Appendix F

Environmental Referral, North West infrastructure Multi User Iron Ore Export (Landside) Facility

Dust Assessment

NWI Environmental Study for Multi User Iron Ore Export Port Facility – Port Hedland

AIR QUALITY AND GREENHOUSE GAS STUDY – PORT OPERATIONS

- Rev 5
- 05 September 2011

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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 dust dispersion modelling for the 50 million tonne per annum Multi User Iron Ore Export Port Facility proposed by the North West Infrastructure (NWI). The services were provided in accordance with the scope of services set out in the contract between SKM and Coffey Environments, referred to hereafter as the 'Client'. That scope of services, as described in this report, was developed with the Client.

Modelling and forecasting is not a precise science. Forecasts are only an indication of what might happen in the future and they may not be achieved. They rely upon complex sets of input data and assumptions. There is no guarantee that these assumptions will in fact be correct or accurate and there are numerous factors which can influence the Project, many of which are beyond the control or reasonable foresight of the forecaster. Examples of this include extreme weather events or bush fires. Whilst the risk of inaccuracies cannot be eliminated, it can be reduced through a detailed process, including, but not limited to the adoption of reasonable assumptions, the use of accepted modelling standards and techniques, and peer review. This process, in particular the key assumptions, applied by SKM for the purposes of this report were discussed and agreed with the client at various stages of the report.

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Executive Summary

Coffey Environments has engaged Sinclair Knight Merz (SKM) to provide consultancy services to complete an air quality and greenhouse assessment for the proposed North West Infrastructure (NWI) 50 million tonne per annum (Mtpa) multi user iron ore export port facility, to be located in Port Hedland, Western Australia.

This report details the air quality and greenhouse assessments undertaken, with specific focus on quantifying the potential impact of emissions in the form of particulates (dust) and accounting for the main sources of greenhouse gas emissions expected from port operations. The dust assessment was carried out in accordance with the Air Quality and Air Pollution Modelling Guidance Notes (DOE 2006). The greenhouse study was undertaken with reference to the National Greenhouse Accounts (NGA) Factors reference manual (DCC 2010).

The main objective of the air quality assessment is to determine the potential ground level impact of particles (dust) from the proposed NWI Facility on the town of Port Hedland and other receptors in the region. The operations of interest for this assessment include car dumping, stacking, reclaiming, shiploading and material transfers.

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

- 70 $\mu g/m^3$ for PM_{10} as a maximum 24-hour average (based on Port Hedland Dust Taskforce PM_{10} Standard) as determined at all sensitive receptors in Port Hedland.
- 50 $\mu g/m^3$ for PM_{10} as a maximum 24-hour average (based on NEPM standard) as determined at all sensitive receptors outside of Port Hedland (Wedgefield and High School).
- 90 $\mu g/m^3$ (24-hour average desirable not to be exceeded) and 150 $\mu g/m^3$ (24-hour average never to be exceeded) for TSP (based on Kwinana EPP Area C Standard) as determined at all sensitive receptors.
- 2 g/m^2/month maximum increase in total dust deposition (based on NSW EPA Dust Deposition Standard) as determined at all sensitive receptors.

Greenhouse accounts are compared to the *National Greenhouse and Energy Reporting Act 2007* (the NGER act) reporting thresholds to determine if the NWI Facility will be required to report their greenhouse emissions.

The dust generating operations investigated as part of this study include:

- Unloading material from car dumpers.

- Vehicle (wheel) generated dust.
- Wind erosion from product stockpiles and unsealed areas.
- Fugitive emissions from conveyor transfer stations and conveyors.
- Ore stockpiling and reclaiming.
- Product load out via ships.

Potential air quality impacts from the proposed NWI Facility have been assessed using the Victorian EPA's AUSPLUME (Version 6.0) computer dispersion model. This model is a primary air dispersion model used for assessing air quality impacts from industrial sites within Australia and has been used for dust modelling by other Port Hedland exporters including Port Hedland Port Authority (PHPA), BHP Billiton Iron Ore and Fortescue Metals Group (FMG).

The model predicts an increase in dust concentrations from the validated 2004/2005 Port Hedland dust model across the receptors selected for this assessment. The Hospital is the exception to this with less extreme concentrations predicted due to the removal of crushing and screening sources in the 2004/2005 model.

The model predicts PM_{10} concentrations will have the greatest impact at St Cecilia's in the future. This is due to the model poorly handling low wind speeds leading to over predictions (EPA 2000). The 99th percentile statistics should be considered more indicative of the likely impact from operations. The 99th percentile statistics show the Hospital and Harbour receptors are predicted to be the most affected by operations going into the future.

The distribution of predicted TSP concentrations is similar to PM_{10}, with an overall increase experienced at the Primary School, South Hedland and Wedgefield receptor points. The Harbour and Hospital are shown to have lower maxima, and a comparable annual average concentration. The predicted contribution to dust deposition at Port Hedland and other receptor locations is minimal compared to existing levels. The largest predicted contribution is in the immediate vicinity of the proposed stockyards as expected.

The graphical representation of PM_{10} modelling in the future scenario shows that emissions from the proposed NWI Facility are not predicted to have a significant impact on Port Hedland, with emissions mostly influencing the immediate area around stockyards and shiploading through Southwest Creek. This is shown through a comparison between the PM_{10} contour plots in **Figure 6.9** and **Figure 6.14**. TSP and deposition plots show negligible change to the north and east with only the stockyards and shiploading operations producing a notable difference between the plots.

A summary by scenario of predicted maximum and average PM_{10} concentrations, and number of 70 $\mu g/m^3$ exceedences at each receptor location is presented in **Table E.1**.

Greenhouse estimates have included:

- Fuel burn based on estimated daily vehicle activity.
- Annual electricity consumption figures for the Facility.
- Land clearance (loss of carbon sink).

Based on the expected annual energy use and fuel burn for the Facility, it is likely that the Facility will be required to quantify and report their greenhouse gas emissions under the NGER act.

Table E.1 Summary of 24-hour PM_{10} model predictions by scenario

Receptor	2004/2005 Validation (μg/m³)	Future (no NWI) (μg/m³)	Future (with NWI) (μg/m³)	Future (with NWI and Outer Harbour) (μg/m³)
	106 Mtpa	432 Mtpa	482 Mtpa	722 Mtpa
Maximum				
Harbour Monitor	152	163	170	172
BMX	-	146	147	147
Hospital Monitor	182	153	153	155
St Cecilia's	-	184	199	201
Port Hedland Shop	-	109	120	123
Port Hedland Primary School	76	75	78	79
Hedland Senior High School	63	71	71	73
Wedgefield	63	83	84	84
Taplin St	-	162	176	178
Average				
Harbour Monitor	49	60	62	63
BMX	-	51	52	53
Hospital Monitor	44	47	48	49
St Cecilia's	-	37	37	38
Port Hedland Shop	-	32	33	34
Port Hedland Primary School	22	25	26	26
Hedland Senior High School	19	23	23	24
Wedgefield	19	28	29	30
Taplin St	-	38	38	39
No. Days/Year exceeding receptor criteria limit				
Harbour Monitor	39	96	101	110
BMX	-	50	53	55
Hospital Monitor	39	54	60	61
St Cecilia's	-	17	18	21
Port Hedland Shop	-	14	16	17
Port Hedland Primary School	1	2	2	2
Hedland Senior High School	5	9	9	10
Wedgefield	5	20	25	31
Taplin St	-	19	23	25

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Document history and status

Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type
A	12/01/2011	Miles Sowden	Scott Bainbridge	07/02/2011	Technical Review
B	07/02/2011	Brendan Creavin	Scott Bainbridge	18/02/2011	Project Director Review
0	21/02/2011				Issued to client for comment
1	14/04/2011				Finalisation of report for client
2	09/04/2011	Miles Sowden & Brendan Creavin	Scott Bainbridge	10/04/2011	Update to model scenarios
3	01/08/2011	Brendan Creavin	Brendan Creavin	02/08/2011	Update to model scenarios
4	15/08/2011	Brendan Creavin	Brendan Creavin	15/08/2011	Update to criteria levels
5	05/09/2011	Scott Bainbridge	Scott Bainbridge	05/09/2011	Inclusion of Taplin St results

Distribution of copies

Revision	Copy no	Quantity	Issued to
0	- (electronic)	1	Martine Scheltema (Coffey Environments) Shane Hashim (Coffey Environments)
1	- (electronic)	1	Martine Scheltema (Coffey Environments) Shane Hashim (Coffey Environments)
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4	- (electronic)	1	Martine Scheltema (Coffey Environments)
5	- (electronic)	1	Martine Scheltema (Coffey Environments)

Printed:	5 September 2011
Last saved:	5 September 2011 09:20 AM
File name:	I:\WVES\Projects\WV05047\Deliverables\Reports\Modelling\WV05047_FA_RP-0001_5_NWI AQ&GHG StudyPort.docx
Author:	Scott Bainbridge
Project manager:	Scott Bainbridge
Name of organisation:	Coffey Environments
Name of project:	NWI Environmental Study for Multi User Iron Ore Export Port Facility – Port Hedland
Name of document:	Dust Modelling and Greenhouse Gas Study
Document version:	Rev 5
Project number:	WV05047

1. Introduction

Coffey Environments has engaged SKM to provide consultancy services to complete air quality modelling and greenhouse gas assessment for the proposed NWI 50 Mtpa Multi User Iron Ore Export Port Facility (hereafter referred to as 'the Facility'), to be located in Port Hedland, Western Australia.

This report details the air quality assessment undertaken, with specific focus on potential emissions in the form of particulates (dust). The air quality assessment was carried out in accordance with the Air Quality and Air Pollution Modelling Guidance Notes (DOE 2006). This report also provides an estimate of greenhouse gas expected to be generated by the Facility.

The objective of the air quality assessment is to determine the potential ground level impact of particulate matter from the proposed NWI operations on the town of Port Hedland and other receptors in the region by comparison against relevant criteria. The operations of interest for this assessment include car dumping, stacking, reclaiming, overland conveying, shiploading and general material transfers and handling.

The objective of the greenhouse gas assessment is to determine the total emission of CO_2e (equivalent) based on estimates of land clearance, power consumption and fuel burn from the operation of the Facility to determine what obligations NWI has in managing their emissions.

To achieve these objectives the following tasks have been undertaken and are reported:

- Description of local meteorology covering long term trends such as winds, temperature, humidity and rainfall.
- Analysis of the meteorology used in modelling.
- Estimation of emissions of particulates the proposed NWI Facility, and compilation of emissions data from current and future operations in the region.
- Discussion of dispersion model selection, set-up and limitations.
- Determination of potential air quality impacts from modelling results, and comparison to assessment criteria at key sensitive receptor locations.
- Summary of data input and methodologies used to calculate greenhouse gas emissions.

The report is structured as follows:

- Description of the health and environmental impacts of air pollutants, and summary of air quality standards and assessment criteria (**Section 2**).
- Analysis of local meteorological and environmental conditions (**Section 3**).

- Discussion on the estimation of dust emissions from proposed site operations, model inputs and model methodology, including model validation (**Section 4 and 5**).
- Presentation of model results (**Section 6**).
- Definition of greenhouse gas study and emission estimates (**Section 6.5**)
- Assessment conclusions and recommendations (**Section 8**)

2. Air Pollutants Potential Impacts and Criteria

This section outlines the potential impact of particulate emissions from the proposed NWI Facility, and the criteria relevant to each particle size fraction. The pollutants in this section represent those associated with the activity. Some pollutants associated with the proposed Facility, such as combustion by-products like sulphur dioxide and oxides of nitrogen, are not considered to be produced in sufficient quantity to have a significant impact on relevant air quality criteria and have not been assessed further.

2.1. Particulate Matter

Airborne or suspended particulate matter can be defined by size, chemical composition and source. Primary particles include soil from wind erosion, agitated dust from bulk materials handling processes, sea salt from evaporating sea spray, pollens and soot particles from incomplete combustion. Secondary particles include those that are formed from gas to particle conversion, these typically being odelin and nitrogen compounds (WHO 2005).

Particle size is an important factor that influences dispersion and transport of dust emitted into the atmosphere, and the consequent impact on human health and the environment. As a general rule, finer particulate remains suspended in the atmosphere for longer with the potential to impact over a larger area. In contrast, heavier particles deposit faster, leading to higher concentrations near to sources, but lower concentrations further out.

2.1.1. Total Suspended Particulates (TSP)

The term total suspended particulates (TSP) generally refers to particles of approximately 50 microns or less in equivalent aerodynamic diameter. TSP is generally considered to be associated with aesthetic impacts (DEP 2001), as this range includes particles too large for inhalation. TSP is therefore unsuitable for developing criteria based on observed health impacts (WHO 2000).

In Western Australia, the main criterion used to assess TSP impacts is the Kwinana Environmental Protection Policy (EPP). The Kwinana EPP specifies three different zones; Area A, B and C. These areas represent industrial zoning (A), buffer zoning (B), and the zone outside Area A and B (C) (EPA 1999). Typically the Area C target is used at sensitive receptor locations. These standards are presented in **Table 2.1**.

Table 2.1 Total suspended particulate (TSP) ambient air standards

Pollutant	Source	Averaging Period	Target ($\mu g/m^3$)	Limit ($\mu g/m^3$)	Allowable Exceedences
Total suspended particulate (TSP)	Kwinana EPP (Area A)	24 hour	150	260	None
	Kwinana EPP (Area B)	24 hour	90	260	None
	Kwinana EPP (Area C)	24 hour	90	150	None

Note: All values expressed at 0 ^{o}C and 101.3 kPa.

2.1.2. PM_{10}

PM_{10} refers to particulate with an aerodynamic diameter of 10 microns (µm) or smaller. Particulate of this size range is capable of entering the respiratory system (WHO 2000). The health effect of particulates in the PM_{10} range is mainly the exacerbation of respiratory problems, with the elderly, people with existing respiratory and/or cardiovascular problems and children the most susceptible (US EPA 2010).

In Western Australia, the main criterion used to assess PM_{10} impacts is the Ambient Air Quality NEPM. In Port Hedland, the Port Hedland Dust Taskforce (PHDTF) has the role of implementing the Port Hedland Air Quality and Noise Management Plan (DSD 2010). This plan outlines the strategy for reducing the impact of dust on residents of Port Hedland. The plan provides a criterion for PM_{10} concentrations across the town, recommended by the Department of Health (DoH). The PM_{10} criteria for NEPM and PHDTF are presented in **Table 2.2**.

Table 2.2 PM_{10} ambient air standards

Pollutant	Reference	Averaging Period	Maximum Concentration ($\mu g/m^3$)	Allowable exceedences of Maximum Concentration
Particles as PM_{10}	NEPM	1 day	50	5 days per year
	Port Hedland Dust Taskforce		70 (Port Hedland only)	10 days per year

While the PHDTF criteria for PM_{10} specifies that up to ten days are allowed for exceedences, it is to be noted that special events like dust storms or bushfires that would cause exceedences are difficult to be reliably simulated in dispersion modelling and are not included in this assessment. Because of this limitation, any predicted exceedence of the 70 $\mu g/m^3$ target should be seen as a potential breach of criterion limits and treated as such. Background PM_{10} concentrations in Port Hedland often approach this target level (see **Section 3.2**).

2.1.3. Deposition

Deposition is the term used to describe the settling of suspended particulate on a surface. Excessive deposition of particulate matter on fabrics (such as laundry), house roofs and movement of dust into water tanks can potentially generate community concern. The deposition of larger particles can also cause aesthetic or chemical contamination of water bodies or vegetation, forest and farm crop damage and negatively impact on personal comfort, amenity and health (USEPA 2010).

In Western Australia there is no specified criteria for dust deposition, however an impact assessment criteria does exist in NSW (NSW EPA 2005) for nuisance dust to humans. 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 and deposition data for the project region, the NSW criteria for allowable increases have been used in this assessment.

2.2. Criteria Used in this Assessment

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

- 70 $\mu g/m^3$ for PM_{10} as a maximum 24-hour average (based on PHDTF PM_{10} Standard) as determined at all sensitive receptors in Port Hedland.
- 50 $\mu g/m^3$ for PM_{10} as a maximum 24-hour average (based on NEPM standard) as determined at all sensitive receptors outside of Port Hedland (Wedgefield and South Hedland).
- 90 $\mu g/m^3$ (24-hour average desirable not to be exceeded) and 150 $\mu g/m^3$ (24-hour average never to be exceeded) for TSP (based on Kwinana EPP Area C Standard) as determined at all sensitive receptors.
- 2 g/m^2/month maximum increase in total dust deposition (based on NSW EPA Dust Deposition Standard) as determined at all sensitive receptors.

3. Existing Environment

This section provides a description of environmental characteristics of the Project Area relevant to an air quality assessment, including the prevailing meteorological conditions and the meteorological data used for the air dispersion odeling.

3.1. Climate

Port Hedland is a coastal town located in the Pilbara region of Western Australia. The region is characterised by low and variable rainfall levels, cyclonic activity and consistently high temperatures. Rainfall occurs mostly during summer months from cyclones and thunderstorms, with tropical cloud bands during the May-June period making up the remainder. The regional coast experiences the greatest cyclonic activity in Australia, although the cyclone season and most storms are generally restricted to the summer months (BoM 2010a).

The meteorological data used for modelling in this assessment was sourced from the Bureau of Meteorology (BoM) Port Hedland dataset for the 2004/2005 financial year. This particular dataset was chosen for consistency with other prior studies carried out in the area, and due to the availability of data suitable for model validation (BHPBIO 2006, SKM 2010).

3.1.1. Wind

Winds in Port Hedland typically cycle from easterlies/south-easterlies in the morning to north-westerlies in the afternoon. This pattern is subject to seasonal variations. During October to February, there is no clearly dominant wind direction in the morning with wind speeds mostly medium to low. Wind strength picks up to medium-strong in the mornings during mid year. Afternoon winds are north-westerly for the entirety of the year, though between April and August there is a comparable amount of northerly winds. Afternoon wind speeds are the strongest between September and March (BoM 2010b). A graphical representation of Port Hedland seasonal winds used in modelling is available in **Section 5.3.7**.

The predominant wind directions (north and north-westerly) make it unlikely NWI emissions will frequently contribute to dust impacts at receptor locations (to the north-east).

3.1.2. Rainfall

Rainfall in Port Hedland is limited to the summer and autumn months with very little rainfall occurring between winter and spring. Most rain occurs in the space of a few days per month, consistent with the cyclonic and storm events of the region. The impact of this is shown in **Figure 3.1** which highlights a large difference between maximum and mean rainfall per month measured between 1948 to present.

The low rainfall for most of the year in the region means that dry deposition will be the major form of dust deposition from the stockpiling and ore handling operations. The deposition process used in modelling is discussed further in **Section 5.3.3.**

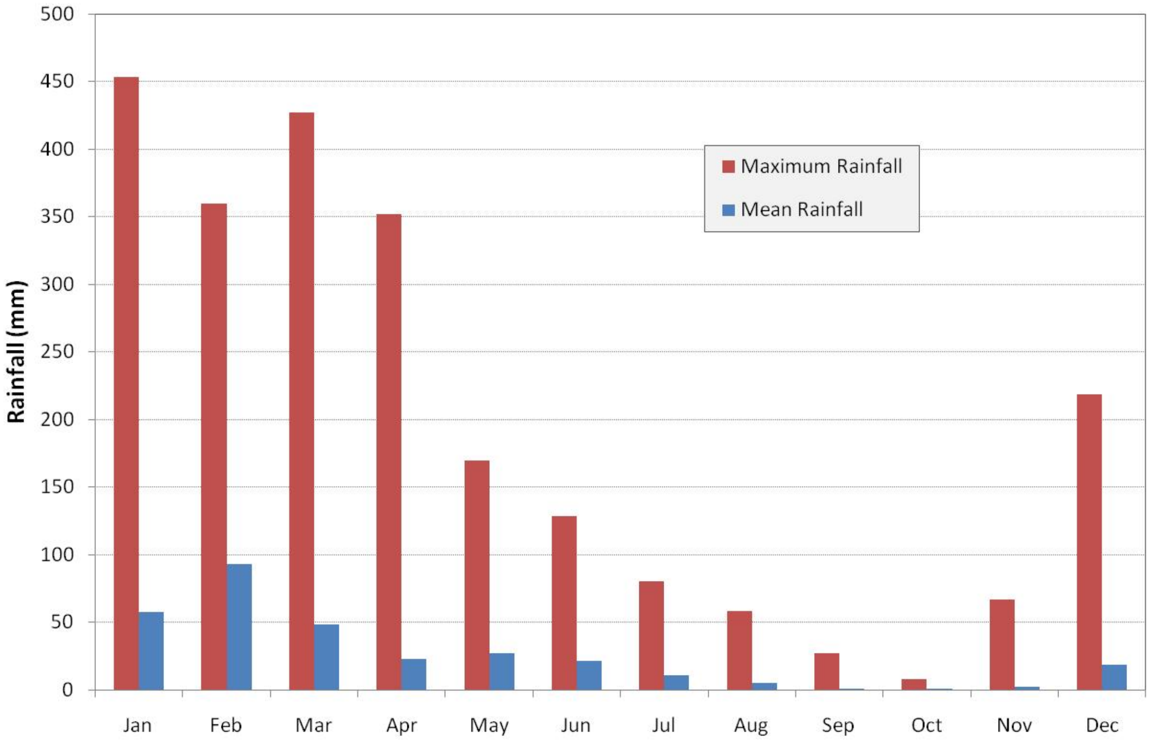
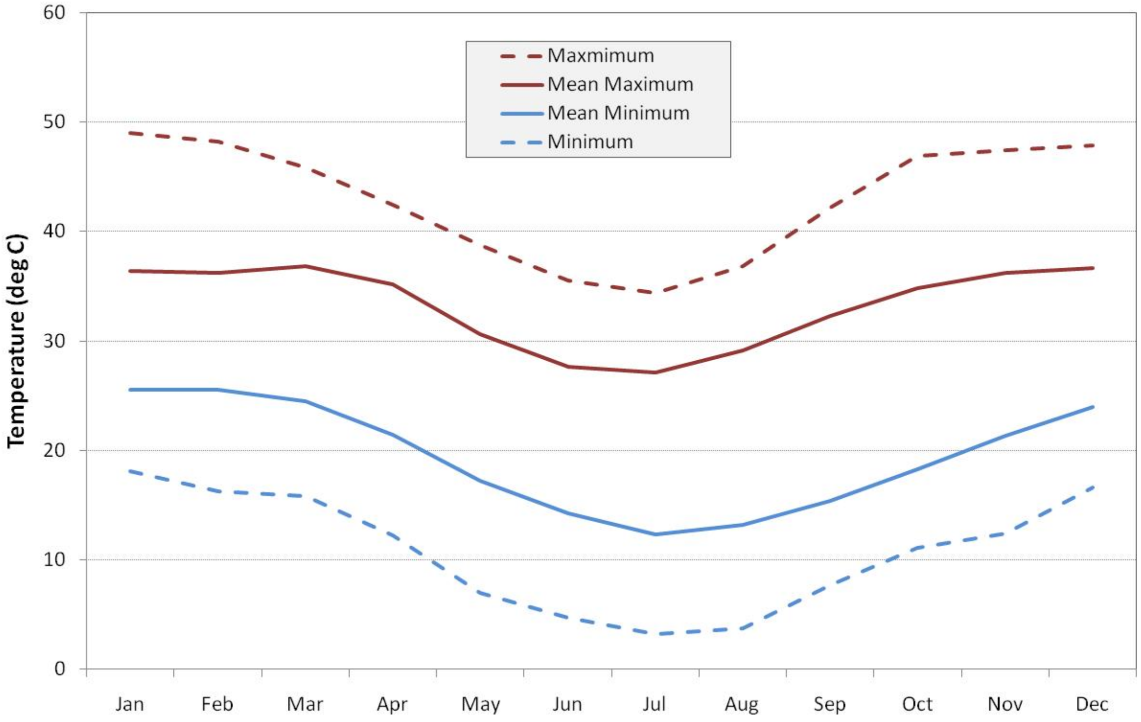


Figure 3.1 Seasonal rainfall data for Port Hedland (BoM 2010b)

3.1.3. Temperature

The long term monthly temperatures for Port Hedland are presented in **Figure 3.2**. This figure contains the average monthly maxima and minima as well as the highest and lowest temperature recorded during this period. From this figure it can be seen that the average temperatures in Port Hedland range from 24 °C to 37 °C during summer, with maximums of up to 49 °C recorded. During winter the temperature can vary from 12 °C through to 29 °C, with minimum temperatures just above 3 °C.

High temperatures are typically associated with a high evaporation rate. An increase in temperature (and thus evaporation) increases the potential for wind erosion as surfaces dry up. Without sufficient dust suppression and control, there is an elevated risk of dust emissions during from November to April.

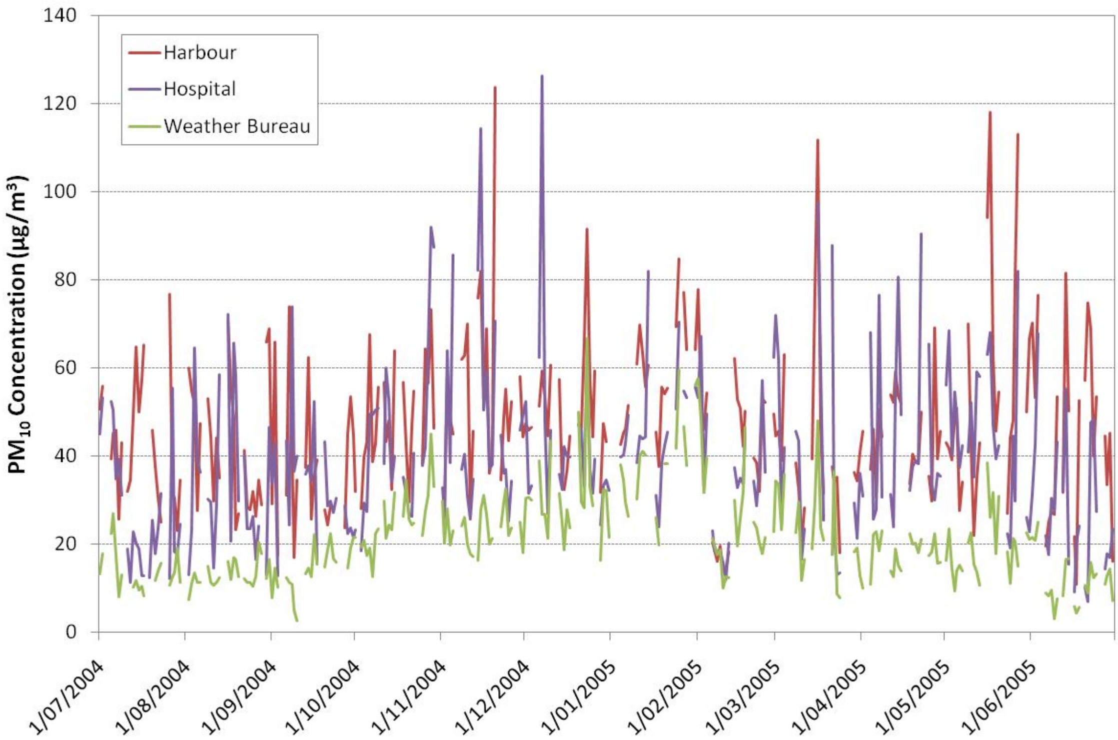


- **Figure 3.2 Seasonal temperature for Port Hedland (BoM 2010b)**

3.2. Existing Dust Conditions

The Pilbara region is characterised as a dusty environment. Wind generated dust provides a noticeable contribution to overall dust concentrations in the region. The aggregated emission study conducted by SKM (SKM 2003) found the Pilbara emitted approximately 170,000 tonnes of airborne particulate in the 1998/1999 financial year. The study also found that most of the PM_{10} measured in the town of Port Hedland is generated from local sources.

The PM_{10} monitoring data recorded by BHP Billiton Iron Ore from July 2004 – June 2005 (BHPBIO 2006) is presented in **Figure 3.3**. The figure shows the PM_{10} concentrations as recorded by BHP Billiton Iron Ore at their Port Hedland Hospital, Harbour, and Weather Bureau monitoring stations. Due to their locations, the Harbour and Hospital are more likely to be influenced by port operations and localised sources, while the Weather Bureau station is more indicative of background dust levels. The measured concentrations at the Weather Station are shown to approach the 70 $\mu g/m^3$ PHDTF criterion maximum, though do not exceed it. This level of particulate is representative of naturally occurring dust levels in the Pilbara (SKM 2003).



- **Figure 3.3 Daily average PM_{10} concentrations (July 2004 – June 2005) (BHPBIO 2006)**

Using this data background dust levels over a year have been compiled for model input, consistent with the meteorological year used in the model. The values have been determined from the lowest daily recorded value of the three stations. Missing data used the average of available data consistent with the 2004/2005 validation study, discussed further in **Section 5.5**. The Weather Bureau site located at the Port Hedland Airport is shown to consistently record the lower backgrounds, and forms the majority of background concentrations used in this assessment.

The background concentrations used in this assessment are consistent with background concentrations used in similar assessments in Port Hedland (BHPBIO 2006, SKM 2007b, 2008. 2010).

4. Emission Estimates

This section details the emission identification and estimation techniques applied in this assessment. Emission estimates for existing and proposed future expansions in the port are consistent with those that are publicly available, or have been made available to SKM for use in this assessment. If an operation's emissions data were not available, emissions have been estimated using techniques detailed further in this section.

4.1. Operations at Port Hedland

Currently, there are three operators exporting bulk ore materials out of Port Hedland. The Port Hedland Port Authority (PHPA) operates out of Nelson Point and exports approximately 3 Mtpa of bulk product. In September 2010 PHPA brought their Utah Point Multi-user facility online. BHP Billiton Iron Ore is approaching exports of a nominal 155 Mtpa as per Rapid Growth Project (RGP) 4 out of both Nelson Point and Finucane Island operations. Fortescue Metals Group (FMG) operates out of Anderson Point with a nominal export capacity of 45 Mtpa.

In the future, it is expected the number of operators and total exports from the port will increase. To represent future growth and the potential operational scenario of Port Hedland at the time of the NWI Facility coming online, this assessment includes BHP Billiton Iron Ore's RGP6 expansion at Nelson Point and Finucane Island, the proposed Outer Harbour development, FMG expansions at Anderson Point, and the Roy Hill Project proposed at Boodarie.

