggests that ozone forms over ocean and is advected over land by the sea breeze.

- Investigation of the relationship between meteorological conditions and NO_2 concentration shows that:
- elevated concentration occurs with light north-westerly to south-westerly winds at Karratha and Dampier, and with north-easterly to north-westerly winds at Mardie;
- peak NO_2 concentration with north-westerly winds at the three receptors;

- there is evidence of both indirect (i.e. sea breeze re-circulation) and direct (i.e. plume advection directly from source) impacts on NO_2 concentration at the three receptors

Assessment of the model results show that increased NO_x emissions into the air shed may in fact decrease O_3 concentration, suggesting a 'VOC-limited' air shed. Short-term NO_2 concentration is predicted to increase over the Cape Preston region, but is unlikely to exceed the air quality guideline.

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