Port Hedland Outer Harbour Development

DUST MODELLING AND ASSESSMENT

- Revision 02
- 13 February 2011
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- PREP-1210-G-12094

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Executive Summary

Project Description

This report outlines the methodology for undertaking predictive modelling of dust impacts associated with the Boodarie stockyard configurations and associated infrastructure (car dumpers, transfer stations, conveyors, shiploaders) being considered for the proposed Port Hedland Outer Harbour development. The proposed stockyards comprise ten rows of ore stockpiles of various product types, ten stackers, six reclaimers, four shiploaders, five car dumpers and associated transfer stations. Five lump rescreening plants with a dedicated Returned Screened Fines (RSF) circuit will service the development.

The modelling assessment incorporates other existing and proposed BHP Billiton Iron Ore operations contributing to dust emissions in the area, specifically BHP Billiton Iron Ore's proposed Inner Harbour Operations at 255 Mtpa.

Modelling of cumulative emissions was also undertaken as part of this assessment. Emissions from the Port Hedland Port Authority (PHPA), proposed Utah Point operations, the proposed expansion operations at Anderson Point by Fortescue Metals Group (FMG), proposed Roy Hills operations at South West Creek and the proposed North West Iron Ore Alliance (NWIOA) operations also at South West Creek were assessed along with the predicted emissions from BHP Billiton Iron Ore's Inner Harbour Operations and the proposed Outer Harbour Development.

Overview of the Assessment

Legislated air quality criteria provide the framework to assess the effects of existing and predicted emissions on human health, the environment and occupational health requirements. The criteria used for the Study have been derived from Ministerial Statement 740, Upgrade Dust Managed at Finucane Island and Nelson Point Port Hedland and the Port Hedland Dust Management Taskforce report (Department of State Development 2010).

The dust reduction targets prescribed in Ministerial Statement 740 are based upon concentrations measured at the Hospital monitoring site whilst the Port Hedland Dust Management Taskforce report is based on dust concentrations measured at Taplin Street. The potential impact of emissions is determined with reference to the Hospital and Taplin Street and other sensitive receptors in the community. The locations of the sensitive receptors for this Study are the BHP Billiton Iron Ore Harbour and Hospital ambient monitoring sites, the BMX course, St Cecilia's , Holiday Inn, Port Hedland Shop, All Seasons Hotel, Council offices, the telecommunication tower, Port Hedland Primary School, Wedgefield and South Hedland Secondary School.

Air quality impacts from operations have been modelled using the Victorian Environmental Protection Authority's (EPA's) AUSPLUME computer dispersion model (Version 6.0). It is a steady state model, and assumes that over time, the average concentration distribution of the plume is Gaussian. AUSPLUME has recently been upgraded to enable a more rigorous treatment of atmospheric dust dispersion than the previous versions. AUSPLUME is one of the primary models for assessing impacts from industrial sites in Australia.

Key Findings – Conclusions and Recommendations

The model predicts there will be a general increase in the ground level dust concentrations across all receptor locations, however, with the introduction of relevant engineering controls the model predicts Ministerial Condition 740 targets were achievable. Controls considered included:

- enclosure and dust extraction on the new transfer station on Finucane Island;
- enclosure and dust extraction on the transfer station on the shiploader wharf;
- installation of either wet scrubbers or fogging systems on selected transfer stations;
- belt wash stations on all new transfer stations;
- use of chemical surfactants on the stockpiles and open areas to reduce emissions associated with wind erosion; and
- additional dust abatement measures are currently been investigated.

Modelling of current and proposed BHP Billiton Iron Ore operations indicates that at the Hospital monitoring station and the proposed Taplin Street location:

- the PM_{10} 24 hour short term concentration target will be achieved;
- the annual average PM_{10} target should be met;
- the TSP annual average target will be achieved and; and
- using the Hospital criteria as comparison, the dust impact at South Hedland and Wedgefield will meet criteria limits.