All operations included in this assessment are described in **Table 4.1** in terms of their annual tonnage throughput capacity.

Table 4.1 Annual tonnage through port operations in Port Hedland

Operator	Validated operations (2004/05) (SKM 2008)	Cumulative future operations
PHPA Nelson Point	3 Mtpa	1 Mtpa
PHPA Utah Point Multi-user	-	16 Mtpa
BHP Billiton Iron Ore Inner Harbour	103 Mtpa	240 Mtpa
BHP Billiton Iron Ore Outer Harbour	-	240 Mtpa
FMG Anderson Point	-	120 Mtpa
Roy Hill Iron Ore Project	-	55 Mtpa
NWI	-	50 Mtpa
Total	**106 Mtpa**	**722 Mtpa**

For this assessment, emissions data from other operations in the region were obtained with permission from the operators, or was estimated using the techniques described below with reference to publicly available documentation.

4.2. Emission Estimation

The material handling operations investigated at the proposed NWI Facility include:

- Unloading material from car dumpers.
- Vehicle (wheel) generated dust.
- Wind erosion from product stockpiles and unsealed areas.
- Fugitive emissions from conveyor transfer stations and conveyors.
- Ore stockpiling and reclaiming.
- Product load out via ships.

Where existing emission estimates for current and proposed developments were unavailable for use in this assessment, TSP and PM_{10} emission rates for material handling activities were estimated based on the methodologies and values outlined in the National Pollutant Inventory (NPI) *Emission Estimation Technique Manual (EET) for Mining Version 2.3* (DEH 2001).

4.2.1. Bulk Material Handling

Dust emissions from bulk material handling were estimated using the default emission factor for "Handling, transferring and conveying including wheel and bucket reclaimers" from Table 2 of the NPI EET for Mining (DEH 2001). The emissions factors used for PM_{10} and TSP are presented in **Table 4.2**.

- **Table 4.2 Emission factors for bulk material handling (DEH 2001)**

Activity	Emission Factor (High Moisture Content Ores)	Emission Factor (Low Moisture Content Ores)
Handling, Transferring and Conveying including Wheel and Bucket Reclaimers	0.005 kg/tonne TSP 0.002 kg/tonne PM_{10}	0.06 kg/tonne TSP 0.03 kg/tonne PM_{10}

High moisture content is defined as having a moisture content of more than 4% by weight. As the moisture content of the ore is expected to be maintained at or above 7% (as advised by NWI design engineers), emission factors used in this assessment are for high moisture content ores.

While the NPI emission factor described above does allow for conveyor estimates, this assessment has instead estimated emissions using the equation presented in the Dampier 145 Mtpa Environmental Impact Statement (SKM 2007a). This equation was selected due to the length of the overland conveyor; a factor which the NPI emission factors do not account for. The equation to estimate conveyor emissions is presented as **Equation 4-1**.

- **Equation 4-1**

$$Q = K \times L \times U^{P}$$

Where:
Q = PM_{10} emission rate (g/s)
K = 0.0016 (g/s per m length)
U = wind speed (m/s)
L = length of conveyor (m)
P = 0.5

4.2.2. Wheel Generated Road Dust

The emissions of particulate matter due to vehicular activity at the port were determined using the equation from the NPI EET Manual for Mining (DEH 2001) presented in **Equation 4-2**.

- **Equation 4-2**

$$EF = k \times \left(\frac{s}{12}\right)^{A} \times \frac{\left(\frac{W}{3}\right)^{B}}{\left(\frac{M}{0.2}\right)^{C}}$$

Where:
EF = emission factor in kilograms per vehicle kilometre travelled (kg/VKT)
k = 2.82 for particles less than 30 micrometres aerodynamic diameter
k = 0.733 for particles less than 10 micrometres aerodynamic diameter
s = surface material silt content, %
W = vehicle gross mass, t
M = surface material moisture content, %
A = empirical constant: 0.8 (for PM10) & 0.8 (for TSP)
B = empirical constant: 0.4 (for PM10) & 0.5 (for TSP)
C = empirical constant: 0.3 (for PM10) & 0.4 (for TSP)

In the absence of site specific data, the surface material silt content and moisture content used were the default values provided in the manual (10% and 2% respectively). For this assessment there are no bulking or mobile surface equipment operations estimated; only light vehicles are considered. A value of two tonnes was used for vehicle gross mass. The calculated emission rates using these values in **Equation 4-2** are presented in **Table 4.3**.

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Table 4.3 Wheel generated road dust – emissions factors

Description of Road Type	PM_{10} Emission Factor (kg/VKT)	TSP Emission Factor (kg/VKT)
Vehicles	0.27	0.79

Vehicular activity was distributed across 12 hour day/night and weekday/weekend cycles to reflect events like shift changes and higher movements during the day on Monday to Friday. Vehicle kilometres travelled were estimated based upon the size of the site and the number of vehicles expected to be operating during different times of the week. The vehicle assumptions for each site are presented in **Table 4.4**.

Table 4.4 Wheel generated road dust – vehicle traffic assumptions

Description of Road Type	VKT per vehicle (hourly)	Vehicles (Weekends)	Vehicles (Weekdays)
NWI	1.5	20 (day) 5 (night)	5 (day) 2 (night)

4.2.3. Wind Erosion

To estimate wind erosion emissions, the formulae used for determining wind erosion presented in "Improvement of NPI Fugitive Particulate Matter Emission Estimation Techniques" (SKM 2005) were utilised:

Equation 4-3

$$PM_{10}(g/m^2/s) = k\left[WS^3 \times \left(1 - \frac{WS_0^{\,2}}{WS^2}\right)\right], \qquad WS > WS_0$$

$$PM_{10}(g/m^2/s) = 0, \qquad WS < WS_0$$

Where:
WS = wind speed (m/s);
WS_0 = threshold for dust lift off (m/s); and
k = a constant.

The constant *k* used was 2.5 x 10^{-6} with a wind speed threshold of 6 m/s. The constant *k* and wind speed threshold value is consistent with other dust studies in the Pilbara (SKM 2007b, 2008, 2010). Solving **Equation 4-3** results in an average PM_{10} emission rate of 3.6 kg/ha/hr which is greater than the default emission factor of 0.2 kg/ha/hr that is used in the EET for mining (DEH 2001). Using a higher emission factor than the NPI default allows the model to factor in the high temperatures (and thus evaporation rates) of Port Hedland (**Section 3.1.3**).

For this assessment wind erosion was taken to occur from all stockpiles and active open areas (e.g. lay-down areas) susceptible to wind erosion.

4.2.4. Dust Control Measures

While most emission sources are quantified using these emission factors, the various dust controls mitigate emissions differently at each source. The extent to which control factors reduce dust emissions is defined also in the NPI EET for Mining (DEH 2001).

Sealed roads are not provided with an emission reduction value in the NPI EET Manual for Mining. For this assessment a nominal reduction of 90% on sealed roads has been assumed. A full 100% is has not been assumed as some minor access roads will not be sealed.

In the operation of a plant where there are multiple identified controls, the product of the percentage reductions for the plant is taken to give an overall reduction.

- **Table 4.5 Controls for various port operations.**

Operation	Type of Control	% Reduction in Emissions
Stacking and Shiploading	Water Sprays Variable Height Stacker	50 25
Reclaiming	Water Sprays	50
Stockpile and Open Area Wind Erosion	Water Sprays	50
Car Dumping	Hooding and Baghouse	65
Vehicle emissions	Main roads sealed	90
Miscellaneous Transfers	Hooding	70
Overland conveyor	Shielding	70

5. Modelling Methodology

The section describes the air dispersion model employed for this assessment and the modelling methodology adopted to complete the assessment.

5.1. Overview

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, dispersion models generally rely heavily on empirical methods.

5.2. Modelling Methodology

Potential air quality impacts from the proposed NWI Facility at Port Hedland have been assessed using the Victorian EPA's AUSPLUME (Version 6.0) computer dispersion model. This model 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, such as 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. The primary reason for utilising this model is to ensure consistency with previous modelling and results conducted for similar bulk material handling operations in the region (BHPBIO 2006, SKM 2007b, 2008, 2010).

5.3. 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 include:

- 500 m grid spacing (**Section 5.3.1**)
- assumption of no terrain (**Section 5.3.2**)
- dry depletion included (**Section 5.3.3**)
- Pasquill Gifford dispersion curves (**Section 5.3.4**)
- roughness length of 0.1 m. (**Section 5.3.5**)
- meteorological data from hourly observations (**Section 5.3.6** and **5.3.7**)
- hourly variable emissions data (**Section 5.4.1**)

5.3.1. Grid System

AUSPLUME can calculate concentrations both on a set grid (typically Cartesian) or at specified locations. The model was configured to predict the ground-level concentrations on a rectangular grid of spacing established at 500 m intervals. This grid approach was chosen to optimise the duration of model runs while still maintaining a reasonable spatial resolution of model output.

5.3.2. Model Terrain

The model was run without incorporating terrain effects, due to the lack of significant terrain features across the Port Hedland region. In addition, any terrain effects would not be significant, compared to the uncertainties in source emission estimates.

5.3.3. Dry Depletion Method

Particles settling under gravity are subject to dry deposition. For this option, particle size distribution data and the particle density for each size fraction is required. AUSPLUME then calculates a settling velocity and a deposition velocity for each of these size categories. The settling velocity causes an elevated plume to "tilt" 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 or later versions of AUSPLUME employ the deposition algorithm used in the USEPA 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 development was taken as the same as that given for the previous studies undertaken for the region (SKM 2007b, 2010) and is presented in **Table 5.1**.

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- **Table 5.1 Particle size distribution (% 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

AUSPLUME also has the ability to simulate wet deposition, which is the removal of airborne dust through precipitation (rainfall events). This feature has switched off to allow emitted dust to spread out as far as possible, increasing the conservatism of model predictions.

5.3.4. 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 Port Hedland, horizontal dispersion was determined using the Pasquill Gifford curves which are applicable to surfaces releases.

5.3.5. Roughness Length

Terrain features such as vegetation, buildings and roads influence the vertical dispersion of dust within an air flow. As a general rule, dense vegetation and tall buildings cause turbulent air flow. Low lying vegetation and flat terrain has less of an influence on the dispersion of airborne dust. AUSPLUME uses an average surface roughness for the modelled area. For this assessment, the 'flat rural' setting was selected, simulating a roughness length of 0.1 metres, consistent with previous studies undertaken for the region (SKM 2007b, 2010).

5.3.6. 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 data was derived from meteorological measurements recorded at Port Hedland Airport by the BoM during the 2004 and 2005 financial year. This site was chosen instead of obtaining meteorology from The Air Pollution Model (TAPM) as this model has been found to underestimate the upper wind speeds and as such would result in an under prediction of emission rates from wind erosion sources.

Wind speed and direction were obtained from the 10m above ground level (agl) wind records, collected at 30 minute intervals by BoM automatic weather station (AWS).

Ambient air temperature was obtained from the surface (approximate 1.2 m agl) measurements at the airport.

Atmospheric stability categories were determined using the net radiation index method, or Turner's method as described in USEPA (2000). This method estimates stability from solar altitude, wind speed and cloud observations. Wind speed was derived from the hourly wind speed and cloud observations, with solar angle calculated from standard algorithms.

Mixing heights were estimated from surface observations using wind speed and stability class estimates to determine the Monin-Obukhov length and surface friction velocity. From these the mechanical mixing heights were computed using the methods reported by the NSW EPA (2005). This approach is noted as an approximate measure, particularly during the day, though is considered sufficient for the surface releases of dust when only 24 hour and longer averages are recorded. For elevated sources such as tall stacks where hourly average concentrations are predicted, more accurate methods are recommended.

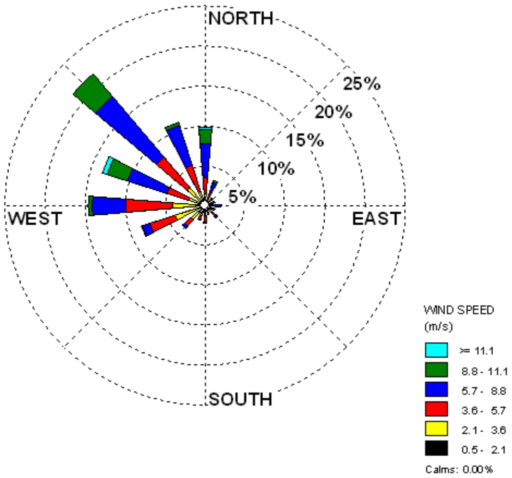
A summary of the stability, wind speeds, and mixing heights of this data is given in **Appendix A**.

5.3.7. Winds, Mixing Height and Stability Classes

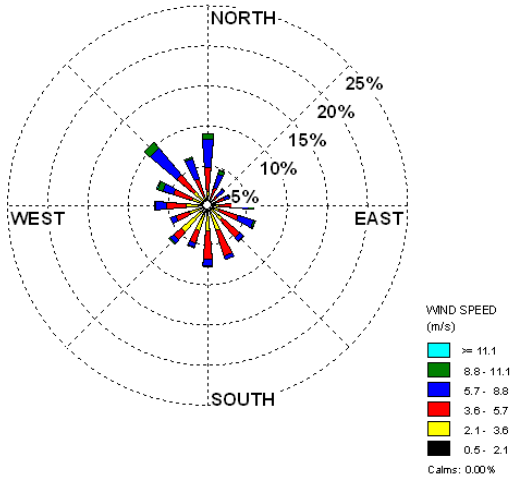
Wind data input to the model is used to determine what direction and what shape the plume takes during an emission event. As a generalisation, high wind speeds in the model typically produce a narrow plume that extends over a long distance. Conversely, low wind speeds in the model produce a shorter, wider plume.

The seasonal wind roses for 2004/2005 modelling year are presented in **Figure 5.1** to **Figure 5.4**. These figures show that the dominant annual wind directions are north westerly winds during the summer months and south easterlies during the winter months. Spring also shows high north-westerly dominance.

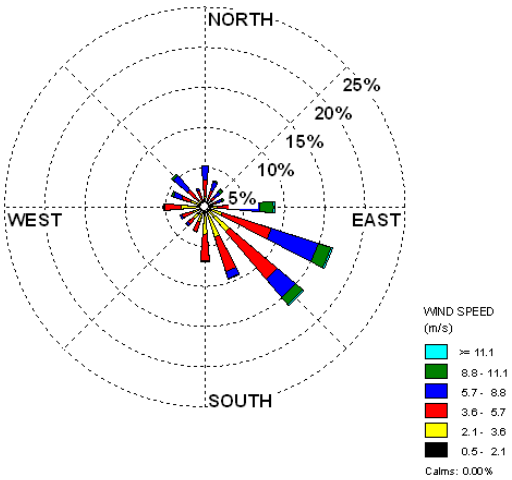
Due to local terrain and micro meteorological effects, the actual wind conditions at any location within the study area may differ slightly to that shown in the wind roses. However, the broad patterns exhibited in the analysis of the data are likely to be very similar to those in the Port Hedland area.



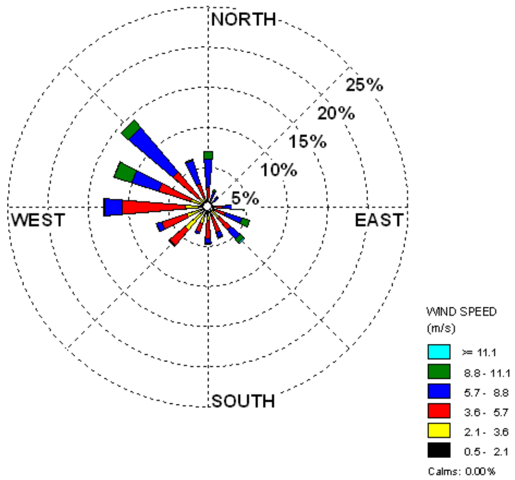
■ **Figure 5.1 Dec – Feb wind rose**



■ **Figure 5.2 Mar – May wind rose**



■ **Figure 5.3 Jun – Aug wind rose**

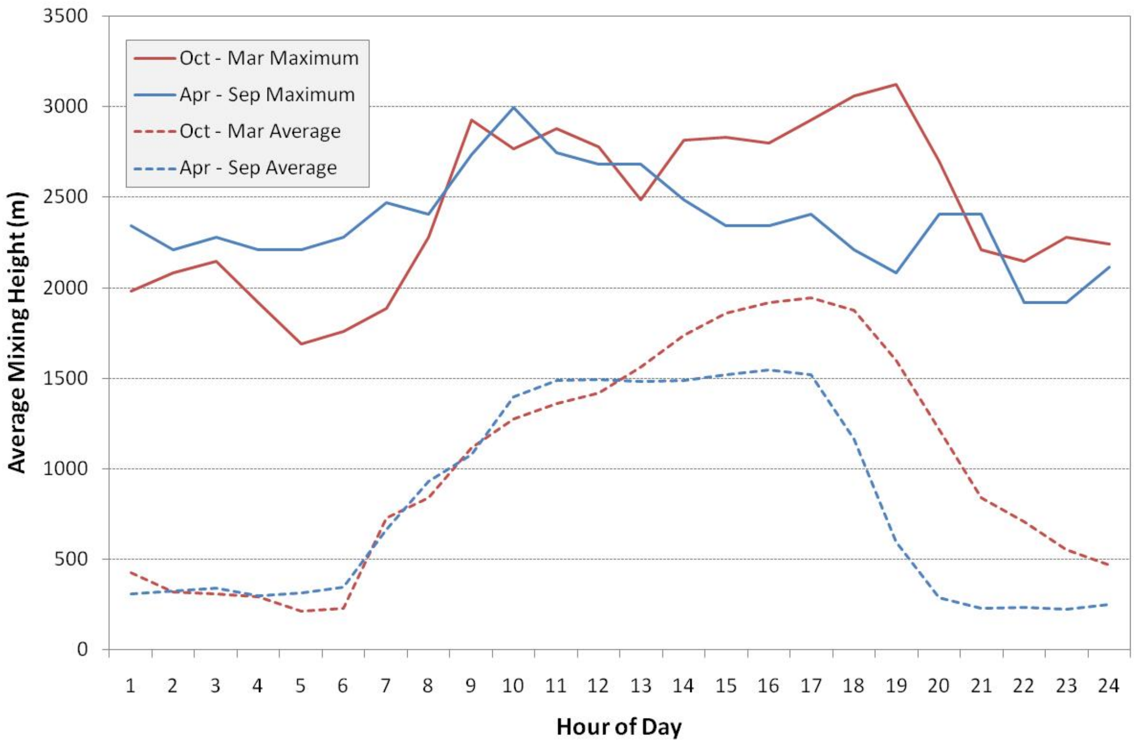


■ **Figure 5.4 Sep – Nov wind rose**

Mixing height loosely describes the layer of atmosphere in which emissions to air can disperse within. High mixing heights allow pollutants to disperse over a larger volume of atmosphere, the consequence of this being lower ground level concentrations. A low mixing height will usually result in higher ground level concentrations.

The average mixing heights by hour for Port Hedland as calculated at the BoM station for the 2004/2005 financial year are presented in **Figure 5.5** and show the average mixing height increasing as the day progresses before lowering overnight.

The October to March data show this extends later into day, likely due to the slightly longer and hotter days during this time of year. The morning mixing height levels are shown to be relatively consistent throughout the year. The data in the graphs indicate that dust events due to poor mixing conditions are likely to be pre-dawn through the year and after sunset in winter.



- **Figure 5.5 Average mixing heights in Port Hedland (2004/2005)**

Stability class is the categorisation of atmospheric turbulence. The Pasquill stability classes are used to describe the strength of dispersion processes within a layer of atmosphere. There a six classes, ranging from A (the most turbulent) to F (the most stable). Class A represents a highly unstable atmosphere, usually associated with higher temperatures, a large influx of solar radiation and low wind speeds. Class D is considered to be a neutral atmosphere, while class F represents a very stable atmosphere with little mixing, typically occurring overnight.

The annual average stability class distribution over a 24-hour period is presented in **Figure 5.6**. It is shown from midnight to 8 am the region is dominated by neutral and stable conditions (D, E and F classes). From 8 am onwards C and B class stabilities with some A classes become the norm, gradually declining back to a D, E and F classes being dominant during the afternoon and evening.

The stable atmosphere in the mornings and overnight under the low mixing heights at these times (**Figure 5.5**) presents a high risk for large dust impacts to be predicted by AUSPLUME downwind**.** It is likely that high ground level concentrations will be predicted at receptors overnight and early in mornings.

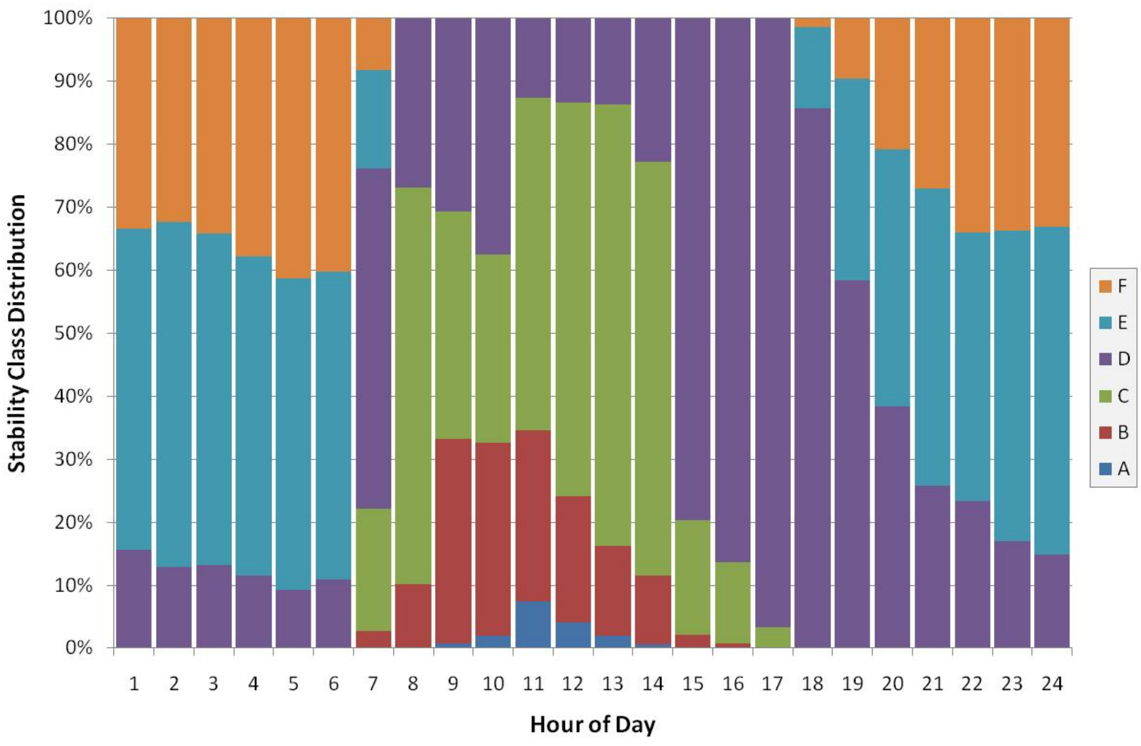


Figure 5.6 Stability class distribution in Port Hedland (2004/2005)

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5.4. Model Inputs

A model of the proposed NWI Facility and existing/future operations was established to predict 24-hour ground level PM_{10} and TSP concentrations at sensitive receptors to the site. Inputs to the model include:

- meteorological file containing hourly data for 2004/2005 financial year as mentioned in **Section 3.1**
- operational data and emissions release estimates, as discussed in **Section 4**.

An example of an AUSPLUME configuration file used in this assessment is presented in **Appendix B**.

5.4.1. Emission Sources

The sources modelled in this assessment were specific to bulk material handling operations described in **Section 4.2**. Sources included:

- car dumper
- conveyors and transfer stations
- stackers and reclaimers
- shiploaders
- wind erosion (stockpile and open area)
- light vehicles

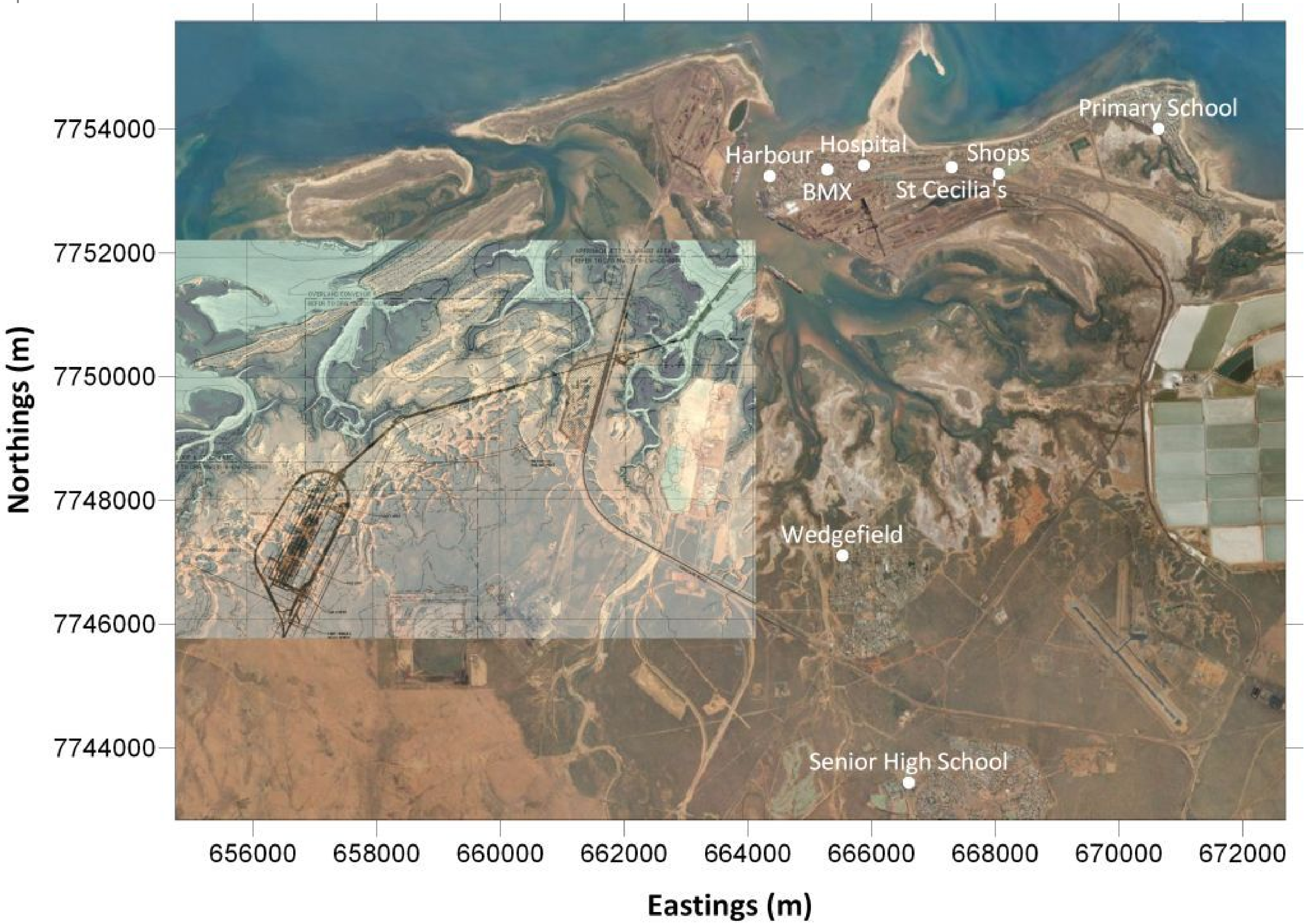
A table detailing source locations and AUSPLUME emission dimension characteristics are presented in **Appendix C**.

5.4.2. Sensitive Receptors

For the purpose of this assessment dust concentrations were modelled at eight discrete receptors within the region detailed in **Table 5.2** and represented in **Figure 5.7** with respect to the project location. The Harbour and Hospital locations were chosen as these represent the existing BHP Billiton Iron Ore ambient dust monitoring sites and were used in the model validation process. The Port Hedland Primary School was chosen to represent the eastern end of Port Hedland as this site potentially represents the most sensitive receptor in this immediate area. The BMX course, St Cecilia's and Port Hedland shops were included as conceptual sites to demonstrate concentrations between the east of town and the main port operations. To model the existing and potential dust concentrations in South Hedland the high school location was used as this also represents the most sensitive receptor within the immediate area. A receptor location was also assigned to Wedgefield. Taplin St was also included as a receptor during PM_{10} model runs.