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1. Introduction

BHP Billiton Iron Ore Pty Ltd has extensive iron ore handling, processing and ship loading facilities at Nelson Point and Finucane Island, in the Pilbara region of Western Australia. The facilities are in close proximity to the town of Port Hedland. BHP Billiton Iron Ore is proposing to expand its port operations with the proposed Port Hedland Outer Harbour Development, which when complete will result in an additional iron ore export capacity of approximately 300 Mtpa (million tonnes per annum).

As part of this assessment dust modelling has been conducted to determine the potential impact from dust emissions resulting from the infrastructure associated with the Outer Harbour Development.

The proposed site for the Boodarie stockyards and associated infurstructure is to the north-west of the decommissioned Hot Briquetted Iron (HBI) Plant. The stockyard comprises the following components:

- five car dumpers each with a nominal capacity of approximately 60 Mtpa;
- ten rows of stockpiles;
- ten stackers;
- six bucket wheel reclaimers;
- five lump re-screening plants; and
- two re-screened fines stockyards.

These components are supported by and integrated with conveyors, transfer stations, dust control measures, dust suppression cannons, and water supply and recovery systems.

This report outlines the methodology for undertaking the predictive modelling of the dust impacts associated with the proposed stockyard configurations and associated infrastructure (car dumpers, transfer stations, conveyors, shiploaders). The modelling assessment also incorporates other existing and proposed BHP Billiton Iron Ore operations contributing to dust emissions in the area. BHP Billiton Iron Ore currently has approval for 240 Mtpa for the Inner Harbour and will seek additional approval as required.

The report presents the predicted ground level concentrations associated with the proposed infrastructure, and makes comparisons to the dust performance targets outlined in the dust management program and for the purposes of this report the Hospital ambient air quality monitoring site and the Port Hedland Dust Management Taskforce report as measured at Taplin Street.

Modelling of cumulative emissions was also undertaken as part of this assessment. Emissions from the Port Hedland Port Authority (PHPA), proposed Utah Point operations, proposed expansion operations at Anderson Point by Fortescue Metals Group (FMG), proposed Roy Hills operations at South West Creek and the proposed North West Iron Ore Alliance (NWIOA) operations also at South West Creek were assessed along with the predicted emissions from BHP Billiton Iron Ore's Inner Harbour Operations and the proposed Outer Harbour Development.

2. Dust Criteria

This section outlines ambient air quality criteria relevant to the assessment.

2.1. Ministerial Conditions

Previously the management of dust generated by BHP Billiton Iron Ore's Port Operations was bound by environmental conditions set in Ministerial Statement 433 *Upgrade Dust Management at Finucane Island and Nelson Point, Port Hedland (955)*, issued in 1996. In 2006, BHP Billiton Iron Ore sought revision of Ministerial Statement 433 so that the conditions better reflected the continual improvement in the company's expanding operations, new standards and technology, and changes to community expectations. The objectives of the amendments were to align the conditions of the Ministerial Statement to more accurately reflect:

- initiatives and developments in BHP Billiton Iron Ore's community consultation programs;
- how dust levels will be managed and further reduced;
- revised ambient dust targets;
- initiatives to improve water-use efficiency; and
- the timeframe for implementation of the revised Dust Management program.

It was intended that the commitments revised through this process would apply to the existing operations and any of the staged growth expansions subsequently approved.

Ministerial Statement 740, released in May 2007, amended the environmental management actions of Statement 433, including the revision of performance targets. Ministerial Statement 740 requires that incremental progress is made towards achieving the performance targets in **Table 2-1** with achievement no later than 31 December 2012. These targets are to be assessed at the Hospital ambient monitoring site.