Table 5.2 Sensitive receptor locations for model interpretation

Location	Easting (m)	Northing (m)
Harbour Monitor	664350	7753240
BMX	665281	7753352
Hospital Monitor	665870	7753420
St Cecilia's	667292	7753390
Port Hedland Shop	668050	7753280
Port Hedland Primary School	670631	7754008
Hedland Senior High School	666600	7743439
Wedgefield	665526	7747107
Taplin St	667094	7753427



▪ **Figure 5.7 Port Hedland modelled sensitive receptor locations**

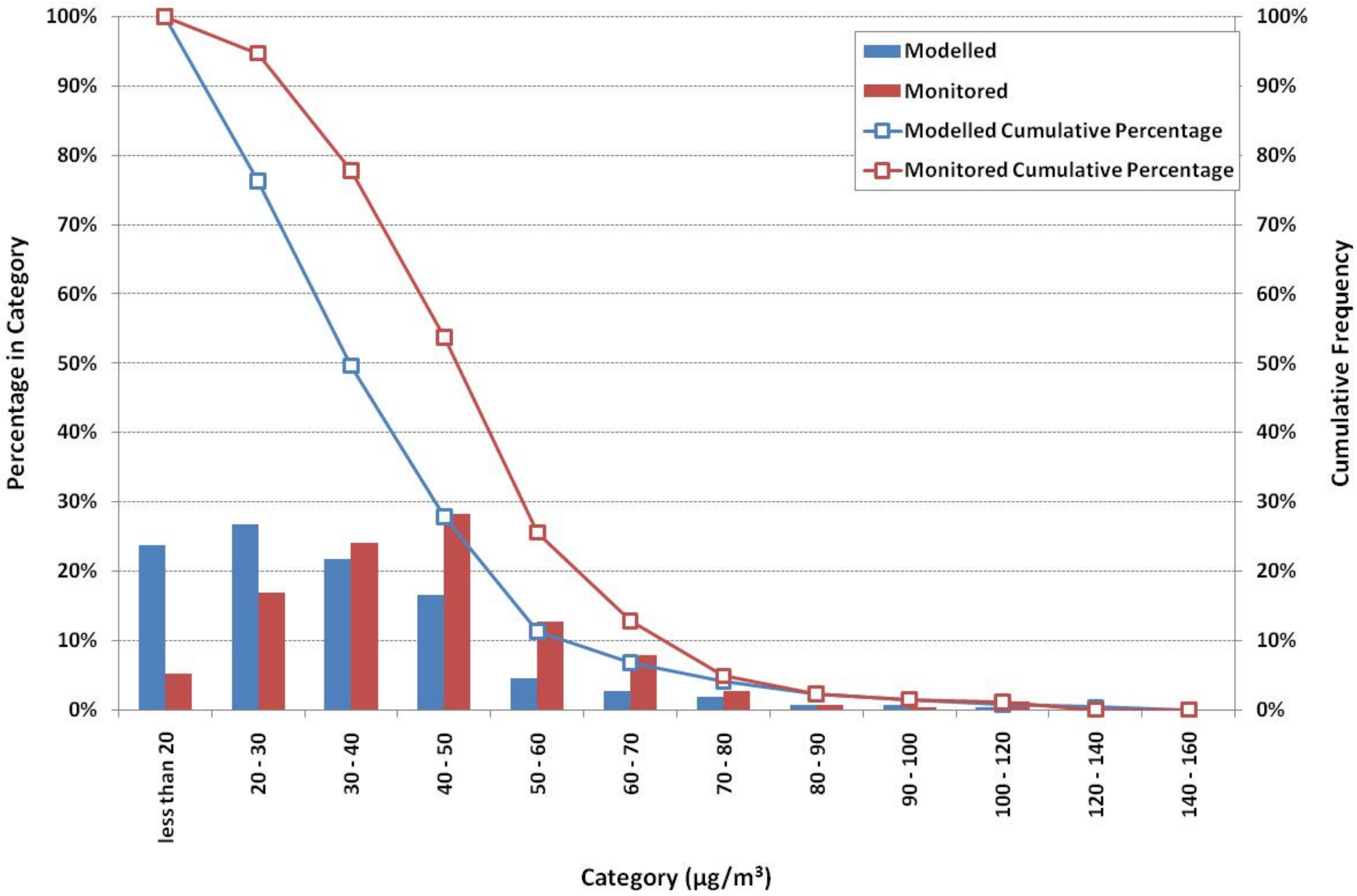
5.5. Model Validation

Model accuracy and reliability can be determined through comparison of predictions to monitored values. This process typically involves the input of recorded meteorological data and measured emission parameters over the same period of time into the model, and comparing model predictions to monitoring data, also over the same period of time, at multiple fixed locations. The model configuration can then be adjusted until model predictions meet monitored levels to the required level of confidence.

In order to validate the AUSPLUME model configuration developed and used for Port Hedland as an accurate and reliable tool, a comparison was made between the model and monitored data. A frequency distribution of predicted ground level concentrations were compared to monitoring data recorded at both the BHP Billiton Iron Ore Harbour and Hospital monitoring stations. To produce its predictions, the model was inputted with an estimate of port operations for the monitoring period used (2004/2005 financial year). This validation was described in the Balla Balla Air Quality Assessment for Utah Point operations (SKM 2008) and is reproduced below.

5.5.1. PM_{10} Validation

The 24-hour PM_{10} model validation at the Harbour monitoring location is presented in **Figure 5.8** as a frequency distribution and in **Figure 5.9** as a quantile/quantile comparison**.** From **Figure 5.8** it can be seen that the model tends to under predict concentrations. The quantile/quantile comparison presented in **Figure 5.9** again shows that the model tends to under predict the concentrations, but that it succeeds in correctly predicting both the concentration and number of days with high concentrations.



▪ **Figure 5.8 24-hour PM_{10} frequency distribution for 2004/2005 at Harbour Monitor**

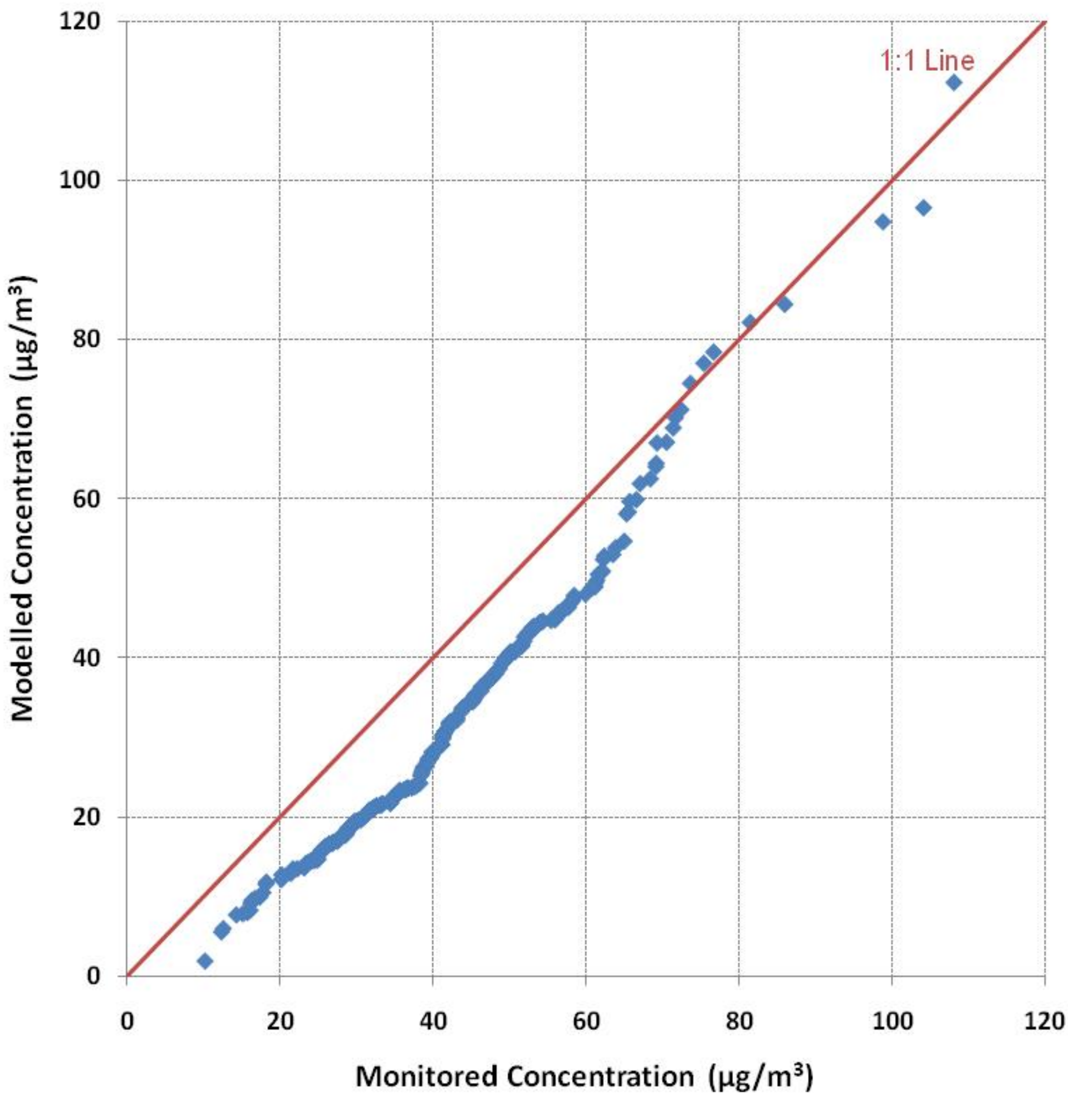
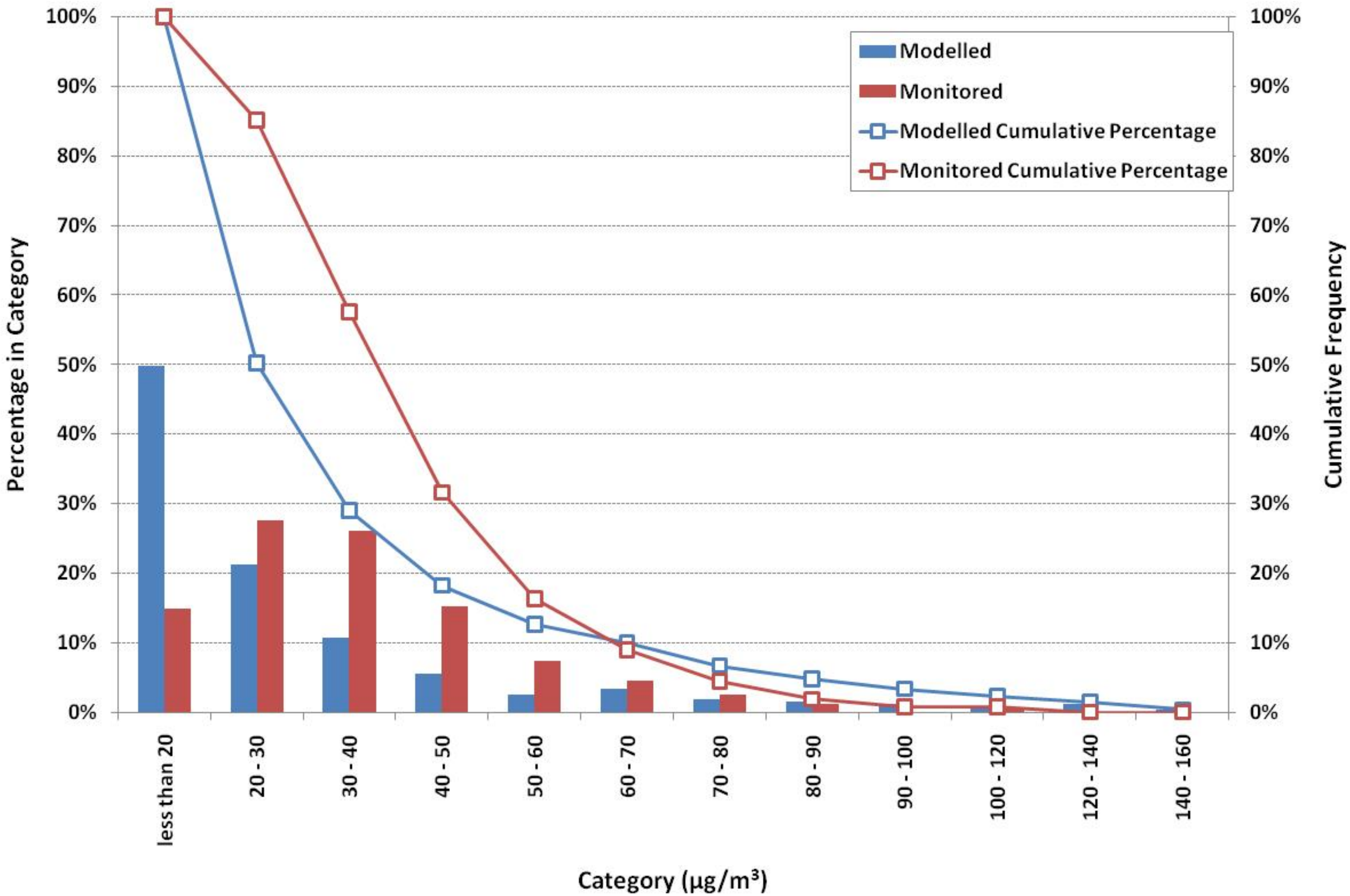
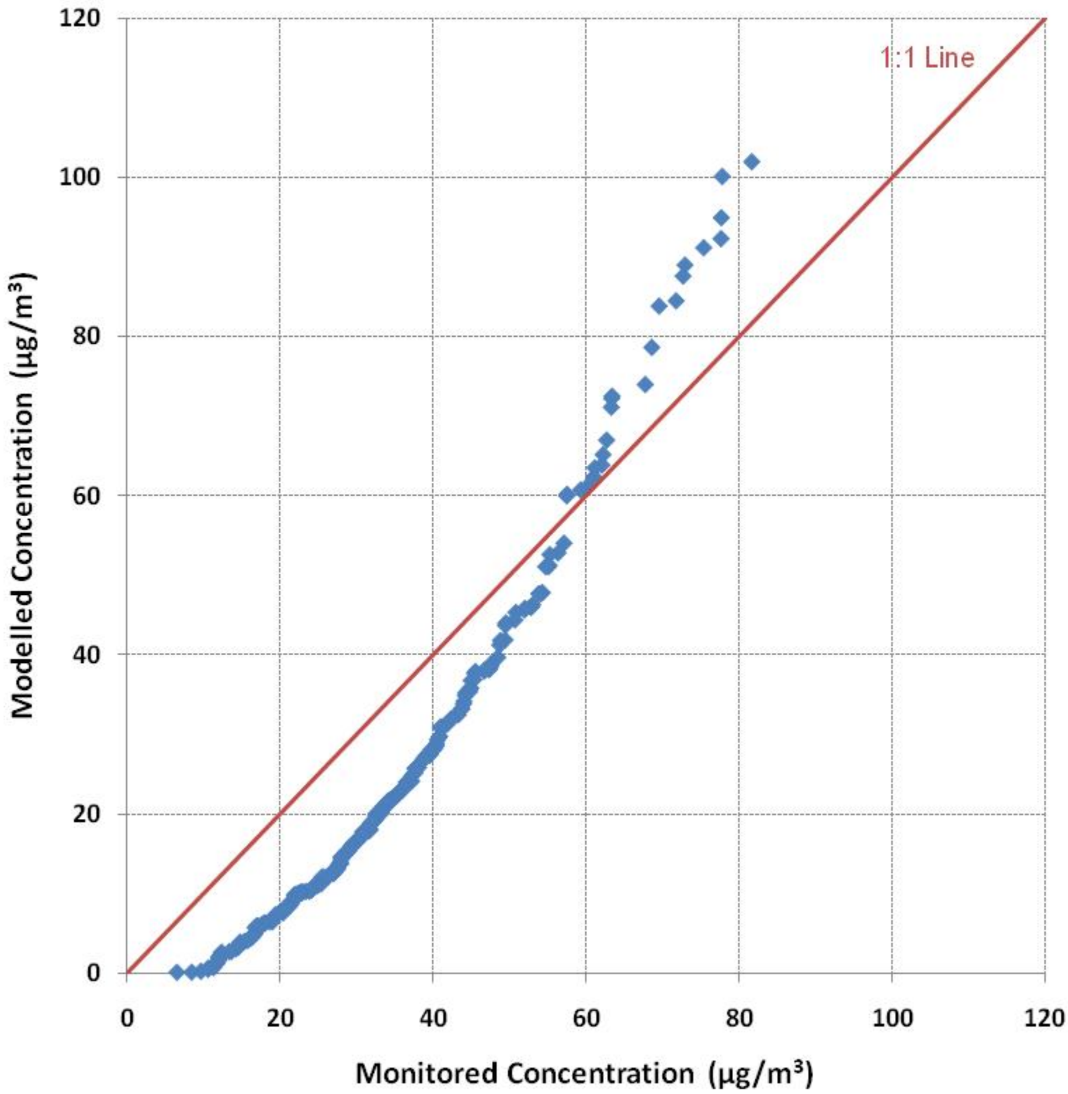


Figure 5.9 24-hour PM_{10} quantile/quantile (1:1) comparison at Harbour Monitor

The model validation at the Hospital monitoring location is presented in **Figure 5.10** as a frequency distribution and in **Figure 5.11** as a quantile/quantile comparison**.** From **Figure 5.10** it can be seen that the model tends to over predict the number of days with low concentrations and under predict the number of days with higher concentrations, though the model does predict higher maximum concentrations than what occurred during this time period. The quantile/quantile comparison presented in **Figure 5.11** shows that the model tends to under predict the monitored data up to 60 $\mu g/m^3$ before the model starts to over predict the concentrations.



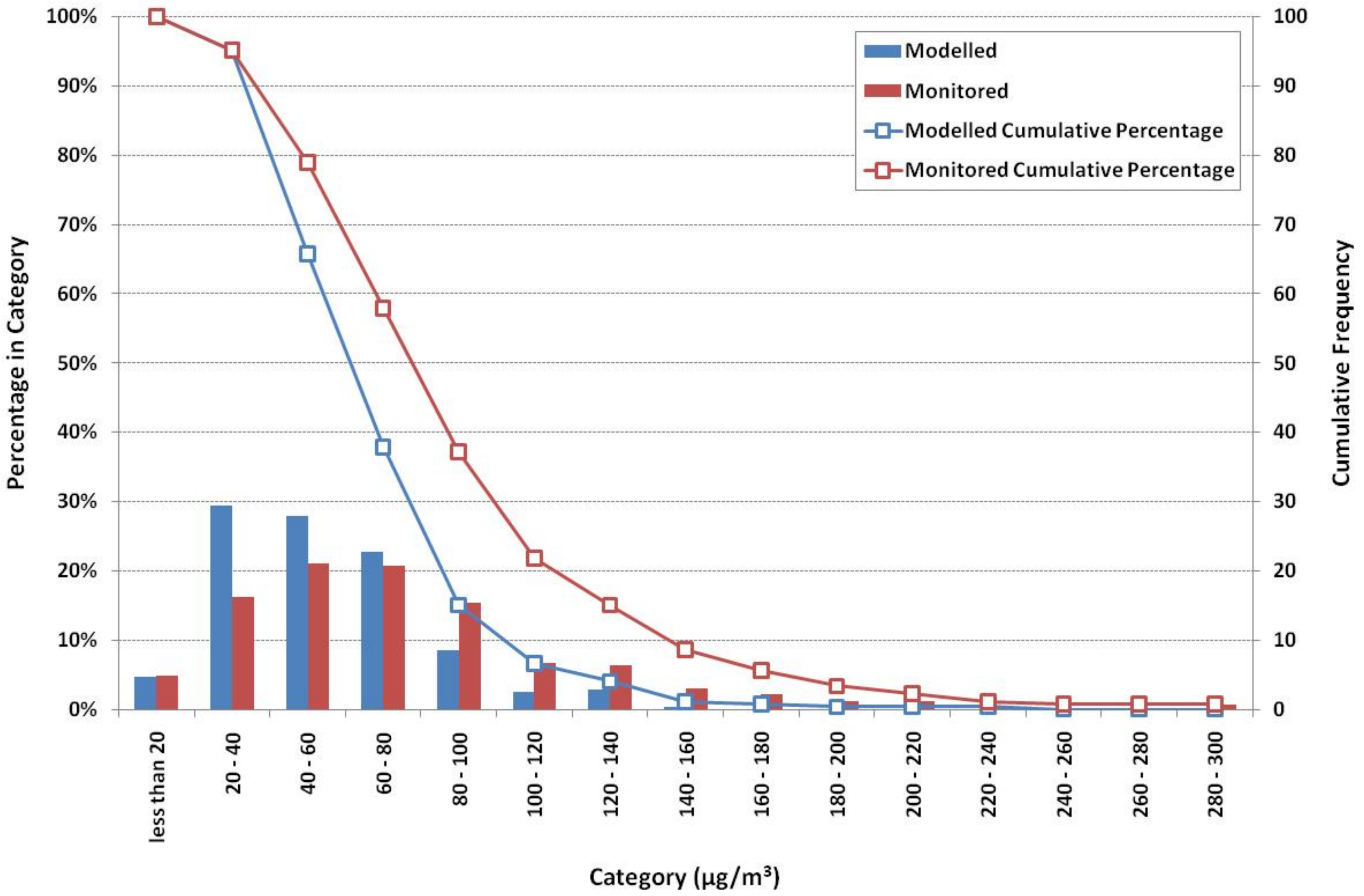
- **Figure 5.10 24-hour PM_{10} frequency distribution for 2004/2005 at Hospital Monitor**



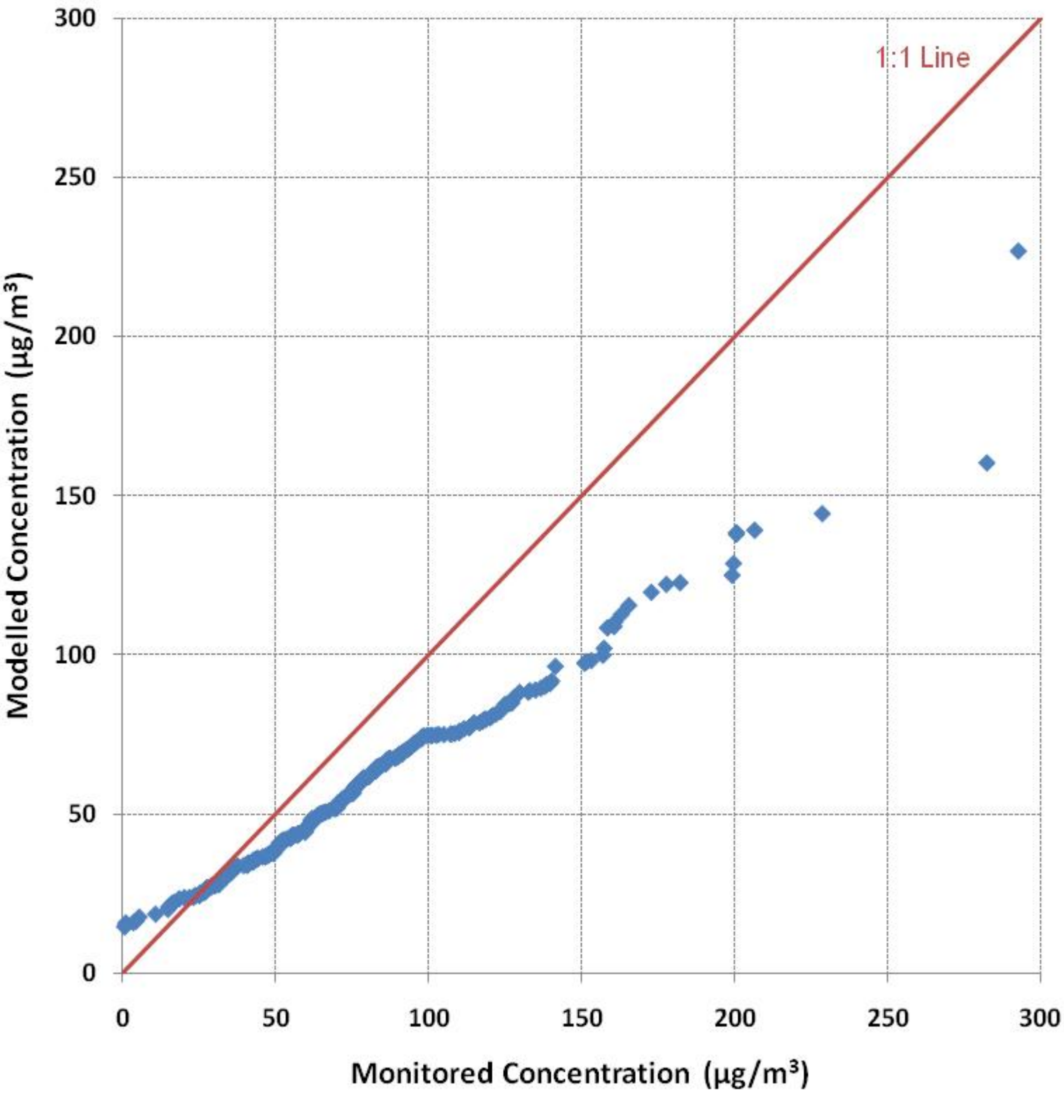
- **Figure 5.11 24-hour PM_{10} quantile/quantile (1:1) comparison at Hospital Monitor**

5.5.2. TSP Validation

The TSP model validation at the Harbour monitoring location is presented in **Figure 5.12** as a frequency distribution and in **Figure 5.13** as a quantile/quantile comparison**.** From **Figure 5.12** it can be seen that the model over predicts the lower concentrations and under predicts the higher concentrations. The quantile/quantile comparison presented in **Figure 5.13** shows that the model tends to under predict the monitored data by up to a factor of 1.5. As the quantile/quantile graph for the PM_{10} validation (see **Figure 5.9**) shows a very close agreement, there could potentially be an issue with the particle size fractions used to simulate TSP.

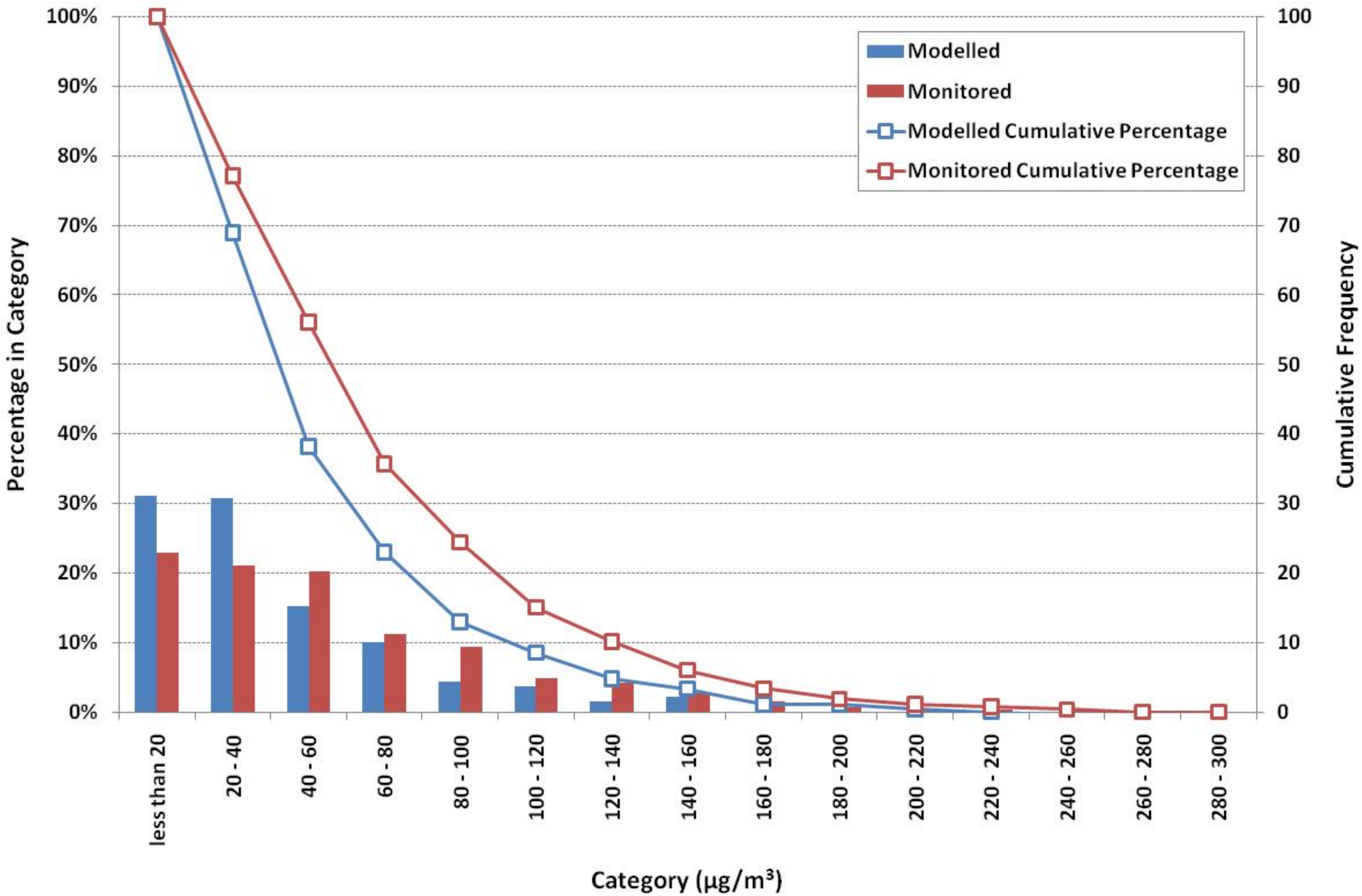


- **Figure 5.12 24-hour TSP frequency distribution for 2004/2005 at Harbour Monitor**



■ **Figure 5.13 24-hour TSP quantile/quantile (1:1) comparison at Harbour Monitor**

The TSP model validation at the Hospital monitoring location is presented in **Figure 5.14** as a frequency distribution and in **Figure 5.15** as a quantile/quantile comparison**.** From **Figure 5.14** it can be seen that the model tends to under predict the lower concentrations and over predict the higher concentrations at this monitoring locations. The quantile/quantile comparison presented in **Figure 5.15** shows that the model tends to under predict the monitoring data at this location, though not to the same extent as what occurs at the Harbour.



■ **Figure 5.14 24-hour TSP frequency distribution for 2004/2005 at Hospital Monitor**

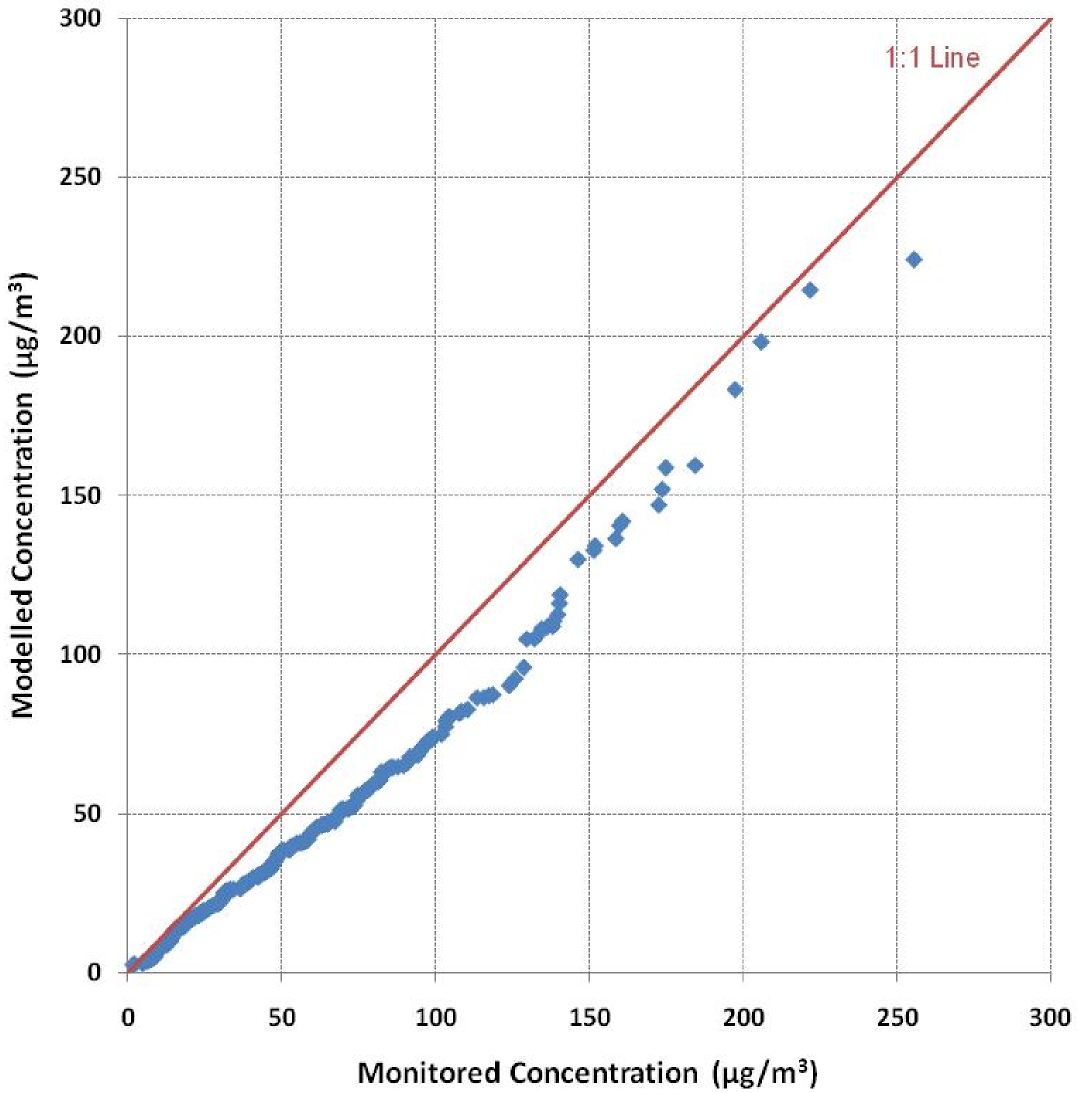


Figure 5.15 24-hour TSP quantile/quantile (1:1) comparison at Hospital Monitor

5.6. Summary of Validation Modelling

The model validation for the existing scenario using the tonnage that was exported during the 2004/2005 financial year at both the BHP Billiton Iron Ore and PHPA operations shows that:

- For PM_{10} the model tends to under predict the lower concentrations at both receptor locations. At the harbour, high-end concentrations are predicted close to monitored levels. At the hospital, the model over predicts upper concentrations. These results indicate the model will likely be conservative in the prediction of the maximum and upper percentile PM_{10} concentrations.
- For TSP the model under predicts the concentrations at the Harbour monitoring location by a factor of 1.5 while at the Hospital monitor the model also under predicts the concentrations though not to the same level as at the Harbour. The predicted TSP concentrations should therefore only be used to determine the relative change in ground level concentrations between the scenarios.

6. Model Results

This section presents the results of atmospheric dispersion modelling undertaken for this assessment. The modelling results are tabulated for the eight sensitive receptor locations with a comparison to the assessment criteria. The maximum predicted concentrations within the defined air quality assessment area (grid) are also plotted. For all non-validation scenarios the 99th percentile concentrations are also plotted, removing extreme predictions to present a smoothed representation of likely impacts.

For this assessment the following five scenarios have been modelled:

- Baseline – 2004/2005 Port Hedland model validation (**Section 6.1**)
- NWI only (**Section 6.2**)
- Future scenario (no NWI), including background dust (**Section 6.3**)
- Future scenario including NWI and background dust (**Section 6.4**)
- Future scenario including NWI, Outer Harbour Development & background dust (**Section 6.5**)

6.1. Baseline Scenario

To establish a baseline for future scenarios to be compared to, the 2004/2005 Port Hedland validated model results have been used, this timeframe being consistent with the baseline model results presented in the Port Hedland Air Quality and Noise Management Plan (DSD 2010). The baseline scenario included operations originally described in the Balla Balla Air Quality Assessment for Utah Point operations (SKM 2008).

6.1.1. PM_{10} Concentrations

The statistics from the PM_{10} modelling for the 2004/2005 base year, with background concentrations, are presented in **Table 6.1**. From this table it can be seen that the maximum concentration is predicted to occur at the Hospital receptor. This trend continues through the higher statistics until the 90th percentile when the Harbour receptor starts to record higher concentrations, with this site predicted to have a higher annual average PM_{10} concentration.

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- **Table 6.1 24-hour PM_{10} statistics of model predictions for 2004/2005 base year (μg/m^3)**

Receptor	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Annual Average	No. days exceeding criteria limit
Harbour	152	120	83	72	57	49	39
BMX[1]	-	-	-	-	-	-	-
Hospital	182	144	92	72	48	44	39
St Cecilia's[1]	-	-	-	-	-	-	-
Shops[1]	-	-	-	-	-	-	-
Primary School	76	55	43	36	24	22	1
High School	63	53	36	30	21	19	5
Wedgefield	63	53	36	30	21	19	5
Taplin St[1]	-	-	-	-	-	-	-

[1]these receptors were not included as part of the validation study

A contour plot of the predicted existing maximum PM_{10} ground level concentrations is presented in **Figure 6.1**. From this figure it is apparent that the PHDTF criterion (**Section 2.1.2**) is exceeded across almost the entire town of Port Hedland primarily due to the high background concentrations (see **Figure 3.3**) recorded in this region.

6.1.2. TSP Concentrations

The statistics from the TSP modelling for the 2004/2005 base year are presented in **Table 6.2**. From this table it can be seen that the maximum concentration is predicted to occur at the Harbour receptor. For the higher statistics it is predicted that the Hospital receptor will record higher concentrations. From the 90th percentile the Harbour monitor is predicted to record higher concentrations, with this site predicted to have a higher annual average TSP concentration.

- **Table 6.2 24-hour TSP statistics of model predictions for 2004/2005 base year (μg/m^3)**

Receptor	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Annual Average
Harbour	283	178	138	124	93	84
BMX[1]	-	-	-	-	-	-
Hospital	245	211	149	123	82	73
St Cecilia's[1]	-	-	-	-	-	-
Shops[1]	-	-	-	-	-	-
Primary School	135	76	62	53	37	35
High School	135	75	56	46	33	31
Wedgefield	135	76	57	47	35	32

[1] these receptors were not included as part of the validation study

A contour plot of the predicted maximum TSP ground level concentrations is presented in **Figure 6.2**. From this figure the Kwinana EPP Area C limit (**Section 2.1.1**) is shown to be exceeded within the western part of Port Hedland. These high concentrations are predominantly due to the high background concentrations present in this region.

6.1.3. Dust Deposition

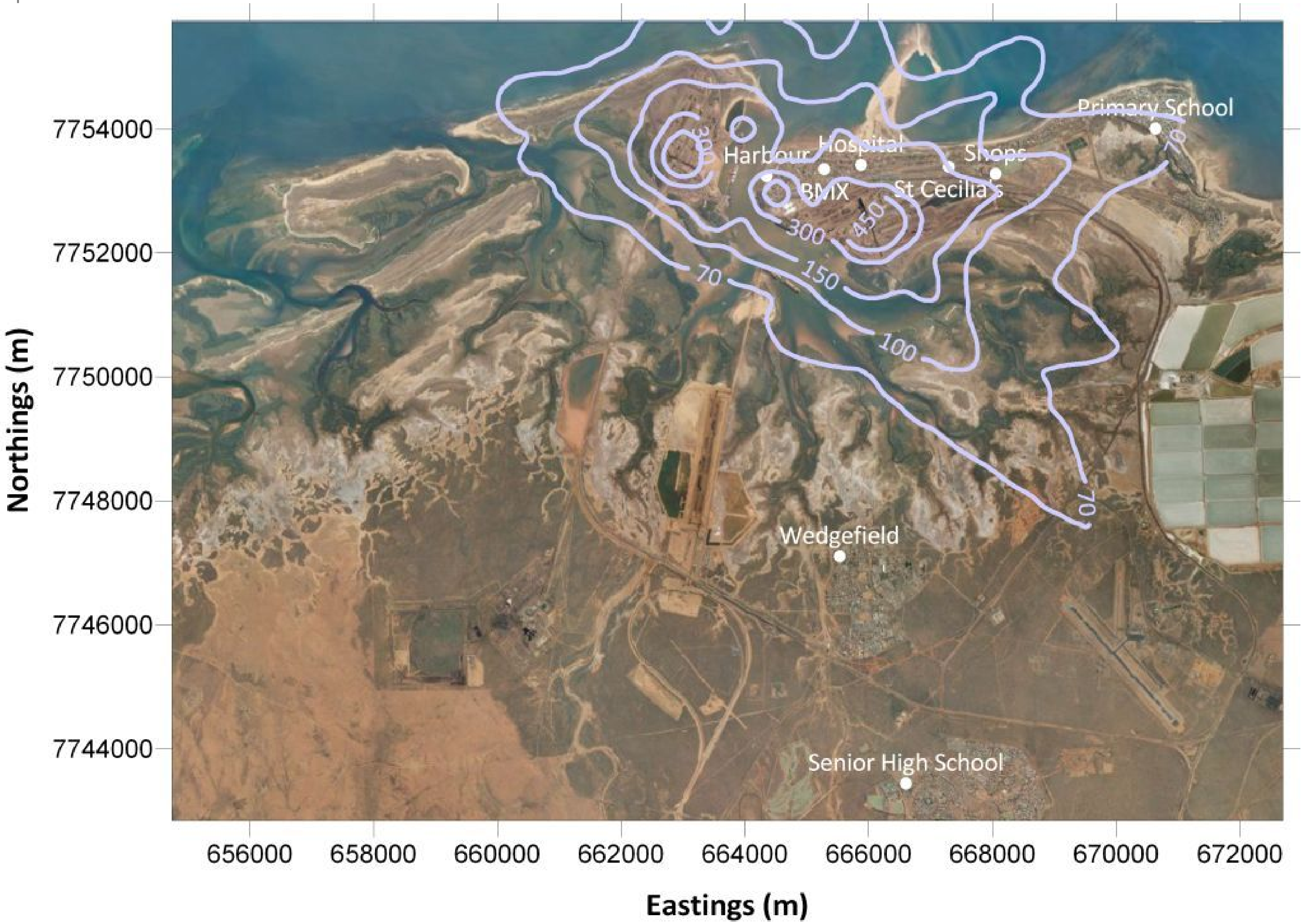
The statistics from the deposition modelling for the 2004/2005 base year are presented in **Table 6.3**. From this table it can be seen that the maximum deposition is predicted to occur at the Harbour receptor, with all months exceeding the criteria limit. The Hospital receptor also experiences concentrations above criteria limits for over half the year. Receptors outside of the main Port Hedland township are shown to experience minimal deposition from existing operations.

Table 6.3 Monthly deposition statistics of model predictions for 2004/2005 base year (μg/m^3)

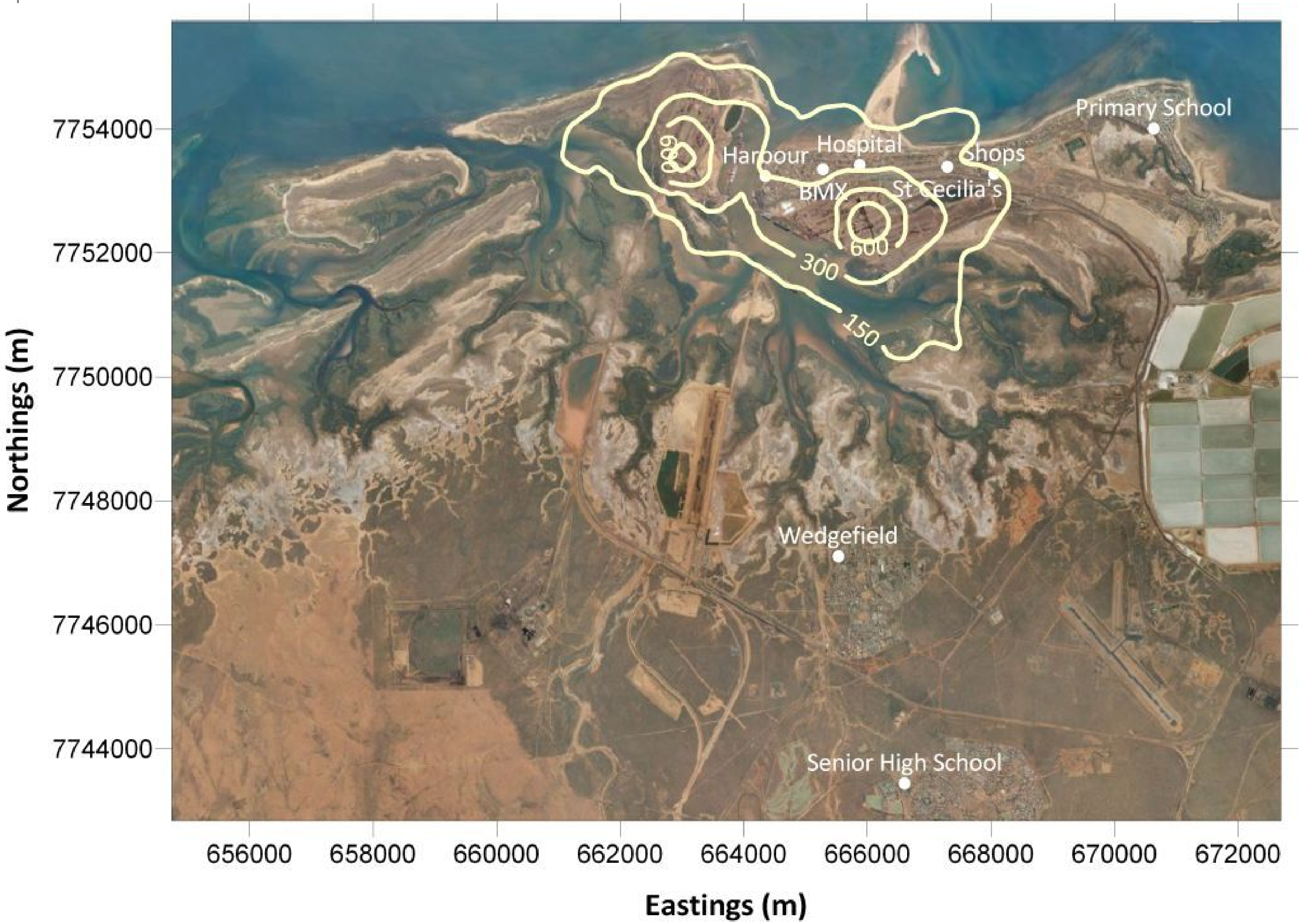
Receptor	Maximum (g/m^2/month)	Months with deposition greater than 2 g/m^2 criteria limit
Harbour	5.29	12
BMX[1]	-	-
Hospital	3.21	7
St Cecilia's[1]	-	-
Shops[1]	-	-
Primary School	0.22	0
High School	0.09	0
Wedgefield	0.24	0

[1] these receptors were not included as part of the validation study

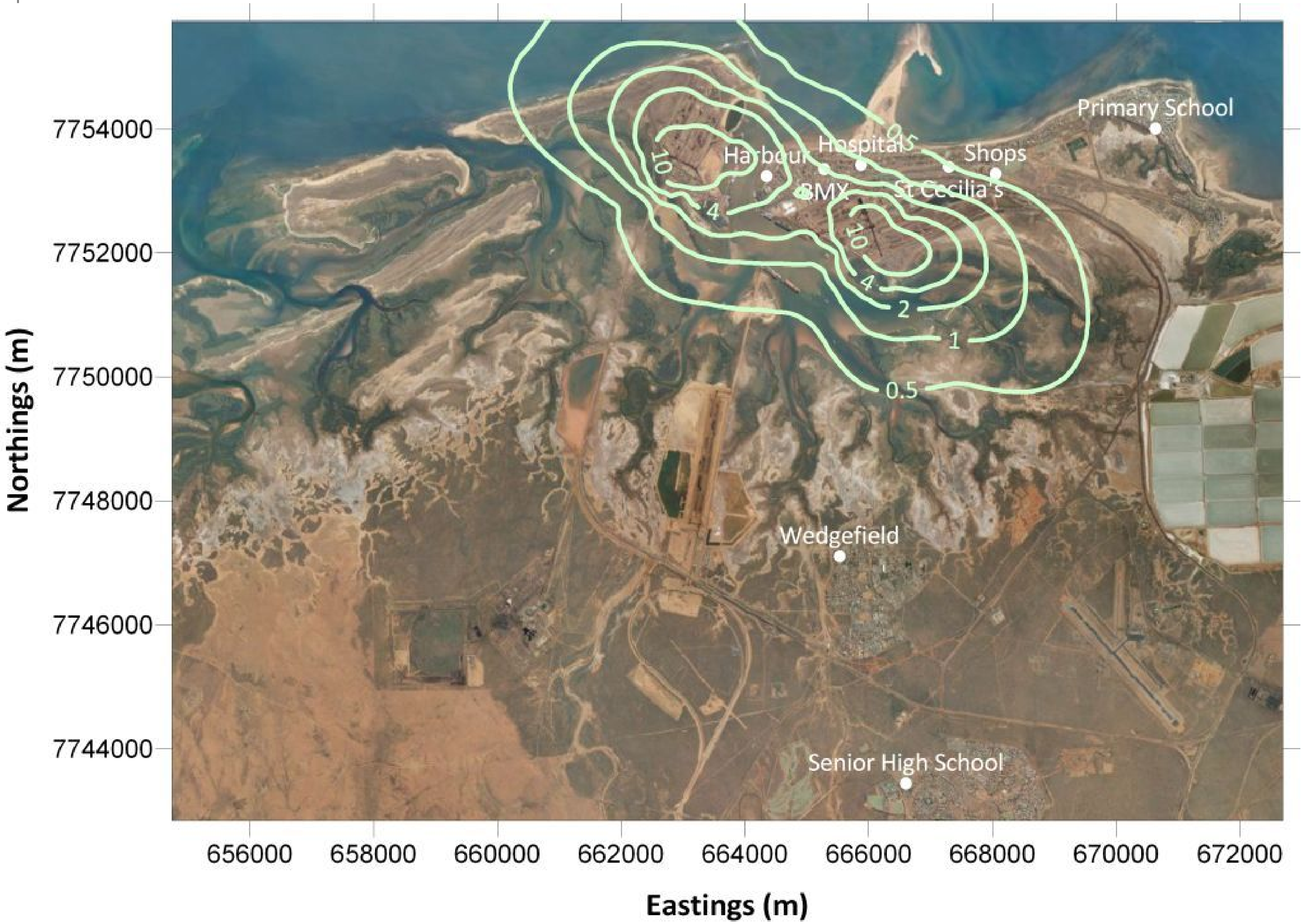
A contour plot of the predicted maximum dust deposition is presented in **Figure 6.3**. This shows deposition impacts focused around BHP Billiton Iron Ore operations. The 2 g/m^2/month contour line shows deposition levels above the criteria limit are limited to the west end of Port Hedland.



■ **Figure 6.1 Maximum predicted validated PM_{10} ground level concentrations (µg/m^3)**



■ **Figure 6.2 Maximum predicted validated TSP ground level concentrations (µg/m^3)**



- **Figure 6.3 Maximum predicted validated monthly dust deposition (g/m^2/month)**

6.2. NWI Impact

This scenario considers NWI Facility in isolation (without background concentrations) to determine the predicted area of impact for the proposed operations.

6.2.1. PM_{10} Concentrations

The predicted 24-hour PM_{10} concentrations from the proposed NWI Facility in isolation are presented in **Table 6.4**. From this table it is apparent that the proposed operations are predicted to have the highest impact at the Harbour, BMX, Hospital, and St Cecilia receptors, though the large difference between the predicted maximum concentrations and 99th percentile statistics indicates that high impacts will only occur a few times a year.

- **Table 6.4 24-hour PM_{10} statistics for NWI (in isolation) ($\mu g/m^3$)**

Receptor	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Average	No. days exceeding criteria limit
Harbour	24	8	4	3	1	1	0
BMX	17	9	4	3	1	1	0
Hospital	11	6	4	2	1	1	0
St Cecilia's	15	5	3	2	1	1	0
Shops	11	4	2	2	1	1	0
Primary School	4	3	2	1	<1	<1	0
High School	3	2	1	1	1	<1	0
Wedgefield	7	4	3	2	1	1	0
Taplin St	13	5	3	2	1	1	0

The data presented in **Table 6.4** also shows a significant gap between maximum predicted concentrations and the 99th percentile. Low wind speeds (0.5 m/s or less) are poorly handled by Gaussian plume models such as AUSPLUME (EPA 2000) and, in conjunction with low mixing heights and F stability class, can lead to over-predictions such as the ones presented in **Table 6.4**. A review of the model meteorological data on days predicted to have high concentrations at multiple receptors is presented in **Table 6.5** confirms days with high concentrations predicted have larger than average combination of low mixing heights (below 100 m), F class stabilities and low wind speeds (below 1 m/s).

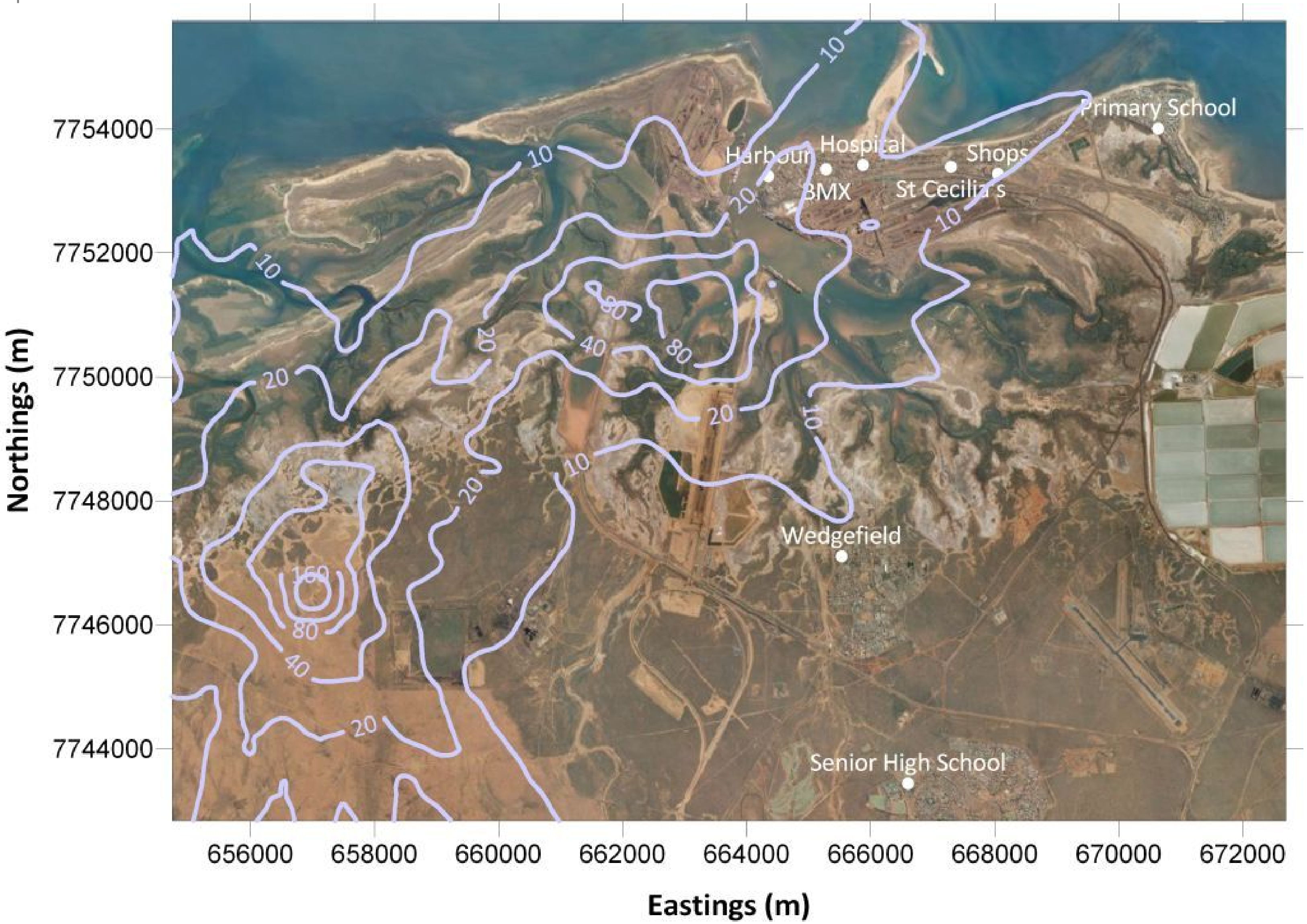
For this assessment the 99th percentile statistics could be considered more likely to represent the impact from the NWI Facility.

- **Table 6.5 Review of model meteorology on days of predicted high concentrations**

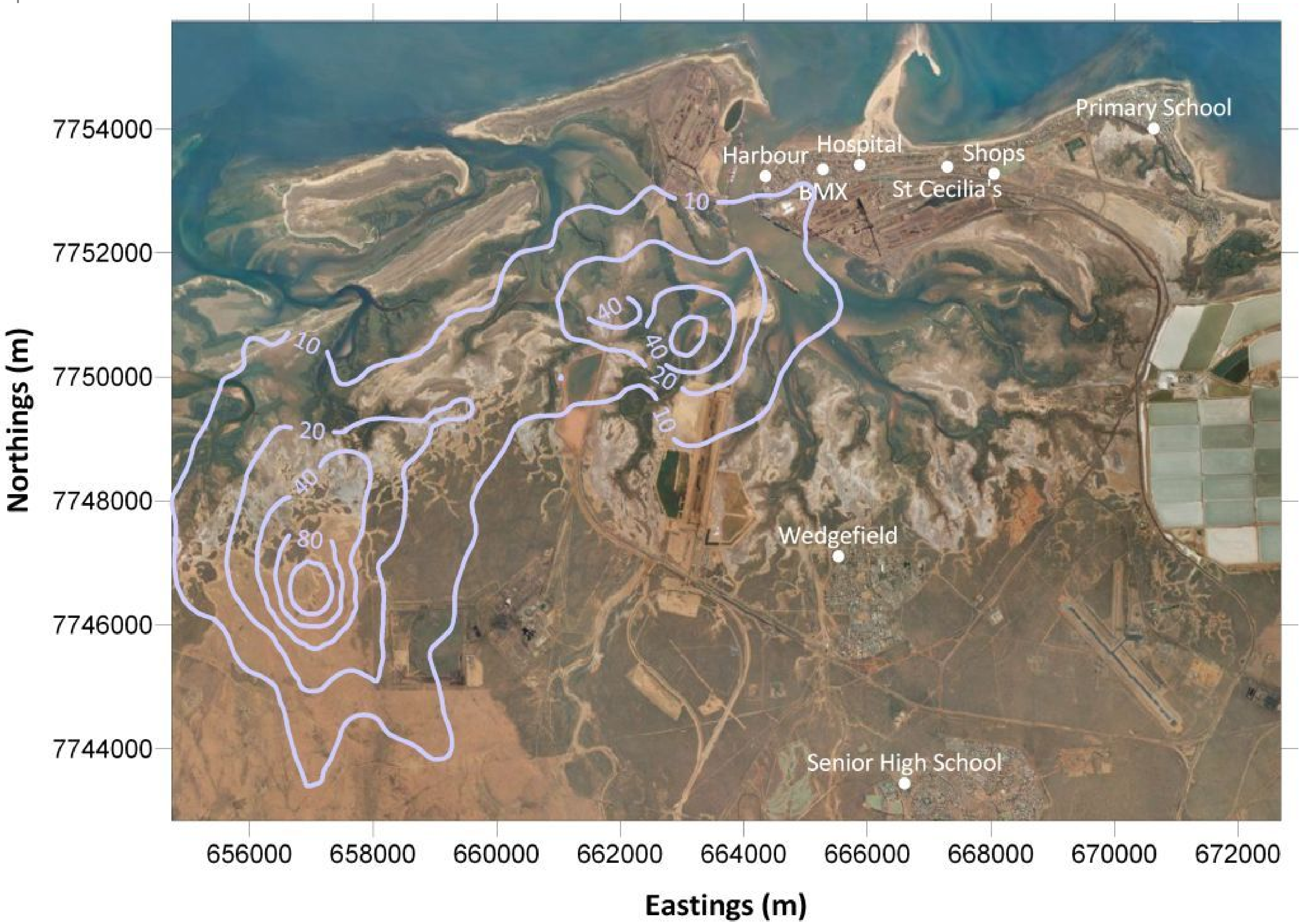
Significant Days	Hours of the day with:		
	Mixing height <100 m	F Stability class	Wind speed equal to or less than 1 m/s
Average day	0.16	0.16	0.02
23-Feb	7	6	2
7-Apr	7	6	3
10-Apr	7	7	3
16-May	5	5	3
8-Jun	8	8	4
18-Oct	6	5	2
19-Oct	6	6	1
26-Oct	7	7	3
2-Dec	7	7	0
21-Dec	9	9	1

The predicted maximum PM_{10} concentrations at the other receptors, and low annual average concentrations predicted at all receptors show that the proposed NWI Facility will have a low overall impact when compared to the 2004/2005 validated model results (see **Table 6.1**).

The contour plots of the maximum and 99th percentile predicted PM_{10} concentrations from the proposed NWI Facility (without background PM_{10} concentrations) are presented in **Figure 6.4** and **Figure 6.5**. From this figure it is evident that the predicted impact from the proposed operations will be centred on the stockyards and shiploader, with maximum concentrations decreasing to below 40 µg/m^3 before impacting upon the town of Port Hedland.