- **Table 2-1 Approved Dust Performance Targets (Ministerial Statement 740)**

Performance Aspect	Performance Target
Air Quality Related – Long Term Average	Improvement in the annual average PM_{10} monitored at the Hospital site to a long-term average target of 30 $\mu g/m^3$
Air Quality Related – Short Term Average	Improvement in the 24 hour average PM_{10} monitored at the Hospital monitoring site to a long-term target of 70 $\mu g/m^3$ with less than 10 exceedences per year
Amenity Related	Progressive reduction in the annual average TSP monitored at the Hospital monitoring site to a long-term target of 65 $\mu g/m^3$

2.2. Port Hedland Dust Management Taskforce

In early 2009, the EPA expressed concern at current dust levels, emerging health research and current land use planning controls within Port Hedland. They stated: "a coordinated government and industry approach to the development and execution of an integrated government and industry strategy with explicit emission reduction strategies and explicit exposure reduction strategies is required with strong and inclusive governance arrangements".

In May 2009, to assist in addressing the issues surrounding particulates concentrations within Port Hedland, especially with the planned increase in export tonnage, the Government of Western Australia established the Port Hedland Dust Management Taskforce (PHDMT). The Taskforce's objective was to develop a comprehensive management plan and implementation strategy for ongoing dust and noise reduction and air quality management in Port Hedland. Taskforce representatives were drawn from Industry, State and Local Government. This objective was met in March 2010 with the release of the '*Port Hedland Air Quality and Noise Management Plan*' (Department of State Development 2010). This report was developed as a strategic air quality management plan for Port Hedland and aims to provide a responsible focus for the ongoing development of the region.

The *Port Hedland Air Quality and Noise Management Plan* (the Plan), developed by the PHDMT, is a comprehensive management plan for ongoing air quality and noise management in Port Hedland, with an implementation strategy and governance framework. The Plan is informed by a thorough review of existing scientific reports and studies and provides a comprehensive and integrated framework that supports the responsible development of Port Hedland for its residents, the port and its users.

To maintain the co-existence of industry and community and manage potential risk to human health, The Taskforce recommended adoption of an interim air management criteria of 70 $\mu g/m^3$ (24 hour average) with 10 exceedences per calendar year. It is expected that this criteria will be met east of Taplin Street and that significant reductions will be achieved between Taplin and McKay Streets. The criteria is part of a continuous improvement framework within which industry can work to reduce emissions over time. It is important to note that this target is a 'cumulative' target and applies to all industries, not a particular company.

2.3. Criteria used in this Assessment

For the purposes of this assessment the following criteria will be used to compare against modelled concentrations of dust:

- improvement in the annual average PM_{10} monitored at the Hospital site to a long-term average target of 30 $\mu g/m^3$;
- improvement in the 24 hour average PM_{10} monitored at the Hospital monitoring site to a long-term target of 70 $\mu g/m^3$ with less than 10 exceedences per year;
- improvement in the 24 hour average PM_{10} monitored at the Taplin Street site to a long-term target of 70 $\mu g/m^3$ with less than 10 exceedences per year; and
- progressive reduction in the annual average TSP monitored at the Hospital monitoring site to a long-term target of 65 $\mu g/m^3$.

3. Climate and Meteorology

The environmental characteristics and prevailing meteorological conditions of the proposed Outer Harbour Development location are identified for air dispersion modelling purposes.

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. The low 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, though the cyclone season and most storms are generally restricted to the summer months (BoM 2008).

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[1]. This particular dataset was chosen as it represents the same time period that BHP Billiton Iron Ore utilised for the revision of the Dust Management Program for Finucane Island and Nelson Point Operations (BHP Billiton Iron Ore 2006) and model validation for their operations at Port Hedland, this timeframe being both the most up to date at the time and representative of a typical meteorological year.

3.1.1. Wind

The seasonal wind roses, for the 2004/2005 financial year, presented in **Figure 3-1** to **Figure 3-4** below show that the dominant annual wind directions are north-westerly during the summer months and south-easterly during the winter months. Spring also shows high north-westerly dominance, though this appears to be a lead up into the summer months. Interannual variations in the wind flow across the region can be expected. However, the distinct seasonal pattern of westerly/north-westerly winds in summer and south-easterly winds in winter is well established. 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.