■ **Figure 6.4 Maximum predicted NWI (in isolation) 24-hour PM_{10} ground level concentrations (µg/m^3)**



■ **Figure 6.5 99th percentile predicted NWI (in isolation) 24-hour PM_{10} ground level concentrations (µg/m^3)**

6.2.2. TSP Concentrations

The predicted 24-hour TSP concentrations from the proposed NWI Facility in isolation are presented in **Table 6.6**. The predicted concentrations in this table follow the same pattern as the predicted PM_{10} concentrations (see **Table 6.4**) in that the proposed operations are predicted to have the highest impact at the Harbour, BMX, Hospital, and St Cecilia receptors. This predicted impact is expected to occur only for a few days per year. It is also of note that predicted TSP levels are comparable to predicted PM_{10} levels which is indicative of heavier particles emitted from the NWI Facility being deposited before reaching the identified receptors.

The maximum predicted TSP concentrations at the other receptors and low annual average concentrations predicted at all receptors indicate that the proposed NWI Facility will have a negligible impact to TSP concentrations at sensitive receptors.

- **Table 6.6 24-hour TSP statistics for NWI (in isolation) (µg/m³)**

Receptor	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Average
Harbour	25	10	6	5	2	2
BMX	18	10	5	4	1	1
Hospital	11	7	4	3	1	1
St Cecilia's	14	5	3	2	1	1
Shops	10	4	3	2	1	1
Primary School	5	3	2	1	1	<1
High School	3	3	2	1	1	1
Wedgefield	8	5	3	2	1	1

A contour plot of the maximum and 99th percentile predicted TSP concentrations from the proposed NWI Facility (without background TSP concentrations) are presented in **Figure 6.6** and **Figure 6.7**. From these figures it is evident that the predicted impact from the proposed operations will be centred on the stockyards and shiploading. When the results of this figure are compared to the validated TSP concentrations (see **Figure 6.2**) the NWI Facility in isolation is shown to impact on Port Hedland at a level an order of magnitude smaller.

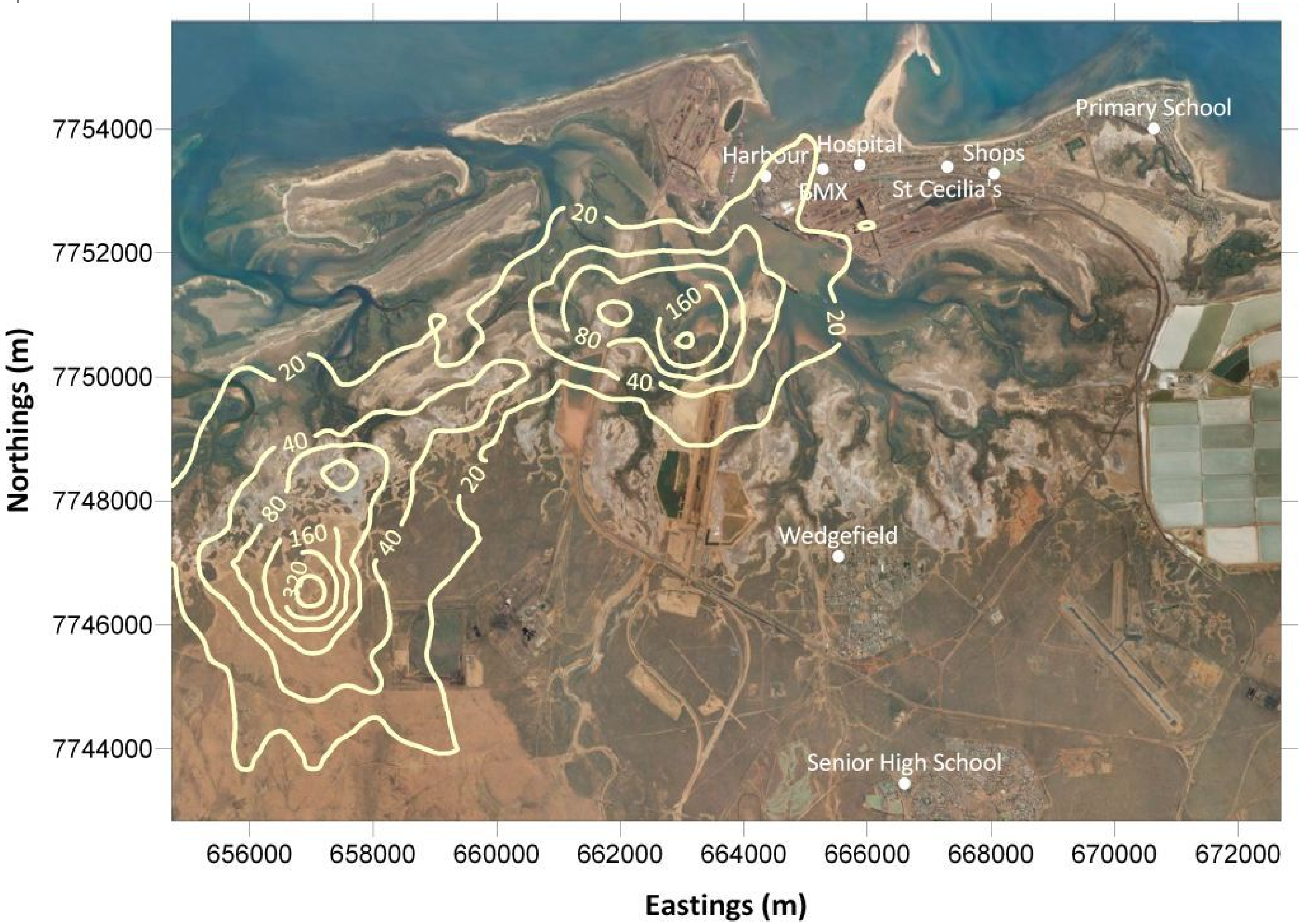
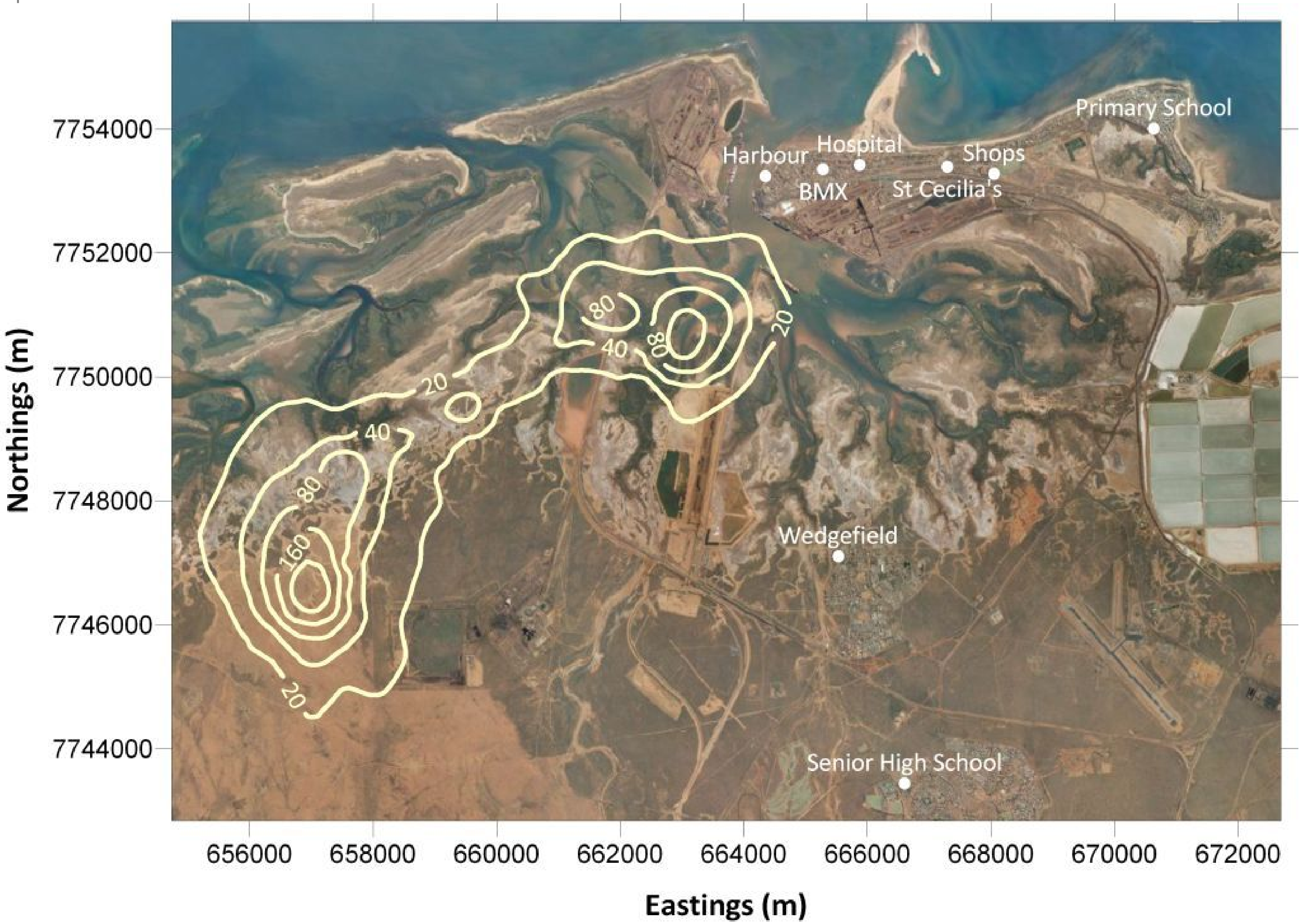


Figure 6.6 Maximum predicted NWI (in isolation) 24-hour TSP ground level concentrations (µg/m³)



■ **Figure 6.7 99th percentile predicted NWI (in isolation) 24-hour TSP ground level concentrations (µg/m^3)**

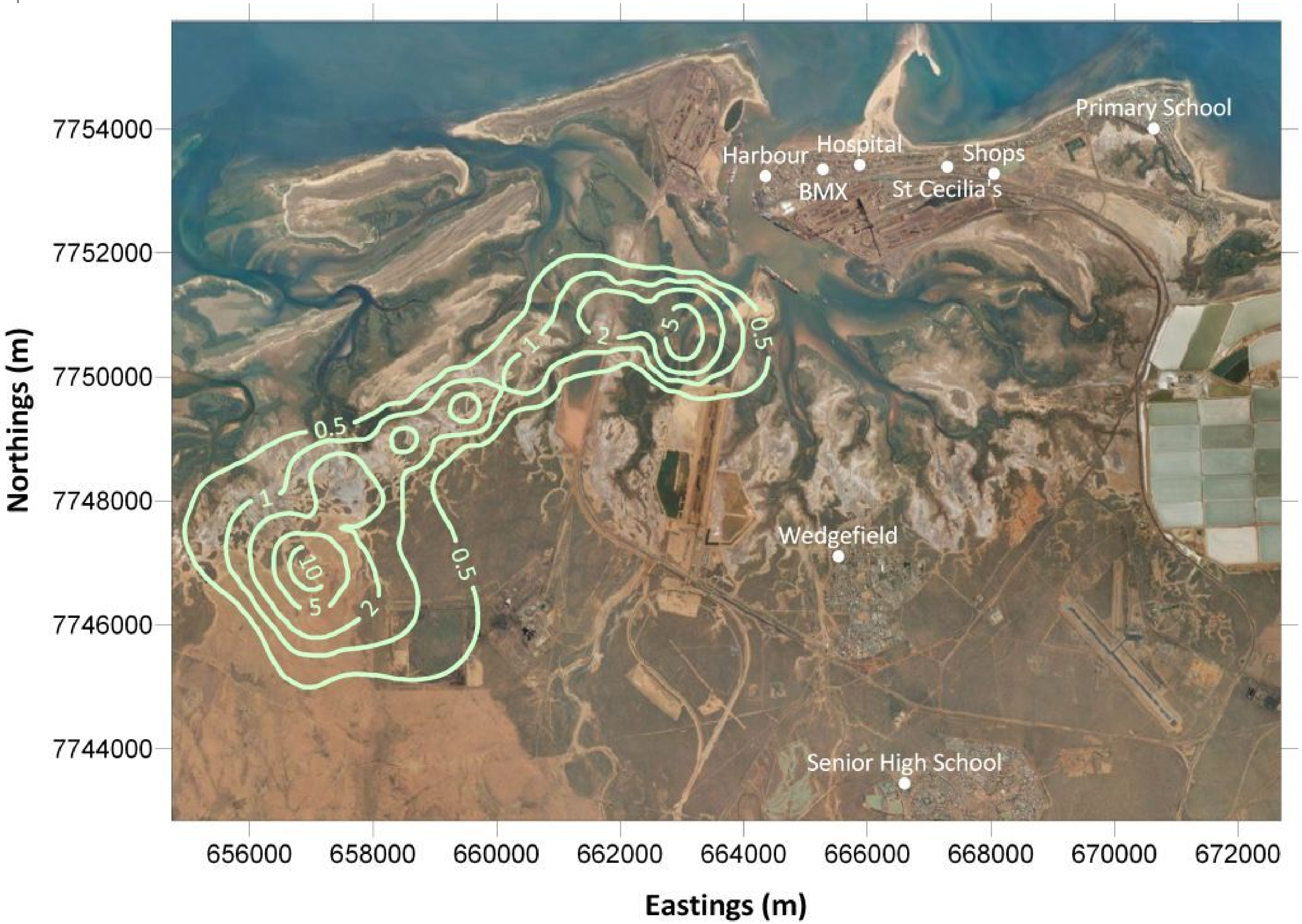
6.2.3. Dust Deposition

The maximum predicted monthly deposition from the proposed NWI Facility in isolation is presented in **Table 6.6**. The deposition impact is shown to be low compared to criteria with the largest impact occurring at Wedgefield (4.5 % of criteria limit).

- **Table 6.7 Monthly deposition statistics for NWI (in isolation)**

Receptor	Maximum (g/m^2/month)	Months with deposition greater than 2 g/m^2 criteria limit
Harbour	0.05	0
BMX	0.04	0
Hospital	0.03	0
St Cecilia's	0.02	0
Shops	0.02	0
Primary School	0.01	0
High School	0.06	0
Wedgefield	0.09	0

A contour plot of the maximum predicted monthly deposition from the proposed NWI Facility is presented in **Figure 6.8**. This figure shows the impact of dust deposition is strictly limited to the proximity of operations, and not expected to have a significant impact on sensitive receptors in the area.



- **Figure 6.8 Maximum predicted NWI (in isolation) monthly dust deposition (g/m^2/month)**

6.3. Future Conditions (no NWI)

With multiple expansion projects being developed in the Port Hedland region, a model run was required to provide perspective and scope on the conditions that the NWI Facility will be operating in conjunction with. This model run includes:

- BHP Billiton Iron Ore RGP6 at 240 Mtpa
- PHPA Utah Point and Nelson Point at a total of 17 Mtpa
- FMG at 120 Mtpa
- Roy Hill operations at 55 Mtpa
- Background concentration from the validated model scenario (**Section 3.2**)

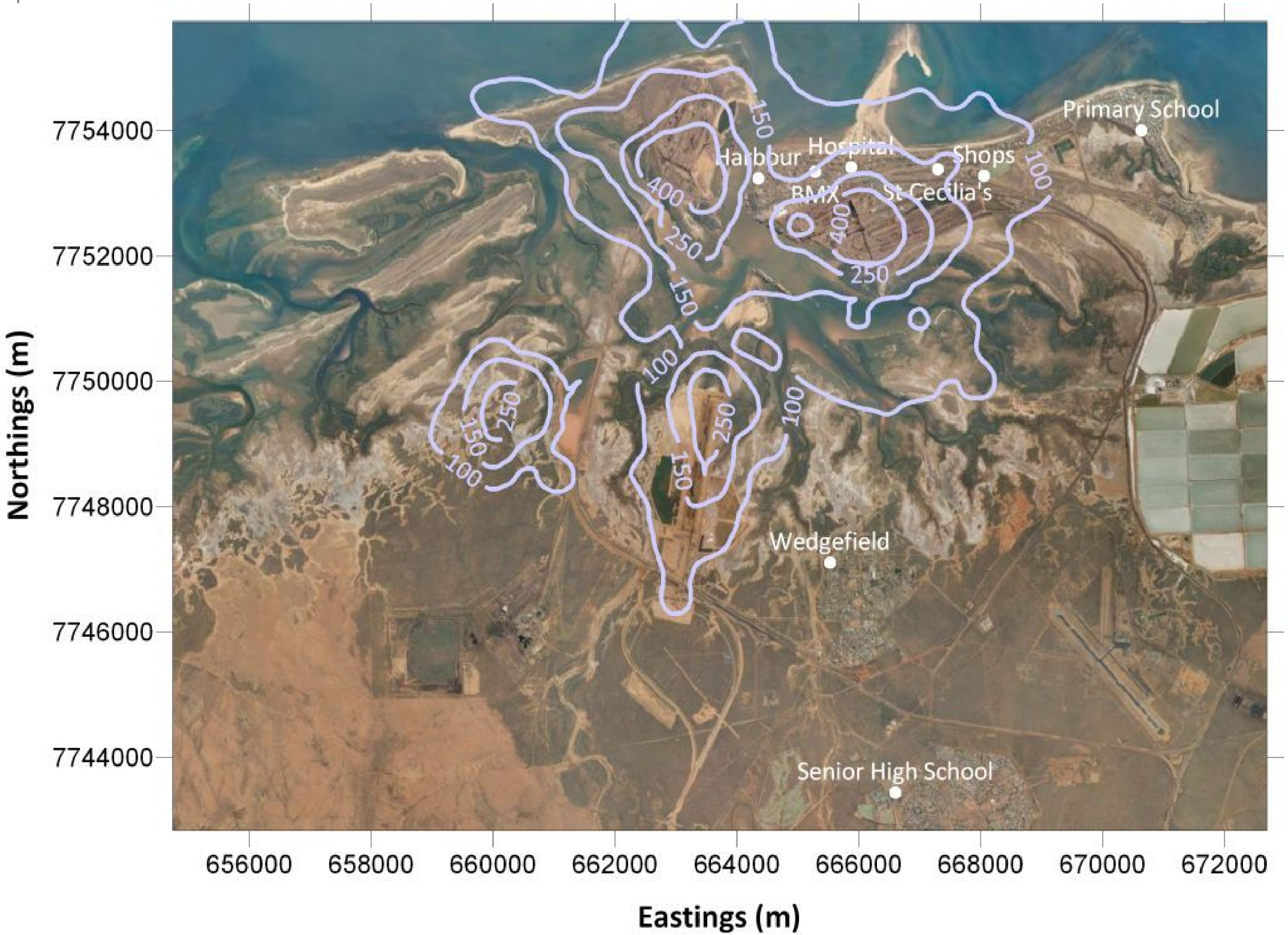
6.3.1. PM_{10} Concentrations

The statistics from the 24-hour PM_{10} modelling for the future case (RGP6, FMG, PHPA, and Roy Hill) are presented in **Table 6.8**. When the results in this table are compared to the results for the validation study (**Table 6.1**) it can be seen that the model predicts that there will be an increase in the maximum concentrations at all receptors except the Hospital receptor. At the Hospital receptor it is shown that the number of days predicted to have high concentrations is below levels predicted in the validation study (represented in the percentile statistics). This decrease is likely due to the removal of crushing and screening emissions in RGP6 emission estimates. The PM_{10} criterion (**Section 2.1.2**) is predicted to be exceeded at most modelled receptors, with a sizeable contribution attributed to naturally occurring dust concentrations which approach 70 µg/m^3 (**Section 3.2**).

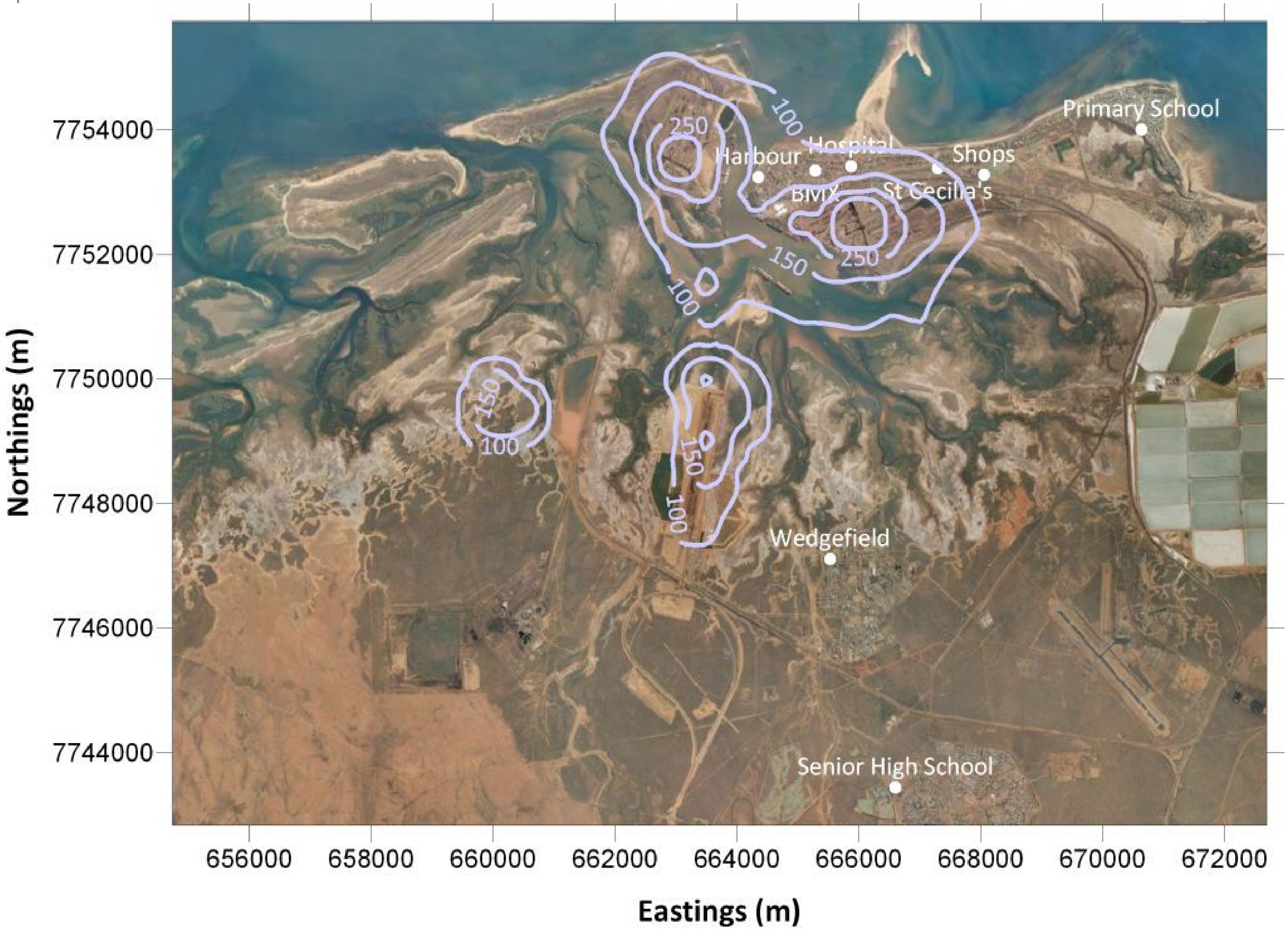
- **Table 6.8 24-hour PM_{10} statistics for RGP6, FMG, PHPA and Roy Hill (µg/m^3)**

Receptor	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Average	No. days exceeding criteria limit
Harbour	163	140	102	86	67	60	96
BMX	146	115	90	77	57	51	50
Hospital	153	135	86	76	54	47	54
St Cecilia's	184	101	68	62	42	37	17
Shops	109	84	66	56	37	32	14
Primary School	75	61	49	43	29	25	2
High School	71	64	42	36	25	23	9
Wedgefield	83	72	51	43	31	28	20
Taplin St	162	111	71	62	44	38	19

The maximum and 99th percentile contour plots of the predicted future PM_{10} ground level concentrations are presented in **Figure 6.9** and **Figure 6.10**. The predicted impacts of operations are focused around operations at Nelson Point, Finucane Island, and Anderson Point.



▪ **Figure 6.9 Maximum predicted 24-hour PM_{10} ground level concentrations for RGP6, FMG, PHPA and Roy Hill ($\mu g/m^3$)**



▪ **Figure 6.10 99th percentile predicted 24-hour PM_{10} ground level concentrations for RGP6, FMG, PHPA and Roy Hill ($\mu g/m^3$)**

6.3.2. TSP Concentrations

The statistics from the 24-hour TSP modelling for the future case (RGP6, FMG, PHPA, and Roy Hill) are presented in **Table 6.9**. When the results in this table are compared to the results for the 2004/2005 validation study (**Table 6.2**) it can be seen that the model predicts a reduction in the maximum ground level concentration at the Harbour and Hospital receptors while both Wedgefield and the two School receptors are predicted to have an increase in maximum ground level concentrations. The average TSP concentration for the year at modelled receptors is similar or higher at all locations when compared to the 2004/2005 scenario.

- **Table 6.9 24-hour TSP statistics for the RGP6, FMG, PHPA and Roy Hill ($\mu g/m^3$)**

Receptor	Maximum	99^{th} Percentile	95^{th} Percentile	90^{th} Percentile	70^{th} Percentile	Average
Harbour	243	191	162	144	113	100
BMX	203	165	132	116	90	80
Hospital	205	180	135	115	86	74
St Cecilia's	213	144	101	89	65	56
Shops	153	116	93	81	57	50
Primary School	151	84	69	63	44	39
High School	151	84	64	53	39	37
Wedgefield	151	99	79	68	51	45

A contour plot of the predicted future (RGP6, FMG, PHPA, and Roy Hill) maximum and 99^{th} percentile TSP ground level concentrations are presented in **Figure 6.11** and **Figure 6.12**. The predicted impact is similar to the PM_{10} contours for this scenario, with impacts centred on Nelson Point, Finucane Island and FMG operations.

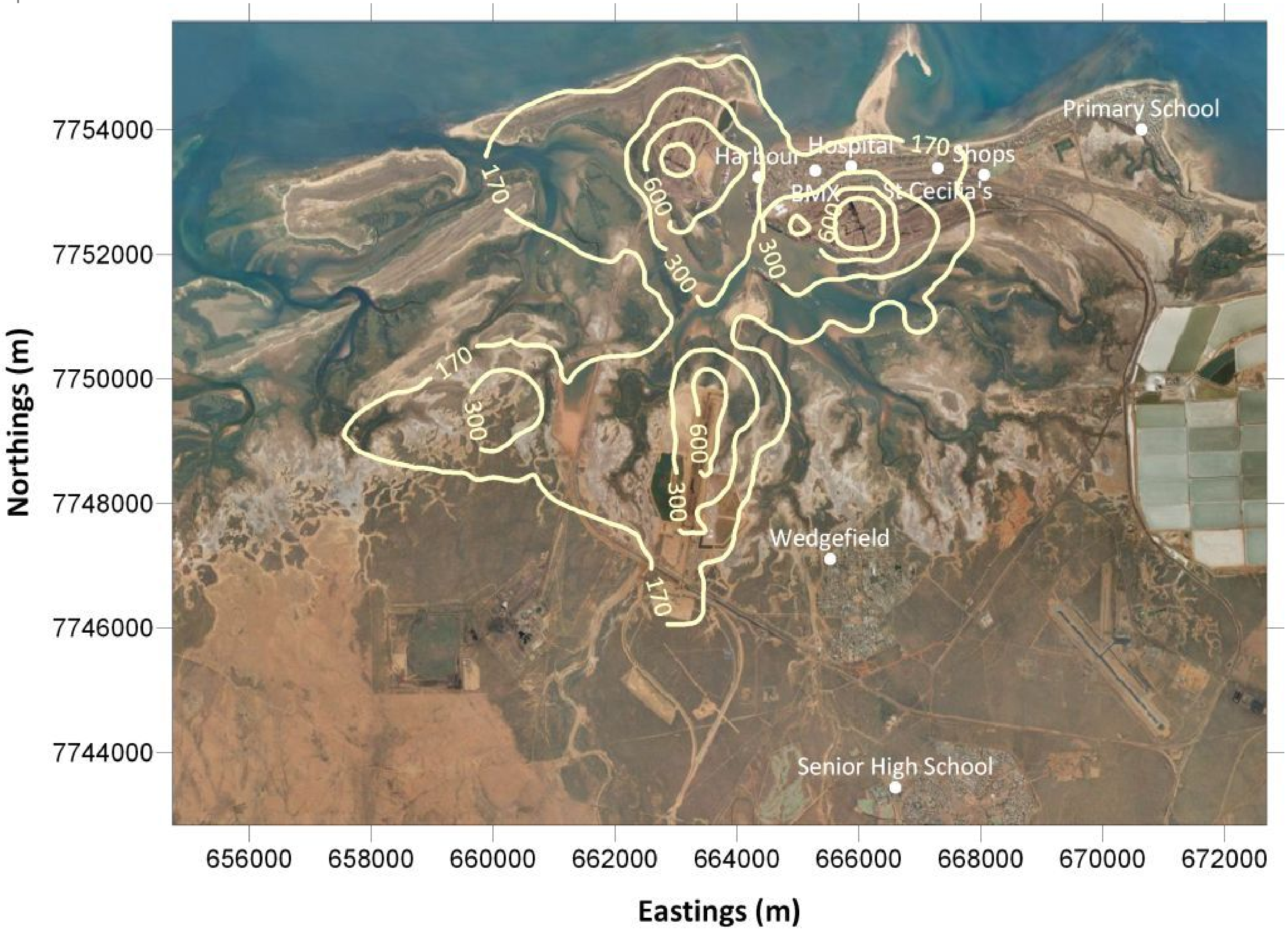
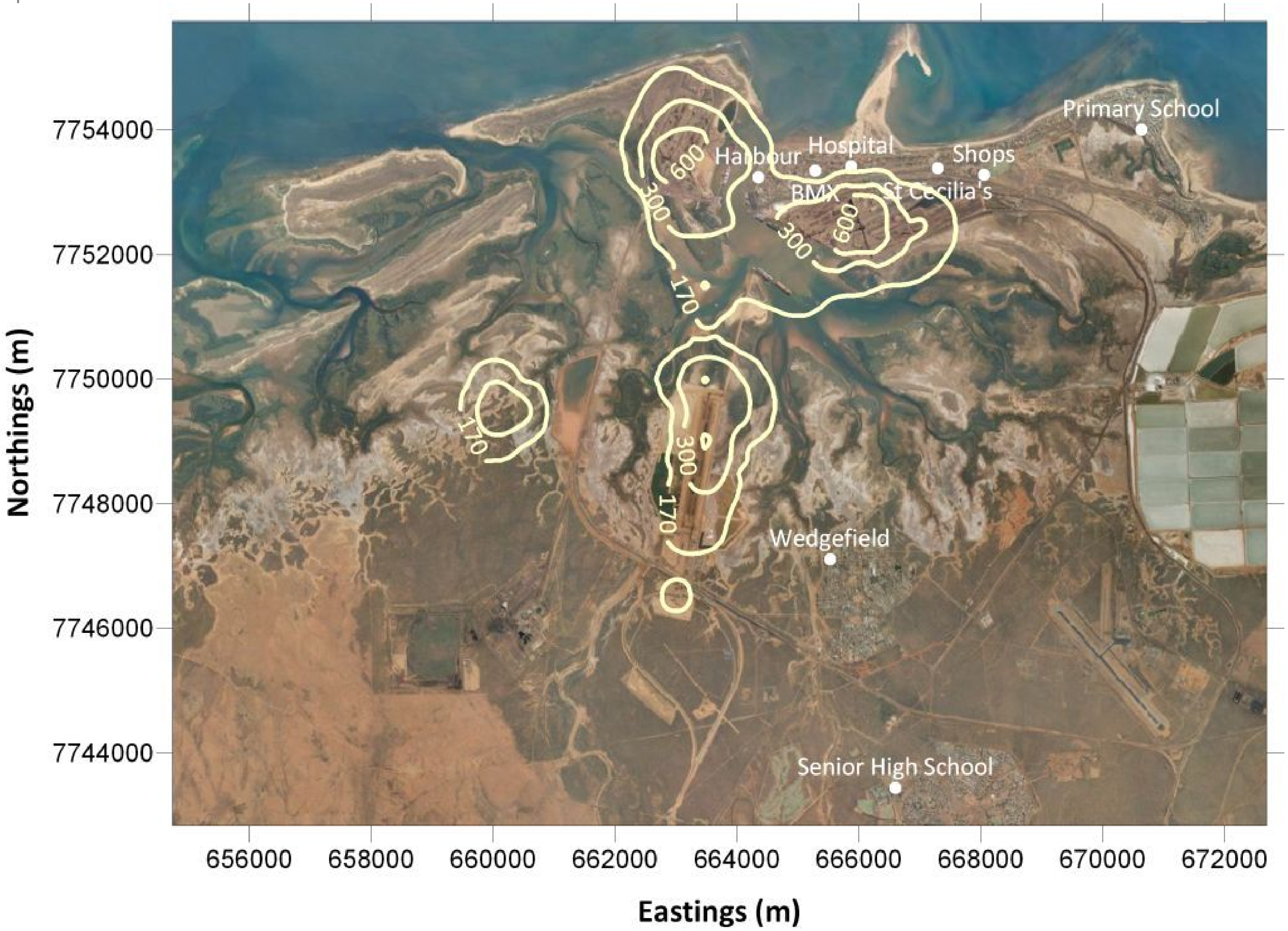


Figure 6.11 Maximum predicted 24-hour TSP ground level concentrations for RGP6, FMG, PHPA and Roy Hill (µg/m^3)



- **Figure 6.12 99th percentile predicted 24-hour TSP ground level concentrations for RGP6, FMG, PHPA and Roy Hill (µg/m³)**

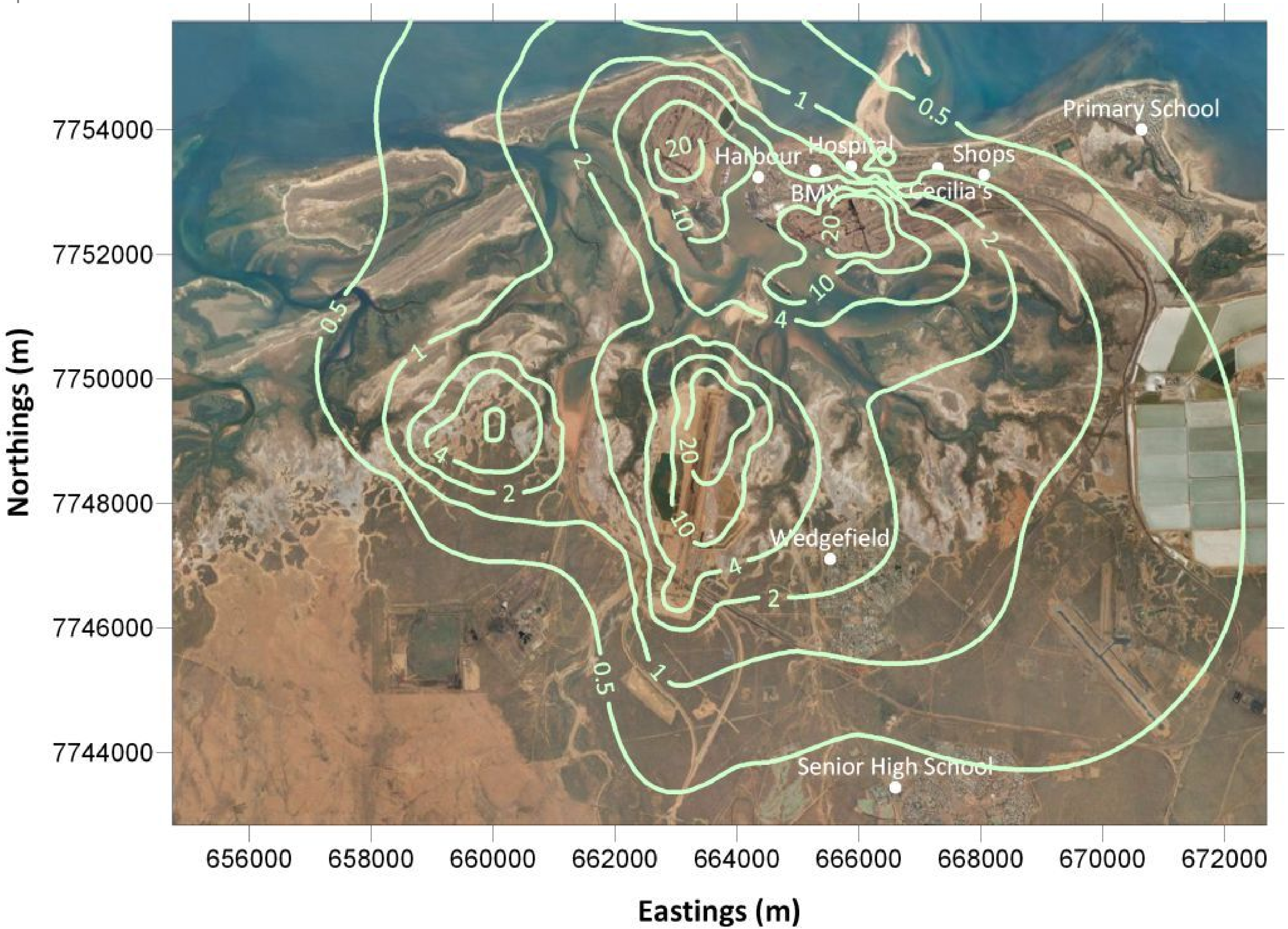
6.3.3. Dust Deposition

The statistics from the monthly deposition modelling for the future case (RGP6, FMG, PHPA, and Roy Hill) are presented in **Table 6.10**. It can be seen that the model predicts the maximum deposition at the Harbour receptor, with the BMX, Hospital and Wedgefield receptors also having high deposition predicted. These four receptors exceed the deposition criteria for this assessment, the Harbour receptor showing all twelve months of the year exceeding criteria.

- **Table 6.10 Monthly deposition statistics for RGP6, FMG, PHPA and Roy Hill**

Receptor	Maximum (g/m^2/month)	Months with deposition greater than 2 g/m^2 criteria limit
Harbour	6.74	12
BMX	3.62	8
Hospital	2.20	2
St Cecilia's	0.97	0
Shops	0.87	0
Primary School	0.32	0
High School	0.36	0
Wedgefield	2.63	1

A contour plot of the predicted future (RGP6, FMG, PHPA, and Roy Hill) maximum dust deposition is presented in **Figure 6.13**. This reflects the PM_{10} and TSP model results with deposition impacts centred on Nelson Point, Anderson Point and Finucane Island operations.



- **Figure 6.13 Maximum predicted monthly dust deposition for RGP6, FMG, PHPA and Roy Hill (g/m^2/month)**

6.4. NWI and Future Conditions

The following section presents the cumulative impact from NWI, RGP6, PHPA, FMG, and Roy Hill operations. Background concentrations from the validated model scenario are included.

6.4.1. PM_{10} Concentrations

The predicted 24-hour PM_{10} statistics from the cumulative modelling assessment are presented in **Table 6.11**. When the statistics in this table are compared to the results in **Table 6.8** the proposed NWI Facility is predicted to result in a marginal increases at all modelled receptors. A notable increase in the predicted maximum at St Cecilia's is observed, though this increase is shown to be an isolated extreme event when comparing the percentile and average statistics, which demonstrate little change to predicted concentrations with the introduction of the NWI Facility. The receptors closer to the proposed NWI stockyards (High School and Wedgefield) show little to no increase in maximum predicted concentrations, though Wedgefield does experience a higher number of days with PM_{10} greater than 50 $\mu g/m^3$.

▪ **Table 6.11 24-hour PM_{10} statistics for NWI, RGP6, FMG, PHPA, and Roy Hill ($\mu g/m^3$)**

Receptor	Maximum	99^{th} Percentile	95^{th} Percentile	90^{th} Percentile	70^{th} Percentile	Average	No. days exceeding criteria limit
Harbour	170	141	103	87	68	62	101
BMX	147	117	92	79	58	52	53
Hospital	153	139	89	77	55	48	60
St Cecilia's	199	103	69	64	43	37	18
Shops	120	87	68	57	37	33	16
Primary School	78	62	50	44	29	26	2
High School	71	64	42	36	26	23	9
Wedgefield	84	72	53	44	33	29	25
Taplin St	176	113	73	63	44	38	23

A contour plot of the predicted future maximum and 99^{th} percentile PM_{10} ground level concentrations (NWI, RGP6, PHPA, FMG, and Roy Hill) are presented in **Figure 6.14** and **Figure 6.15**. The impact of NWI can be seen at their stockyards, west of the main area of dust impact. A comparison between these two figures and those presented in **Figure 6.9** and **Figure 6.10** show the inclusion of the proposed NWI Facility predicts only a marginal increase in the impact over the town of Port Hedland. The 99^{th} percentile plots also show little difference between scenarios, with the only difference of note being the influence of the NWI stockyards and Southwest Creek shiploading operations.

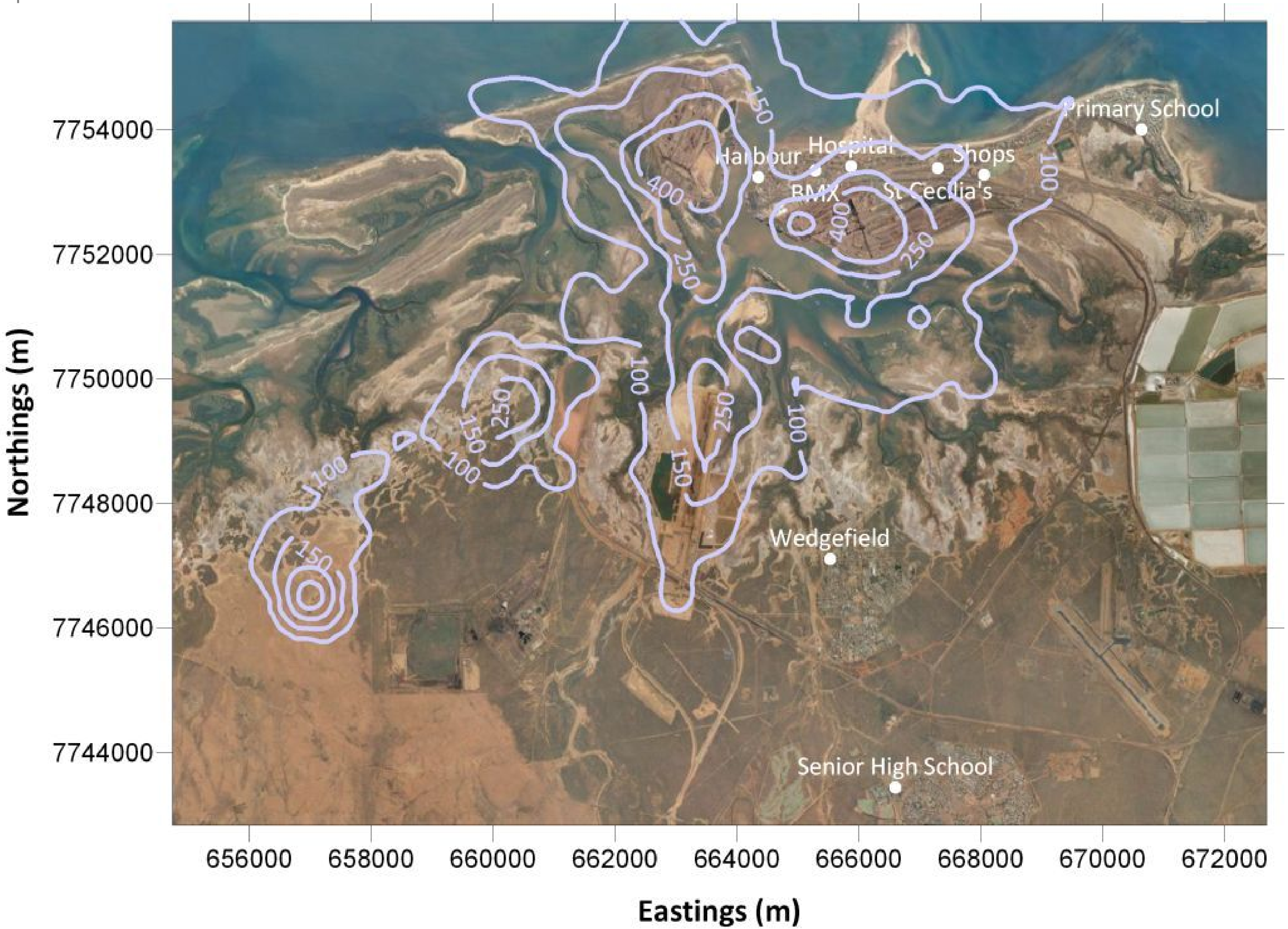
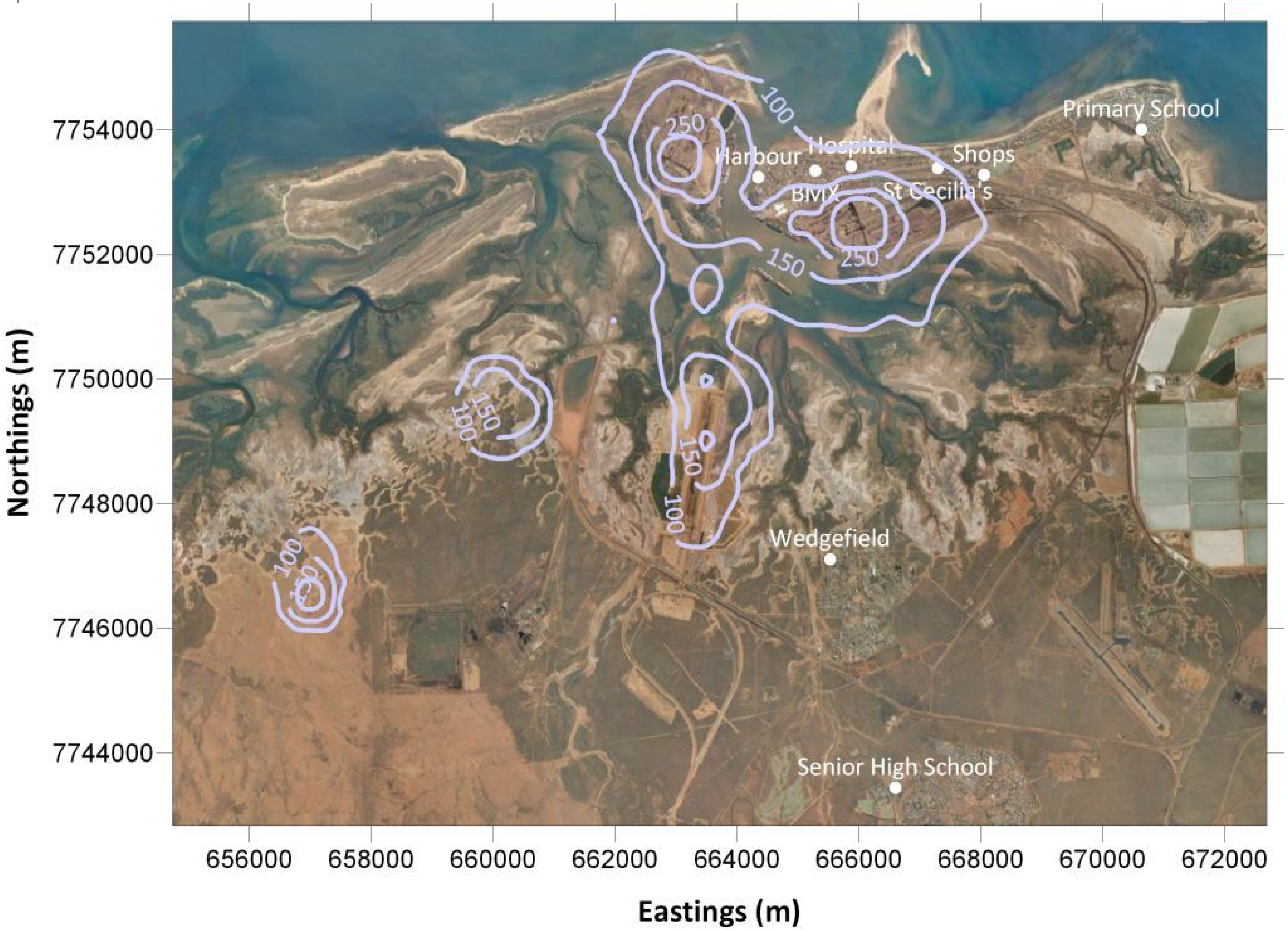


Figure 6.14 Maximum predicted 24-hour PM_{10} ground level concentrations for NWI, RGP6, FMG, PHPA, and Roy Hill ($\mu g/m^3$)



- **Figure 6.15 99th percentile predicted 24-hour PM_{10} ground level concentrations for NWI, RGP6, FMG, PHPA, and Roy Hill (µg/m^3)**

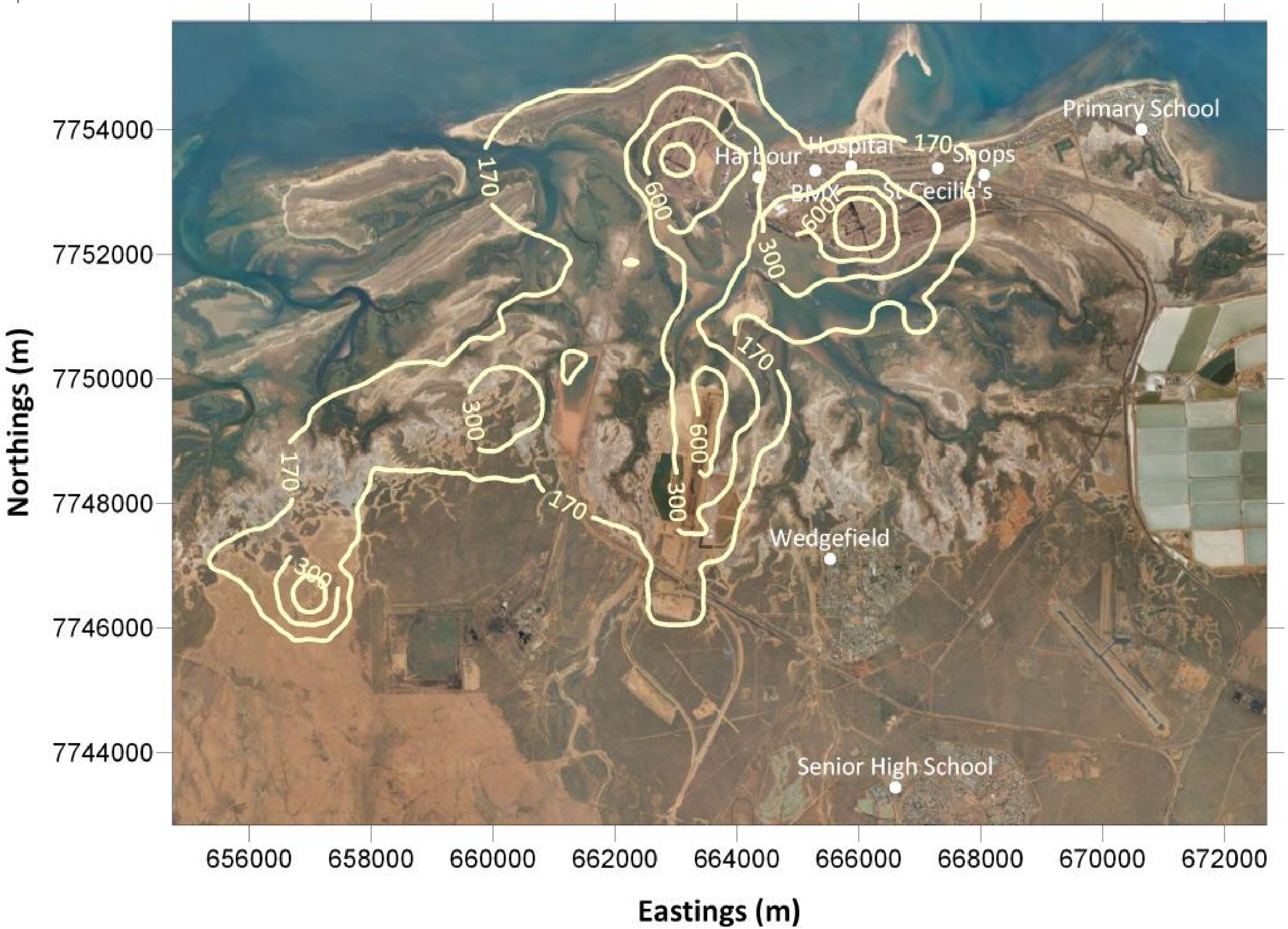
6.4.2. TSP Concentrations

The predicted 24-hour TSP statistics from the cumulative modelling assessment are presented in **Table 6.12**. As with the PM_{10} statistics, when the statistics in this table are compared to the results in **Table 6.9** it is apparent that the introduction of the proposed NWI Facility is predicted to have a negligible impact across the region. Only the St Cecilia receptor shows a notable increase to the predicted maximum with the introduction of the NWI Facility, though the percentile and average statistics show this to be an isolated extreme event, and unlikely to be representative of dust concentrations occurring in the future.

- **Table 6.12 24-hour TSP statistics for NWI, RGP6, FMG, PHPA, and Roy Hill (μg/m^3)**

Receptor	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Average
Harbour	245	193	164	148	114	102
BMX	204	167	134	118	93	82
Hospital	208	187	136	117	88	75
St Cecilia's	226	148	104	91	66	57
Shops	153	118	96	83	58	50
Primary School	151	84	70	64	45	40
High School	151	84	65	54	40	37
Wedgefield	151	102	80	70	53	46

A contour plot of the predicted future maximum and 99th percentile TSP ground level concentrations (NWI, RGP6, PHPA, FMG and Roy Hill) are presented in **Figure 6.16** and **Figure 6.17**. When the contours presented in this figure are compared to those predicted for the future scenario without NWI (see **Figure 6.11**) it is evident that the inclusion of the proposed NWI Facility results in little discernable change to the predicted ground level concentrations across the town of Port Hedland with the only difference of note being the influence of the NWI stockyards and Southwest Creek shiploading operations.



- **Figure 6.16 Maximum predicted 24-hour TSP ground level concentrations for NWI, RGP6, FMG, PHPA, and Roy Hill (µg/m³)**

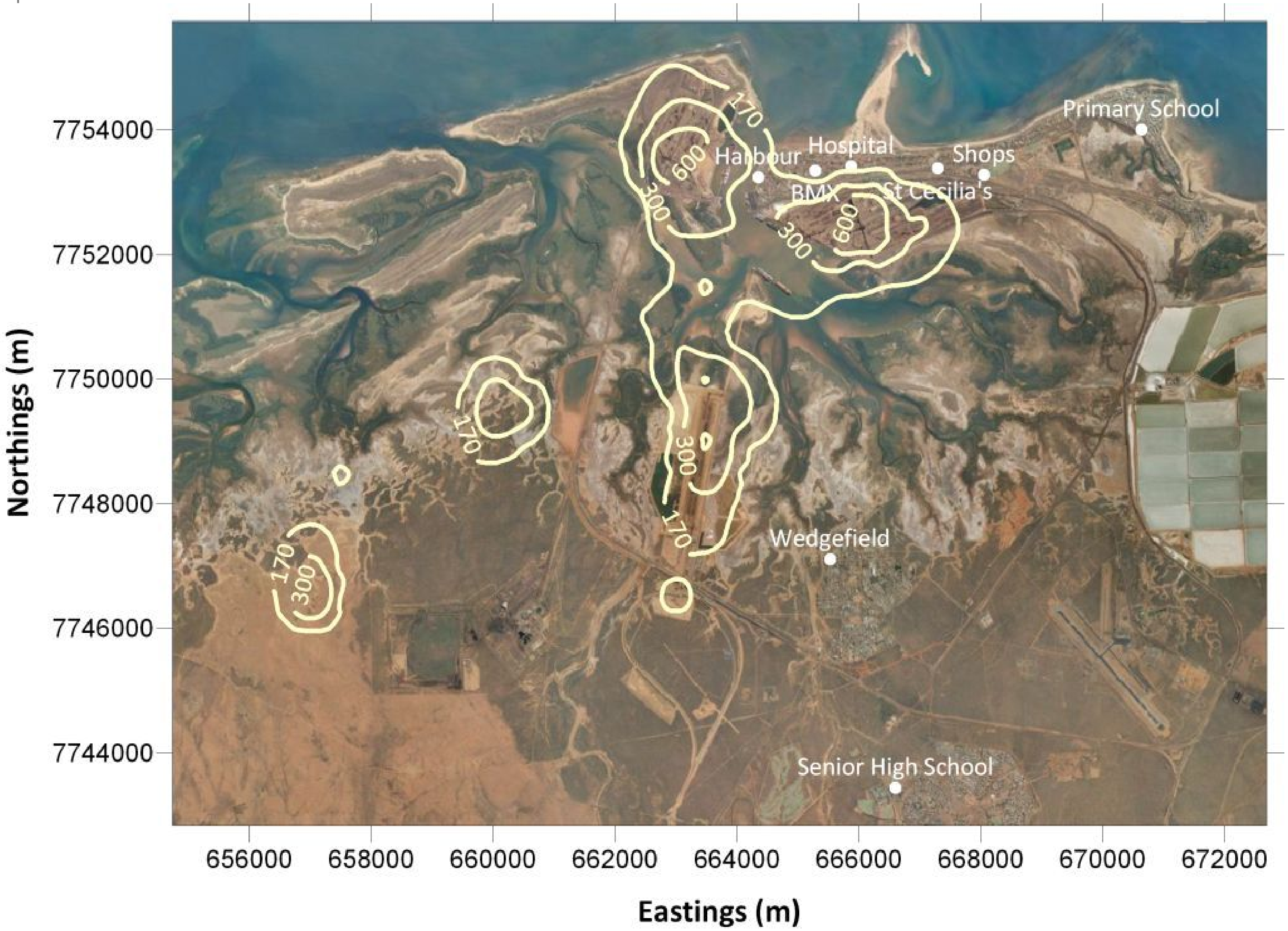


Figure 6.17 99th percentile predicted 24-hour TSP ground level concentrations for NWI, RGP6, FMG, PHPA, and Roy Hill (µg/m^3)

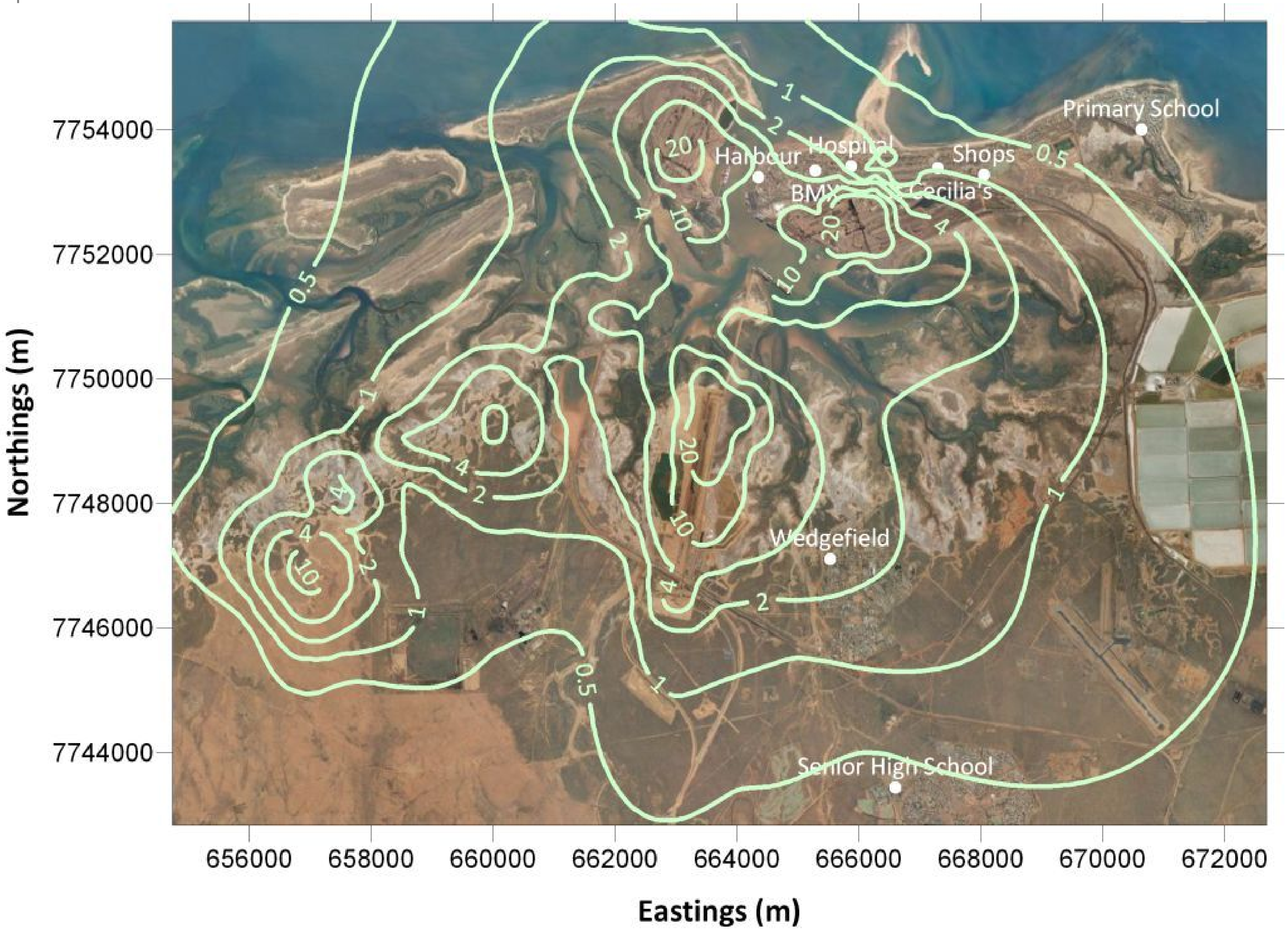
6.4.3. Dust Deposition

The predicted monthly deposition statistics from the cumulative modelling assessment are presented in **Table 6.13**. When the statistics in this table are compared to the results in **Table 6.10** it is apparent that the introduction of the proposed NWI Facility is predicted to have a marginal deposition impact upon most of Port Hedland receptors, with no expected increase to the number of months exceeding criteria limits.

Table 6.13 Monthly deposition statistics for NWI, RGP6, FMG, PHPA and Roy Hill

Receptor	Maximum (g/m^2/month)	Months with deposition greater than 2 g/m^2 criteria limit
Harbour	6.76	12
BMX	3.65	8
Hospital	2.23	2
St Cecilia's	1.00	0
Shops	0.89	0
Primary School	0.33	0
High School	0.40	0
Wedgefield	2.72	1

A contour plot of the predicted future maximum deposition (NWI, RGP6, PHPA, FMG and Roy Hill) is presented in **Figure 6.18**. When the contours presented in this figure are compared to those predicted for the future scenario without NWI (see **Figure 6.13**) it is evident that the inclusion of the proposed NWI Facility results in little change to the predicted deposition across the town of Port Hedland, with the only difference of note being the influence of the NWI stockyards and Southwest Creek shiploading operations.



- **Figure 6.18 Maximum predicted monthly dust deposition for NWI, RGP6, FMG, PHPA, and Roy Hill (g/m^2/month)**

6.5. NWI and Future Conditions (including Outer Harbour Development)

The following section presents the cumulative impact from NWI, RGP6, Outer Harbour, PHPA, FMG, and Roy Hill operations. Background concentrations from the validated model scenario are included.

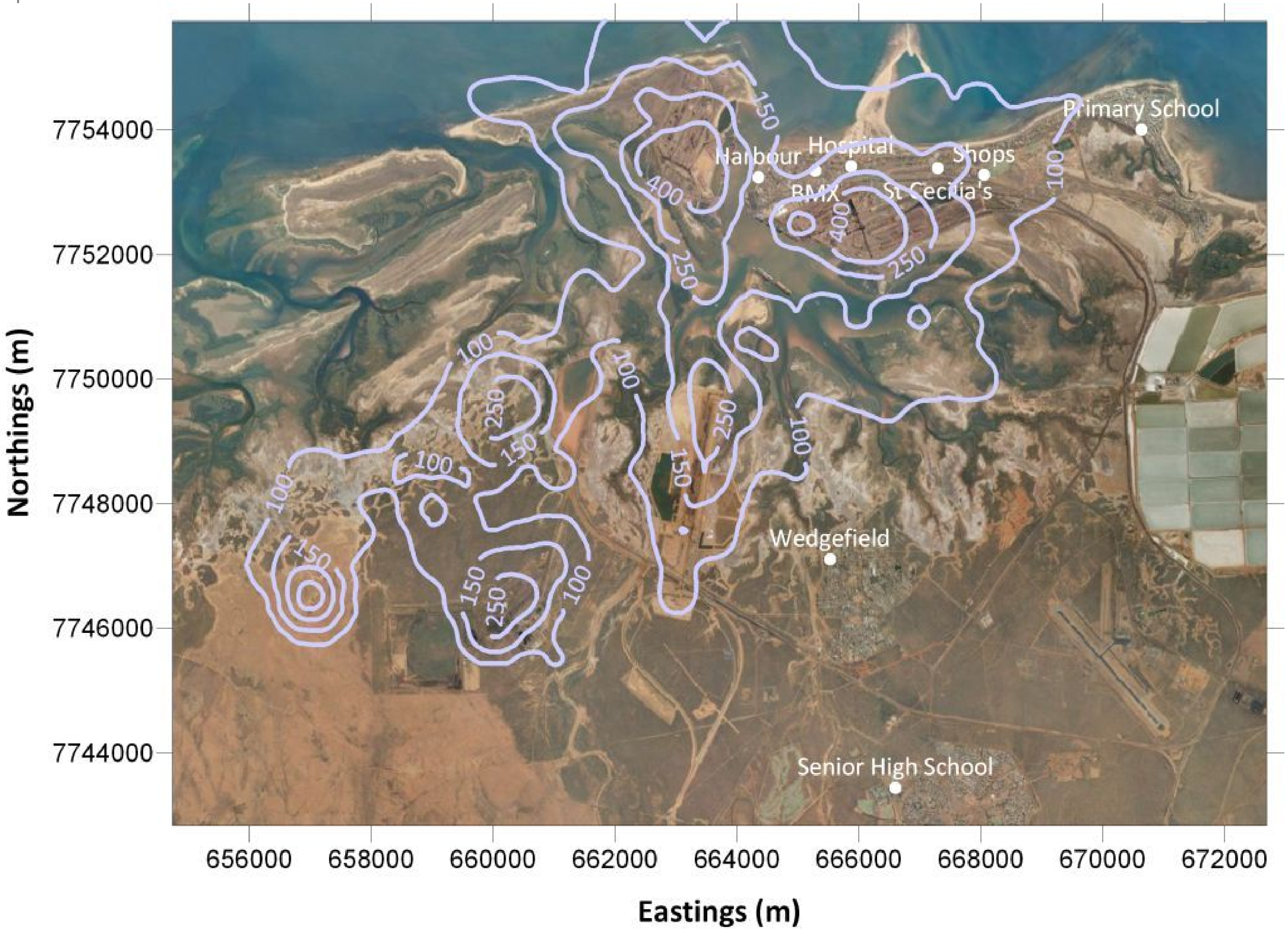
6.5.1. PM_{10} Concentrations

The predicted 24-hour PM_{10} statistics from the cumulative modelling assessment are presented in **Table 6.14**. When the statistics in this table are compared to the results in **Table 6.11** the proposed Outer Harbour Development is predicted to result in a marginal increases at all modelled receptors. The receptors closer to the proposed NWI and Outer Harbour stockyards (High School and Wedgefield) show little to no increase in maximum predicted concentrations (when compared to the scenario with no NWI development). Both receptors experience a higher number of days with PM_{10} greater than 50 µg/m^3, with the High School increasing by one and Wedgefield by six.

- **Table 6.14 24-hour PM_{10} statistics for NWI, RGP6, Outer Harbour, FMG, PHPA, and Roy Hill (µg/m^3)**

Receptor	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Average	No. days exceeding criteria limit
Harbour	172	143	103	88	70	63	110
BMX	147	118	94	81	59	53	55
Hospital	155	141	93	78	56	49	61
St Cecilia's	201	106	71	65	44	38	21
Shops	123	91	68	59	38	34	17
Primary School	79	63	52	45	29	26	2
High School	73	65	43	37	26	24	10
Wedgefield	84	75	54	47	34	30	31
Taplin St	178	117	76	64	45	39	25

A contour plot of the predicted future maximum and 99th percentile PM_{10} ground level concentrations (NWI, RGP6, Outer Harbour, PHPA, FMG, and Roy Hill) are presented in **Figure 6.19** and **Figure 6.20**. The impact of the proposed Outer Harbour Development can be seen at their stockyards, southwest of Port Hedland. A comparison between these two figures and those presented in **Figure 6.14** and **Figure 6.15** show the inclusion of the proposed Outer Harbour Development Facility predicts only a marginal increase in the impact over the town of Port Hedland. The 99th percentile plots also show little difference between scenarios, with the only difference of note being the influence of the Outer Harbour Development stockyards.



- **Figure 6.19 Maximum predicted 24-hour PM_{10} ground level concentrations for NWI, RGP6, Outer Harbour, FMG, PHPA, and Roy Hill ($\mu g/m^3$)**

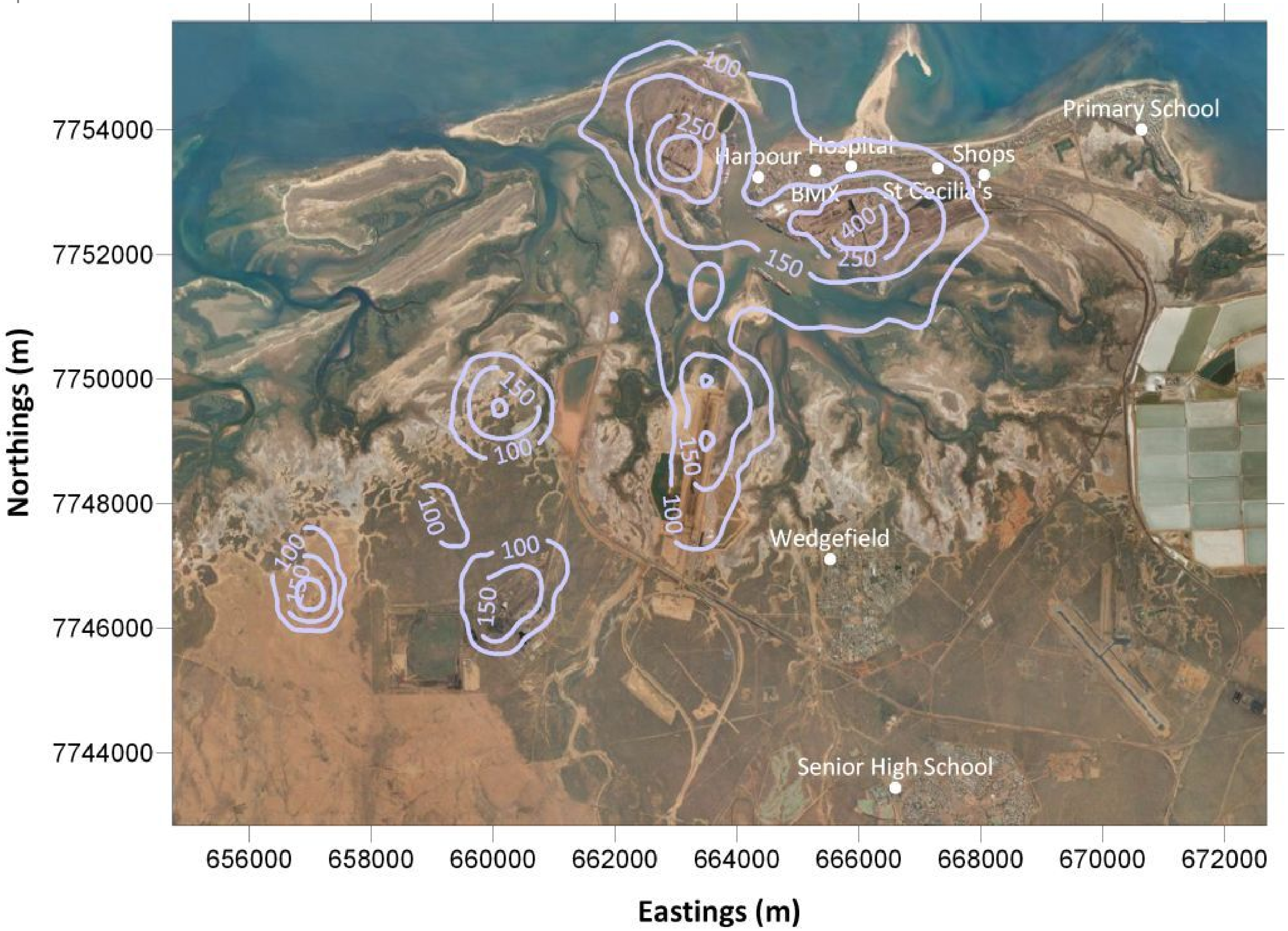


Figure 6.20 99th percentile predicted 24-hour PM_{10} ground level concentrations for NWI, RGP6, Outer Harbour, FMG, PHPA, and Roy Hill (μg/m^3)

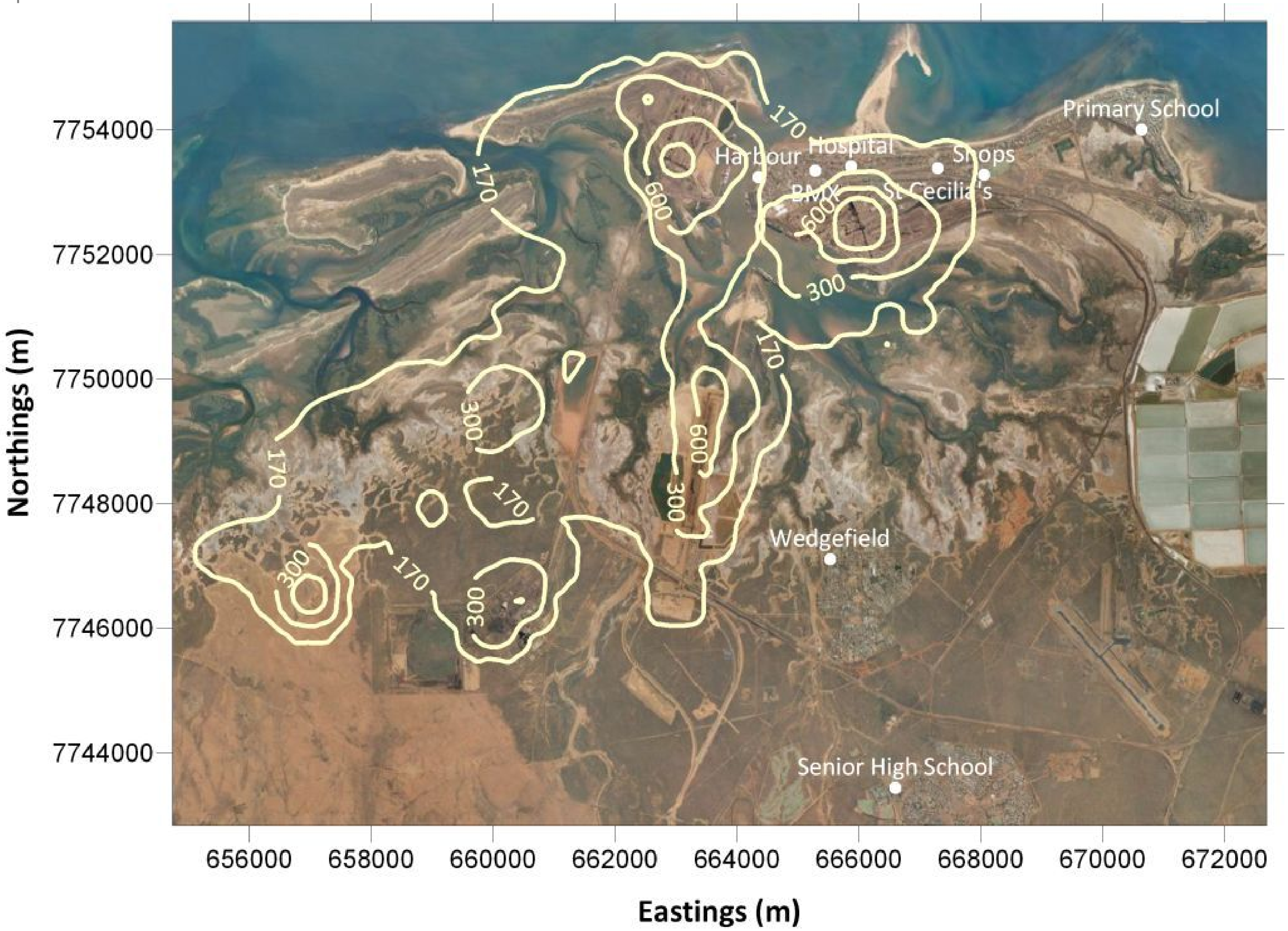
6.5.2. TSP Concentrations

The predicted 24-hour TSP statistics from the cumulative modelling assessment are presented in **Table 6.15**. As with the PM_{10} statistics, when the statistics in this table are compared to the results in **Table 6.12** it is predicted the proposed Outer Harbour Development will result in a negligible increase in TSP concentrations across the region.

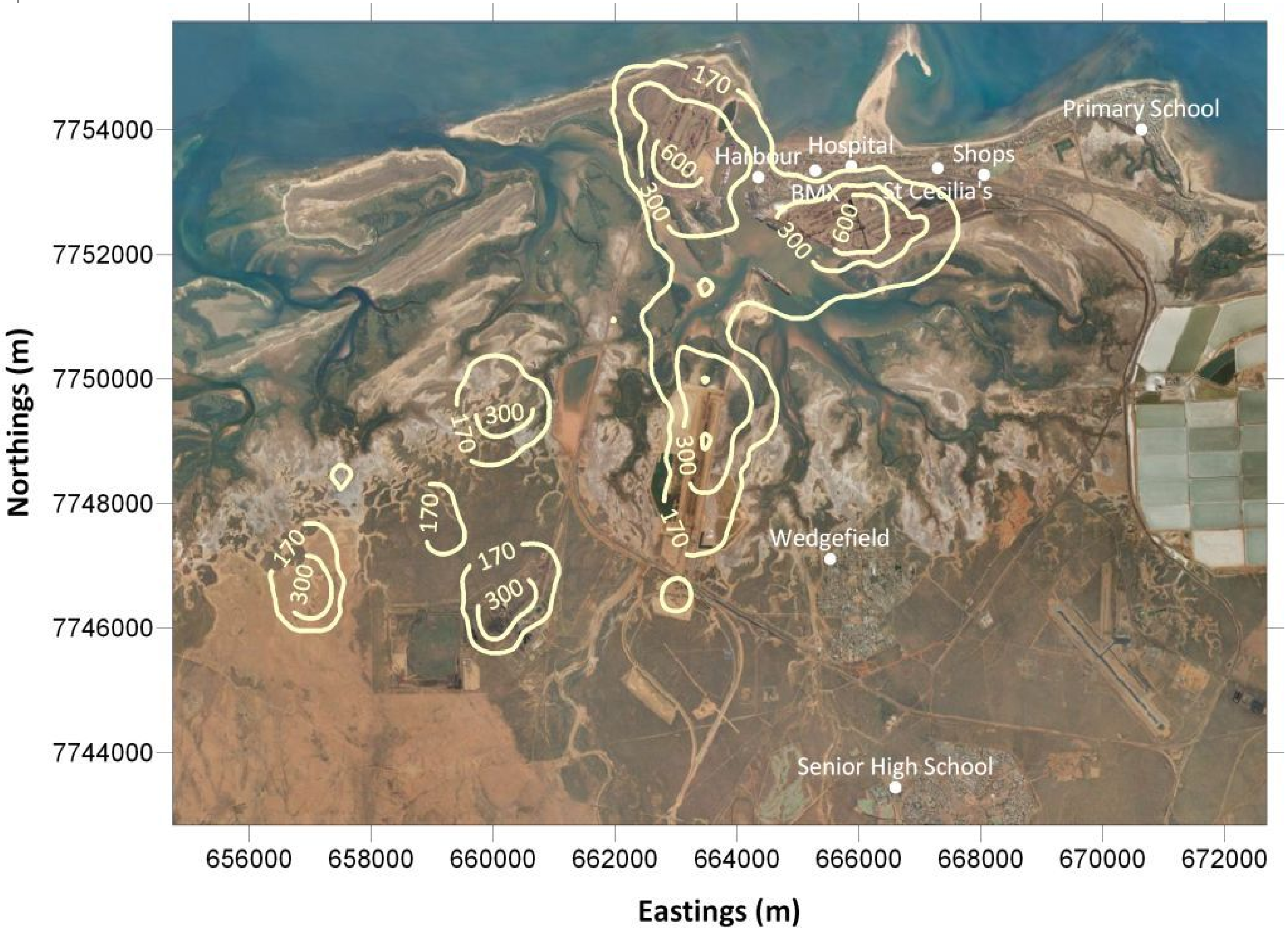
- **Table 6.15 24-hour TSP statistics for NWI, RGP6, Outer Harbour, FMG, PHPA, and Roy Hill (μg/m^3)**

Receptor	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Average
Harbour	249	197	167	150	116	104
BMX	205	167	136	120	94	83
Hospital	210	191	137	119	89	76
St Cecilia's	229	149	106	92	67	57
Shops	153	120	97	84	59	51
Primary School	151	85	71	65	45	41
High School	151	84	66	56	41	38
Wedgefield	152	107	82	73	55	48

A contour plot of the predicted future maximum and 99th percentile TSP ground level concentrations (NWI, RGP6, Outer Harbour, PHPA, FMG and Roy Hill) are presented in **Figure 6.21** and **Figure 6.22**. When the contours presented in this figure are compared to those predicted in Scenario 4 (see **Figure 6.16** and **Figure 6.17**) it is evident that the inclusion of the proposed Outer Harbour Development results in little discernable change to the predicted ground level concentrations across the town of Port Hedland with the only difference of note being the influence of the Outer Harbour Development stockyards.



■ **Figure 6.21 Maximum predicted 24-hour TSP ground level concentrations for NWI, RGP6, Outer Harbour, FMG, PHPA, and Roy Hill (μg/m^3)**



- **Figure 6.22 99th percentile predicted 24-hour TSP ground level concentrations for NWI, RGP6, Outer Harbour, FMG, PHPA, and Roy Hill (µg/m^3)**

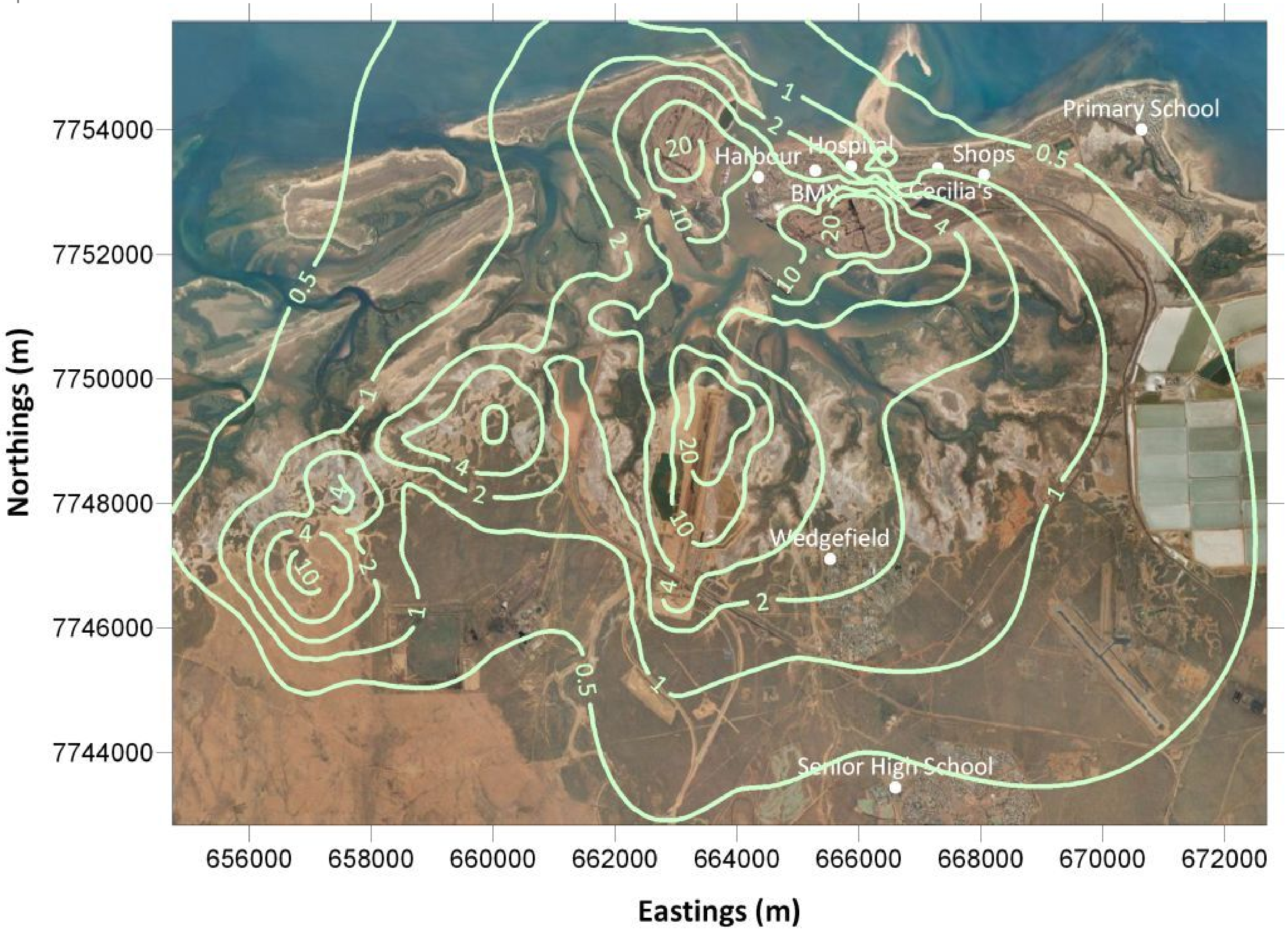
6.5.3. Dust Deposition

The predicted monthly deposition statistics from the cumulative modelling assessment are presented in **Table 6.16**. When the statistics in this table are compared to the results in **Table 6.13** it is apparent that the introduction of the proposed Outer Harbour Development is predicted to have a marginal deposition impact upon most of Port Hedland receptors. Two more monthly exceedences are predicted at the BMX receptor and one more at Wedgefield.

Table 6.16 Monthly deposition statistics for NWI, RGP6, Outer Harbour, FMG, PHPA and Roy Hill

Receptor	Maximum ($g/m^2/month$)	Months with deposition greater than 2 g/m^2 criteria limit
Harbour	6.88	12
BMX	3.68	10
Hospital	2.25	2
St Cecilia's	1.03	0
Shops	0.93	0
Primary School	0.36	0
High School	0.48	0
Wedgefield	2.81	2

A contour plot of the predicted future maximum deposition (NWI, RGP6, Outer Harbour, PHPA, FMG and Roy Hill) is presented in **Figure 6.23**. When the contours presented in this figure are compared to those predicted for the future scenario without NWI (see **Figure 6.18**) it is evident that the inclusion of the proposed Outer Harbour Development results in little change to the predicted deposition across the town of Port Hedland, with the only difference of note being the influence of the Outer Harbour Development stockyards.



■ **Figure 6.23 Maximum predicted monthly dust deposition for NWI, RGP6, Outer Harbour, FMG, PHPA, and Roy Hill (g/m^2/month)**

7. Greenhouse Gas and Climate Change

7.1. Greenhouse Gases

GHGs are found naturally in the atmosphere. They absorb solar radiation, either directly or indirectly through reflection and re-emission from the earth's surface and clouds, and re-emit this as infrared radiation. This re-emission property results in what is known as the 'greenhouse effect', trapping heat within the surface-troposphere system and increases the Earth's average surface temperature (Baede 2007).

The primary GHGs in the atmosphere are water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3). Human-made or anthropogenic gases such as sulfur hexafluoride (SF_6), hydroflurocarbons (HFCs) and perflurocarbons (PFCs) are increasingly recognised as playing an important role in impacts on climate (Baede 2007).

7.1.1. Impact on Climate

An increase in the concentrations of GHGs in the atmosphere leads to an increased infrared opacity of the atmosphere, and hence to radiative forcing[1] and an increase in the greenhouse effect – sometimes known as the *enhanced greenhouse effect*. The enhanced greenhouse effect, in turn, influences the state of the climate by changing its properties, which over time leads to climate change (Baede 2007). Although this process may occur naturally, any further reference to 'climate change' in this report will refer to a change in climate 'which is attributable directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability', as defined by the United Nations Framework Convention on Climate Change (UNFCCC undated). Such change is brought about through the emission of GHGs into the atmosphere by human activity.

The individual properties of GHG species have different effects on radiative forcing, depending on their global warming potential (GWP). GWP is an index measuring the radiative forcing of a unit mass of a given well-mixed GHG in today's atmosphere relative to that of CO_2. The GWP represents the combined effect of the differing times that these gases remain in the atmosphere as well as their effectiveness in absorbing outgoing thermal infrared radiation (Baede 2007). The GWPs of the GHGs pertinent to this study are summarised in **Table 7.1**. This table shows two datasets: the National Greenhouse Accounts (NGA) Factors, which are derived from the Kyoto Protocol accounting provisions (DCC 2010), and the Intergovernmental Panel on Climate Change's Fourth Assessment Report which is provided for context (Forster *et al.* 2007).

[1] 'Radiative forcing' is defined as the change in the net (downward minus upward) irradiance at the tropopause due to a change in an external driver of climate change – e.g. CO_2 concentration (Baede 2007, p. 86)

Table 7.1 Global warming potential of GHGs relative to CO_2

Gas	GWP (NGA Factors)*	GWP (IPCC Fourth Assessment Report)**		
		20-year	100-year	500-year
CO_2	1	1	1	1
CH_4	21	72	25	7.6
N_2O	310	289	298	153

* The GWPs specified by the NGA Factors reference have been used in this assessment.

** The different year values indicate the GWP based on different time integrals with respect to the substance radiative forcing capacity and time-dependant abundance.

7.1.2. Australian Context

The Australian National Greenhouse Strategy 'maintains a comprehensive approach to tackling greenhouse issues' and focuses on three main areas: improving awareness of greenhouse issues, limiting the growth of GHG emissions and developing climate change adaptation responses (AGO 1998). Essentially, the National Greenhouse Strategy provides a framework for the implementation of measures that address the three aforementioned action areas.

The Kyoto Protocol aims to address climate change by enforcing binding international GHG emission targets under the United Nations Framework Convention on Climate Change (UNFCCC). The Australian Parliament recognised the significance of climate change through ratification of the Kyoto Protocol on 12 December 2007 (Joint Standing Committee on Treaties 2008). The promulgation of the National Greenhouse and Energy Reporting (NGER) Act in 2007 made provision for a single, national system for the establishment of a GHG emissions and management reporting structure, with the first reporting period occurring between 1 July 2008 and 30 June 2009. Subsequent legislative and policy tools developed to further the aims of the National Greenhouse Strategy and NGER Act include an emission trading system and the Carbon Pollution Reduction Scheme (CPRS) (DCC 2007). A particularly pertinent publication produced by the Federal Department of Climate Change (DCC) is the National Greenhouse Gas Inventory, which allows for the benchmarking of a facility or entity's GHG emissions against national emissions (DCC 2009).

7.2. Study Boundaries

It is important to define those aspects of the NWI Facility that will be included and excluded from this assessment. As with life cycle studies, GHG assessments are able to follow the cradle-to-grave methodology of investigating the GHG emissions associated with the extraction, manufacturing, production, transportation, use, reuse, recycling and final disposal of a particular product.

The NGA Factors reference manual (DCC 2010) has been prepared by the DCC, and is designed for use by companies and individuals to estimate GHG emissions for the NGER system. The NGA Factors (last updated in July 2010) have been used to calculate GHG emissions in this assessment.

The NGA Factors recognise three types of emission factors.

Direct (or point-source) emission factors give the kilograms of carbon dioxide equivalent (CO_2e) emitted per unit of activity at the point of emission release (i.e. fuel use, energy use, manufacturing process activity, mining activity, on-site waste disposal, etc.). These factors are used to calculate scope 1 emissions.

Indirect emission factors are used to calculate scope 2 emissions from the generation of the electricity purchased and consumed by an organisation as kilograms of CO_2e per unit of electricity consumed. Scope 2 emissions are physically produced by the burning of fuels (coal, natural gas, etc.) at the power station.

Various emission factors can be used to calculate scope 3 emissions. For ease of use, the NGA Factors workbook reports specific 'scope 3 emission factors' for organisations that:

a) burn fossil fuels: to estimate their indirect emissions attributable to the extraction, production and transport of those fuels; or
b) consume purchased electricity: to estimate their indirect emissions from the extraction, production and transport of fuel burned at generation and the indirect emissions attributable to the electricity lost in delivery in the transmission and distribution (T&D) network.

The definition, methodologies and application of scope 3 factors are currently subject to international discussions (DCC 2010) and will not be considered in this assessment.

This assessment only considered the GHG emissions associated with port operation and land clearing. The following activities have been excluded from this assessment:

- Fuel and energy consumption during construction activities (due to the large variability in day to day processes) – loss of carbon sink from land clearance during construction **is** included however.
- Transport of raw materials to the proposed NWI Facility.
- Travel by personnel outside of sites.
- Transport and disposal of generated waste off-site.
- Port vessel operations e.g. diesel consumption of ships at port.

7.3. Greenhouse Gas Emissions

7.3.1. Power Consumption

The NGA Factors reference manual provides the formula presented in **Equation 7-1** to estimate greenhouse gas emissions from purchased electricity

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- **Equation 7-1 Power Consumption**

$$Y = \frac{Q \times EF}{1000}$$

Where:
Y = the emissions as CO_2e (equivalent) tonnes;
Q = the quantity of electricity purchased (kilowatt hours);
EF_{ijoxec} = the emissions factor for the electricity grid supplying the power (kg CO_2-e per kilowatt hour).

The operation of the NWI Facility is estimated to require approximately 140,371 megawatt hours (MWh) per annum to operate, as advised by NWI.

The NGA Factors provide emission factors for the consumption of purchased electricity from major state grids. As the power will not be sourced from the South West Interconnected System (SWIS), the NGA Factor allows the use of the Northern Territory emission factor of 0.68 kg CO_2e/kWH for this assessment.

Using this data **Equation 7-1** can be solved for electricity consumption:

Y = 140,371 x 0.68

*Y = **95,452** tonnes CO_2-e per annum*

7.3.2. Fuel Burn

The operation of the NWI Facility will rely on a number of vehicles and mobile combustion sources. The daily fuel consumption estimate provided by NWI is 1,297 litres. All fuel for this assessment is assumed to be diesel.

The NGA Factors reference manual (DCC 2010) provides the formula presented in **Equation 7-2** to estimate greenhouse gas emissions from vehicle and mobile source fuel combustion.

- **Equation 7-2**

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1000}$$

Where:
E_{ij} = the emissions as CO_2e (equivalent) tonnes;
Q_i = the quantity of fuel consumed (kilolitres);
EC_i = the energy content of fuel consumed (GJ/kL);
EF_{ijoxec} = the emissions factor for each gas type (j) for fuel type (i) as kg CO_2e per gigajoule.

The NGA Factors provide emission factors for the consumption of diesel. These are presented in **Table 7.2**.

- **Table 7.2 Emission factors for the consumption of combustibles**

Fuel combusted	Energy Content Factor (GJ/kL)	Emission factor (kg CO_2e/GJ)		
		CO_2	CH_4	N_2O
Diesel Oil	38.6	69.2	0.2	0.5

Using the information provided above, greenhouse gas emissions from fuel burn may be calculated:

$$E_{ij} = (1.297 \times 365) \times 38.6 \times (69.2 + 0.2 + 0.5) / 1000$$

$$E_{ij} = \mathbf{1,277} \text{ tonnes } CO_2\text{-e per annum}$$

7.3.3. Vegetation Removal (loss of carbon sink)

GHG emissions due to land clearing were calculated using the DCC FullCAM Modelling tool. FullCAM is a fully integrated carbon accounting model for estimating and predicting all biomass, litter and soil carbon pools in forest and agricultural systems.

The proposed works would result a total ground disturbed area of approximately 147.7 hectares (ha) including 144.7 ha of tussock grasslands and 3 ha mangroves. Tree and crop species and management information are contained in FullCAM databases as developed by the National Carbon Accounting System (NCAS). This database currently does not contain native species and regime information for the Port Hedland region. Therefore for the purpose of this assessment carbon masses per hectare were calculated for typical '*local species*' for Western Australia coastal regions in the project region.

An estimate of construction GHG emissions from the clearing of vegetation is provided in **Table 7.3**. It is estimated from FullCAM that a maximum of 17.8 tonnes of carbon per hectare (tC/ha) is stored within the native vegetation within the study area.

- **Table 7.3 Estimation of construction GHG emissions from the clearing of vegetation**

Source	Usage	Average tonnes carbon per ha (FullCAM)*	Emission Factor (tonnes CO_2-e per tonne of carbon cleared)**	Total emissions (tonnes CO_2-e)
Land Clearing local native species	147.7 ha	4.84	3.67	2624

* Carbon contained in soil and existing debris has not been included.

** Source: Snowdown et al (2000)

The estimate of greenhouse gas emissions from the loss of carbon sinks is based on numerous assumptions as outlined above. As such the above estimated emissions should be considered as indicative estimates only.

7.3.4. Greenhouse Gas Summary

While there are no criteria to compare GHG emissions against, it is worth noting that under the *National Greenhouse and Energy Reporting Act 2007* (the NGER act), facilities emitting 25 kilotonnes (kt) CO_2-e or more (and/or consuming 100 terajoules (TJ) or more) in a year and organizations emitting 50 kt CO_2e or more (and/or consuming 200 TJ or more) from 2010/2011 financial year onwards are required to register and report GHG emissions to the Greenhouse and Energy Data Officer (DCC 2008).

For this assessment, annual GHG emissions from power consumption and fuel burn are estimated at 96,729 tonnes of CO_2-e per annum.

The GHG estimates for the proposed NWI Facility indicates that NWI would need to register under the NGER Act and report emissions for ongoing port operations. If construction energy use and fuel burn be expected within the same or one less order of magnitude as operations then registration under the NGER act and reporting of GHG emissions during construction should also be considered.

8. Conclusion

This air quality assessment has been undertaken to determine the potential dust impacts and greenhouse gas emissions associated with the proposed operation of NWI stockyards and shiploading in Port Hedland. The air quality assessment was carried out in accordance with the Air Quality and Air Pollution Modelling Guidance Notes (DoE 2006).

The dust assessment included analysis and description of existing air quality in the region and determination of potential impacts as a result of the proposed NWI Facility. Atmospheric dispersion modelling included incorporation of existing and future developments in the Port Hedland Port area, as well as NWI in isolation, with model predictions compared to relevant assessment criteria.

8.1. Dispersion Model Validation

The model validation shows that:

- For PM_{10} the model tends to under predict the lower concentrations at both receptor locations. At the Harbour, high-end concentrations are predicted close to monitored levels. At the Hospital, the model over predicts upper concentrations. These results indicate the model will likely be conservative in the prediction of the maximum and upper percentile PM_{10} concentrations.
- For TSP the model under predicts the concentrations at the Harbour monitoring location by almost a factor of two. At the Hospital monitor the model also under predicts the concentrations though not to the same level as at the Harbour. Therefore the predicted TSP concentrations should only be used to determine the relative change in ground level concentrations between the scenarios.

8.2. Future Air Quality

Modelling of the future air quality in the Port Hedland Port area included emission sources from BHP Billiton Iron Ore’s 240 Mtpa RGP6 expansion, PHPA facilities at Nelson Point (1 Mtpa) and Utah Point (16 Mtpa), FMG exporting 120 Mtpa from Anderson Point, Roy Hill (55 Mtpa) and NWI (50 Mtpa).

Comparing the validated emissions to future prediction, the model predicts that there will be an overall increase in maximum ground level PM_{10} concentrations across the receptors selected for this assessment. The Hospital receptor is the exception to this with a lower concentration predicted when compared to the 2004/2005 model results. The St Cecilia receptor appears to experience the greatest impact in the future though a review of the 99th percentile statistics indicate that this is an extreme event, and that the Hospital and Harbour receptors will continue to experience the highest concentrations in the future. The Wedgefield and High School receptors show little increase to maximum predicted concentrations, though days greater than 50 µg/m^3 are predicted to increase by one at the High School, and by 11 at Wedgefield as a result of development of NWI and Outer Harbour Development stockyards in Boodarie.

The outcome of TSP predictions is similar to PM_{10}, with an increase in concentrations predicted at the Primary School, South Hedland and Wedgefield receptor points. The Harbour and Hospital are shown to have lower maximum concentrations when compared to the 2004/2005 model results and comparable annual average concentrations.

Despite the increase in tonnage from the validated 106 Mtpa operations to the future 482 Mtpa described in this assessment, impacts from dust emissions are only predicted to present a marginal increase in the future scenario. This decrease is primarily due to the changes that are proposed to occur at the BHP Billiton Iron Ore operations during expansions where crushing and screening operations are removed from Nelson Point.

A summary by scenario of model predictions for PM_{10}, TSP and deposition at each receptor location is presented in **Table 8.1**, **Table 8.2**, and **Table 8.3** respectively.

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Table 8.1 Summary of 24-hour PM_{10} model predictions by scenario

Receptor	2004/2005 Validation (µg/m³)	Future (no NWI) (µg/m³)	Future (with NWI) (µg/m³)	Future (with NWI and Outer Harbour) (µg/m³)
	106 Mtpa	432 Mtpa	482 Mtpa	722 Mtpa
Maximum				
Harbour Monitor	152	163	170	172
BMX	-	146	147	147
Hospital Monitor	182	153	153	155
St Cecilia's	-	184	199	201
Port Hedland Shop	-	109	120	123
Port Hedland Primary School	76	75	78	79
Hedland Senior High School	63	71	71	73
Wedgefield	63	83	84	84
Taplin St	-	162	176	178
Average				
Harbour Monitor	49	60	62	63
BMX	-	51	52	53
Hospital Monitor	44	47	48	49
St Cecilia's	-	37	37	38
Port Hedland Shop	-	32	33	34
Port Hedland Primary School	22	25	26	26
Hedland Senior High School	19	23	23	24
Wedgefield	19	28	29	30
Taplin St	-	38	38	39
No. Days/Year exceeding receptor criteria limit				
Harbour Monitor	39	96	101	110
BMX	-	50	53	55
Hospital Monitor	39	54	60	61
St Cecilia's	-	17	18	21
Port Hedland Shop	-	14	16	17
Port Hedland Primary School	1	2	2	2
Hedland Senior High School	5	9	9	10
Wedgefield	5	20	25	31
Taplin St	-	19	23	25

Table 8.2 Summary of 24-hour TSP model predictions by scenario

Receptor	2004/2005 Validation (µg/m³) – 106 Mtpa	Future (no NWI) (µg/m³) – 432 Mtpa	Future (with NWI) (µg/m³) – 482 Mtpa	Future (with NWI and Outer Harbour) (µg/m3) – 722 Mtpa
Maximum				
Harbour Monitor	283	243	245	249
BMX	-	203	204	205
Hospital Monitor	245	205	208	210
St Cecilia's	-	213	226	229
Port Hedland Shop	-	153	153	153
Port Hedland Primary School	135	151	151	151
Hedland Senior High School	135	151	151	151
Wedgefield	135	151	151	152
Average				
Harbour Monitor	84	100	102	104
BMX	-	80	82	83
Hospital Monitor	73	74	75	76
St Cecilia's	-	56	57	57
Port Hedland Shop	-	50	50	51
Port Hedland Primary School	35	39	40	41
Hedland Senior High School	31	37	37	38
Wedgefield	32	45	46	48

Table 8.3 Summary of monthly deposition model predictions by scenario

Receptor	2004/2005 Validation (g/m²/month) – 106 Mtpa	Future (no NWI) (g/m²/month) – 432 Mtpa	Future (with NWI) (g/m²/month) – 482 Mtpa	Future (with NWI and Outer Harbour) (g/m²/month) – 722 Mtpa
Maximum				
Harbour Monitor	5.29	6.74	6.76	6.88
BMX	-	3.62	3.65	3.68
Hospital Monitor	3.21	2.20	2.23	2.25
St Cecilia's	-	0.97	1.00	1.03
Port Hedland Shop	-	0.87	0.89	0.93
Port Hedland Primary School	0.22	0.32	0.33	0.36
Hedland Senior High School	0.09	0.36	0.40	0.48
Wedgefield	0.24	2.63	2.72	2.81
Months exceeding 2 g/m²/month criteria				
Harbour Monitor	12	12	12	12
BMX	-	8	8	10
Hospital Monitor	7	2	2	2
St Cecilia's	-	0	0	0
Port Hedland Shop	-	0	0	0
Port Hedland Primary School	0	0	0	0
Hedland Senior High School	0	0	0	0
Wedgefield	0	1	1	2

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8.3. Dust Impact of NWI Operations

Modelling of the proposed NWI Facility in the future scenario show emissions will not produce a significant impact over Port Hedland, with emissions mostly influencing the immediate area around stockyards and shiploading through Southwest Creek, shown in PM_{10} contour plots (**Figure 6.9** and **Figure 6.14**).

TSP and deposition plots show negligible change to the north and east of Port Hedland, with only the influence of stockyards and shiploading operations producing a notable difference between the plots.

8.4. Greenhouse Impact of NWI Operations

GHG emissions from power consumption, fuel burn and land clearing were estimated using the NGA Factors and FullCAM calculator.

Clearing of 147.7 ha of vegetation during construction is estimated using FullCAM to give rise to a GHG emission estimate of 17.8 tonnes CO_2-e. Electricity consumption and fuel burn from normal operations is expected to generate 96,729 tonnes CO_2-e per annum.

The GHG estimates for the proposed NWI Facility indicates that NWI would need to register under the NGER Act and report emissions for ongoing port operations. If construction energy use and fuel burn be expected within the same or one less order of magnitude as operations then registration under the NGER act and reporting of GHG emissions during construction should also be considered.

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Appendix A 2004-2005 Meteorological File

Stability Classes

	A	B	C	D	E	F	Total
Number	61	552	1584	2960	2189	1414	8760
Percent	0.70	6.30	18.08	33.79	24.99	16.14	

Stability Class by Wind direction

	A	B	C	D	E	F
N	0.5	7.1	23.8	46.6	11.0	11.0
NE	2.2	15.0	34.0	25.1	10.9	12.8
E	0.9	7.1	29.6	39.7	14.0	8.7
SE	1.0	6.9	20.3	29.9	30.0	11.9
S	1.3	8.6	11.9	17.9	36.7	23.6
SW	0.7	7.6	14.6	10.5	31.8	34.7
W	0.3	1.9	6.5	29.7	40.4	21.1
NW	0.3	5.2	18.1	48.3	17.5	10.7

Stabilty Class by Hour of Day

Hour	A	B	C	D	E	F
1	0	0	0	57	186	122
2	0	0	0	47	200	118
3	0	0	0	48	192	125
4	0	0	0	42	185	138
5	0	0	0	34	180	151
6	0	0	0	40	178	147
7	0	10	71	197	57	30
8	0	37	230	98	0	0
9	3	118	132	112	0	0
10	7	112	109	137	0	0
11	27	99	193	46	0	0
12	15	73	228	49	0	0
13	7	52	256	50	0	0
14	2	40	240	83	0	0
15	0	8	66	291	0	0
16	0	3	47	315	0	0
17	0	0	12	353	0	0
18	0	0	0	313	47	5
19	0	0	0	213	117	35
20	0	0	0	140	149	76
21	0	0	0	94	172	99
22	0	0	0	85	156	124
23	0	0	0	62	180	123
24	0	0	0	54	190	121

Mixing heights — Time (hr)

Mixing heights	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	1	4	2	1	1	2	2	3	16	62	63	56	48	58	81	104	100	84	46	24	9	5	6	3
1800 to 2000 m	10	4	8	2	1	1	5	7	24	27	35	39	59	76	89	75	79	62	42	31	12	7	9	12
1600 to 1800 m	10	6	5	11	8	9	7	8	29	29	34	40	57	53	48	57	57	56	48	24	29	18	8	10
1400 to 1600 m	14	9	9	8	11	11	11	15	22	24	36	46	54	70	52	50	46	41	42	39	24	26	14	9
1200 to 1400 m	18	16	18	13	7	10	27	43	41	51	46	63	60	52	46	41	39	42	28	16	15	25	21	12
1000 to 1200 m	1	3	1	2	2	1	39	50	52	50	69	63	52	28	27	20	26	18	3	3	3	2	1	4
800 to 1000 m	3	4	4	3	4	6	51	61	76	55	39	29	19	17	11	9	12	8	4	3	2	2	3	3
600 to 800 m	0	0	0	1	0	0	67	91	47	39	22	17	8	6	7	4	4	1	0	0	0	0	0	0
400 to 600 m	0	1	0	1	0	0	43	58	31	15	12	8	6	2	3	4	2	2	0	0	0	0	0	0
200 to 400 m	122	125	125	121	126	116	48	20	23	13	7	4	2	3	1	1	0	39	90	103	113	106	117	122
0 to 200 m	186	193	193	202	205	209	65	9	4	0	2	0	0	0	0	0	0	12	62	122	158	174	186	190

Wind Occurence Matrix

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

<0.5 (calm)									0.86
0.5 - 1.9	0.53	0.24	0.42	0.54	0.81	0.71	0.79	0.47	4.50
2.0 - 3.9	2.35	1.16	2.07	4.57	4.65	5.42	5.61	3.93	29.75
4.0 - 5.9	4.02	1.18	2.96	5.35	3.56	2.45	6.82	5.53	31.86
6.0 - 7.9	3.93	0.82	2.31	2.23	0.62	0.51	2.44	5.66	18.52
8.0 - 9.9	2.50	0.57	1.86	1.16	0.16	0.16	1.19	4.67	12.27
10.0 - 11.9	0.31	0.10	0.53	0.33	0.03	0.02	0.21	0.61	2.13
12.0 - 13.9	0.00	0.01	0.02	0.02	0.00	0.00	0.03	0.02	0.11
14.0 - 15.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.0 - 17.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>18.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	13.63	4.09	10.16	14.20	9.83	9.28	17.08	20.88	100.00

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
<0.5 (calm)																	0.9
0.5 - 1.9	0.3	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.5	0.3	0.4	0.4	0.5	0.2	0.3	0.2	4.5
2.0 - 3.9	1.3	0.6	0.6	0.7	1.1	1.3	2.5	2.5	2.4	2.1	3.0	2.8	3.0	2.4	2.1	1.3	29.7
4.0 - 5.9	2.0	1.3	0.5	0.5	1.3	2.7	3.0	2.1	2.0	0.9	1.2	2.0	4.3	2.4	3.4	2.3	31.9
6.0 - 7.9	2.2	0.9	0.5	0.4	1.2	1.8	1.0	0.4	0.4	0.1	0.3	0.5	1.4	1.7	3.7	2.0	18.5
8.0 - 9.9	1.6	0.5	0.4	0.2	1.1	1.2	0.5	0.1	0.1	0.0	0.1	0.1	0.5	1.9	3.2	0.7	12.3
10.0 - 11.9	0.2	0.1	0.1	0.0	0.4	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.2	0.0	2.1
12.0 - 13.9	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	0.1	0.0	0.0	0.1
14.0 - 15.9	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
16.0 - 17.9	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
>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	7.7	3.5	2.3	1.9	5.3	7.5	7.6	5.5	5.4	3.6	4.9	5.8	9.8	9.2	12.8	6.5	100.0

Ave wind speed = 5.16

Wind Speed range (m/s)	Count	Percentage (%)
0.00 - 0.99	135	1.54
1.00 - 1.99	334	3.81
2.00 - 2.99	857	9.78
3.00 - 3.99	1749	19.97
4.00 - 4.99	1439	16.43
5.00 - 5.99	1352	15.43
6.00 - 6.99	959	10.95
7.00 - 7.99	663	7.57
8.00 - 8.99	759	8.66
9.00 - 9.99	316	3.61
10.00 - 10.99	142	1.62
11.00 - 11.99	45	0.51
12.00 - 12.99	8	0.09
13.00 - 13.99	2	0.02
14.00 - 14.99	0	0.00
15.00 - 15.99	0	0.00
16.00 - 16.99	0	0.00
17.00 - 17.99	0	0.00
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 B AUSPLUME Configuration File

```
1          _____________________________________________________________

             NWIOA 50Mtpa 0405 met WV05047 (03/12/10) Contour PM10 smb
          _____________________________________________________________

 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         _____________________________________________________________
```

NWIOA 50Mtpa 0405 met WV05047 (03/12/10) Contour PM10 smb

SOURCE CHARACTERISTICS

VOLUME SOURCE: CD221

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
657042	7746350	0m	3m	3m	2m

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

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (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: TS221

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
656682	7746591	0m	8m	4m	4m

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

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (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: TS244

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
656568	7746637	0m	9m	4m	5m

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

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (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
656761	7746755	0m	7m	50m	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: ST2

   X(m)     Y(m)     Ground Elevation     Height   Hor. spread    Vert. spread
 656951  7747420            0m              7m          50m             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: RC1

   X(m)     Y(m)     Ground Elevation     Height   Hor. spread    Vert. spread
 656906  7747185            0m              7m          30m             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: TS242

   X(m)     Y(m)     Ground Elevation     Height   Hor. spread    Vert. spread
 657456  7748290            0m              8m           4m             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: CV271A

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
657681	7748439	0m	8m	1m	1m

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

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (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: CV271B

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
658120	7748724	0m	8m	1m	1m

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

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (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: CV271C

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
658570	7749009	0m	8m	1m	1m

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

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (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: CV271D

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
659015	7749297	0m	8m	1m	1m

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

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (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: CV271E

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
659465	7749586	0m	8m	1m	1m

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

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (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: CV271F

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
659911	7749876	0m	8m	1m	1m

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

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (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: CV271G

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
660365	7750165	0m	8m	1m	1m

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

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (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: CV271H

  X(m)     Y(m)      Ground Elevation     Height    Hor. spread    Vert. spread
660813  7750455              0m              8m          1m              1m

           (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: CV271I

  X(m)     Y(m)      Ground Elevation     Height    Hor. spread    Vert. spread
661261  7750739              0m              8m          1m              1m

           (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: CV271J

  X(m)     Y(m)      Ground Elevation     Height    Hor. spread    Vert. spread
661709  7751026              0m              8m          1m              1m

           (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: CV271K

  X(m)     Y(m)      Ground Elevation     Height    Hor. spread    Vert. spread
662197  7750883              0m              8m          1m              1m

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

     Hourly multiplicative factors will be used with
```

this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (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: CV271L

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
662696	7750700	0m	8m	1m	1m

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

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (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: TS271

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
661751	7751053	0m	9m	4m	5m

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

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (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: TS321

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
662940	7750609	0m	9m	4m	5m

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

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (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: SL1

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
663165  7750895           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: WE1

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
656783  7746910           0m             10m        30m             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: WE2

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
656876  7747115           0m             10m        30m             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: WE3

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
656980  7747327           0m             10m        30m             3m

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

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

Particle Mass fraction	Particle Size (micron)	Particle Density (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: OWE

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
657499	7748233	0m	1m	60m	0m

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

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (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
656619	7746569	0m	1m	150m	0m

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

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (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

NWIOA 50Mtpa 0405 met WV05047 (03/12/10) Contour PM10 smb

RECEPTOR LOCATIONS

The Cartesian receptor grid has the following x-values (or eastings):

```
654500.m  655000.m  655500.m  656000.m  656500.m  657000.m  657500.m
658000.m  658500.m  659000.m  659500.m  660000.m  660500.m  661000.m
661500.m  662000.m  662500.m  663000.m  663500.m  664000.m  664500.m
665000.m  665500.m  666000.m  666500.m  667000.m  667500.m  668000.m
668500.m  669000.m  669500.m  670000.m  670500.m  671000.m  671500.m
672000.m  672500.m  673000.m
```

and these y-values (or northings):

```
7742500.m 7743000.m 7743500.m 7744000.m 7744500.m 7745000.m 7745500.m
7746000.m 7746500.m 7747000.m 7747500.m 7748000.m 7748500.m 7749000.m
7749500.m 7750000.m 7750500.m 7751000.m 7751500.m 7752000.m 7752500.m
```

```
7753000.m 7753500.m 7754000.m 7754500.m 7755000.m 7755500.m 7756000.m
```

```
 METEOROLOGICAL DATA : 2004/2005 fin. year Port Hedland Met, JDH (1/2/06),
v

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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\WV05047\Modelling\PM10\NWIOA\NWIOA0405_50Mtpa_PM10.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:
 NWIOA 50Mtpa PM10 0405Met smb 1/12/2010

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

 Prefix CD221  allocated: CD221
 Prefix TS221  allocated: TS221
 Prefix TS244  allocated: TS244
 Prefix ST1    allocated: ST1
 Prefix ST2    allocated: ST2
 Prefix RC1    allocated: RC1
 Prefix TS242  allocated: TS242
 Prefix CV271A allocated: CV271A
 Prefix CV271B allocated: CV271B
 Prefix CV271C allocated: CV271C
 Prefix CV271D allocated: CV271D
 Prefix CV271E allocated: CV271E
 Prefix CV271F allocated: CV271F
 Prefix CV271G allocated: CV271G
 Prefix CV271H allocated: CV271H
 Prefix CV271I allocated: CV271I
 Prefix CV271J allocated: CV271J
 Prefix CV271K allocated: CV271K
 Prefix CV271L allocated: CV271L
 Prefix TS271  allocated: TS271
 Prefix TS321  allocated: TS321
 Prefix SL1    allocated: SL1
 Prefix WE1    allocated: WE1
 Prefix WE2    allocated: WE2
 Prefix WE3    allocated: WE3
 Prefix OWE    allocated: OWE
 Prefix VEH    allocated: VEH
```

Appendix C Source Locations and Model Characteristics

- **Table 9.1 NWI Source locations and AUSPLUME emission dimension characteristics**

Source	Easting (m)	Northing (m)	Source Height (m)	Vertical Spread (m)	Horizontal Spread (m)
Car Dumper 221	657042	7746350	3	1.75	2.5
Transfer Station 221	656682	7746591	8	4	4
Transfer Station 244	656568	7746637	9	4.5	4
Stacker 1	656761	7746755	6.5	2	50
Stacker 2	656951	7747420	6.5	2	50
Reclaimer	656906	7747185	6.5	2	30
Transfer Station 242	657456	7748290	8	4	4
Conveyor 271 (A)	657681	7748439	8	0.5	0.5
Conveyor 271 (B)	658120	7748724	8	0.5	0.5
Conveyor 271 (C)	658570	7749009	8	0.5	0.5
Conveyor 271 (D)	659015	7749297	8	0.5	0.5
Conveyor 271 (E)	659465	7749586	8	0.5	0.5
Conveyor 271 (F)	659911	7749876	8	0.5	0.5
Conveyor 271 (G)	660365	7750165	8	0.5	0.5
Conveyor 271 (H)	660813	7750455	8	0.5	0.5
Conveyor 271 (I)	661261	7750739	8	0.5	0.5
Conveyor 271 (J)	661709	7751026	8	0.5	0.5
Conveyor 271 (K)	662197	7750883	8	0.5	0.5
Conveyor 271 (L)	662696	7750700	8	0.5	0.5
Transfer Station 271	661751	7751053	9	4.5	4
Transfer Station 321	662940	7750609	9	4.5	4
Shiploader	663165	7750895	10	3	15
Stockpile Wind Erosion 1	656783	7746910	10	2.5	30
Stockpile Wind Erosion 2	656876	7747115	10	2.5	30
Stockpile Wind Erosion 3	656980	7747327	10	2.5	30
Open Area Wind Erosion	657499	7748233	1	0.25	60
Vehicles	656619	7746569	1	0.25	150