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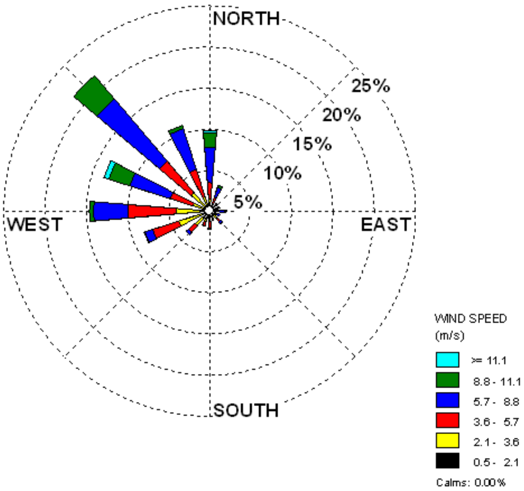
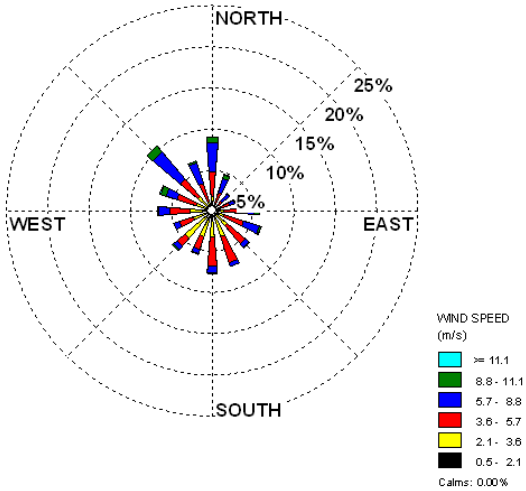
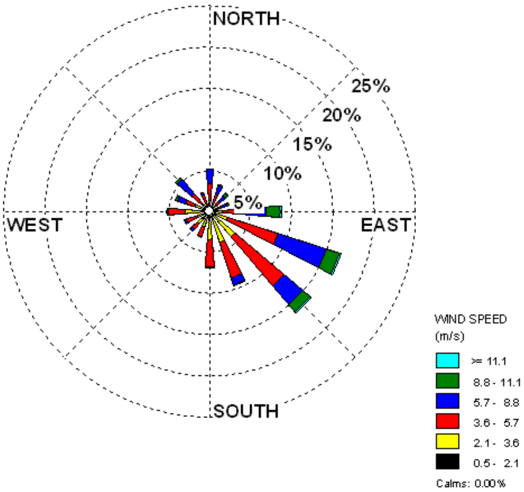
[1] A full explanation of this met data is presented in SKM (2006) and an analysis of the meteorological file is presented in **Appendix D**



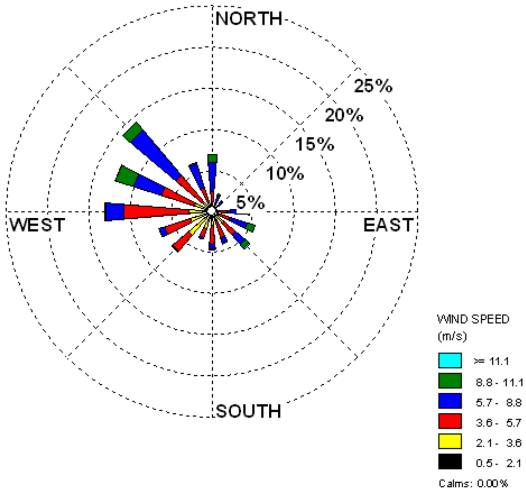
■ **Figure 3-1 Summer Wind Rose (2004/2005)**



■ **Figure 3-2 Autumn Wind Rose (2004/2005)**



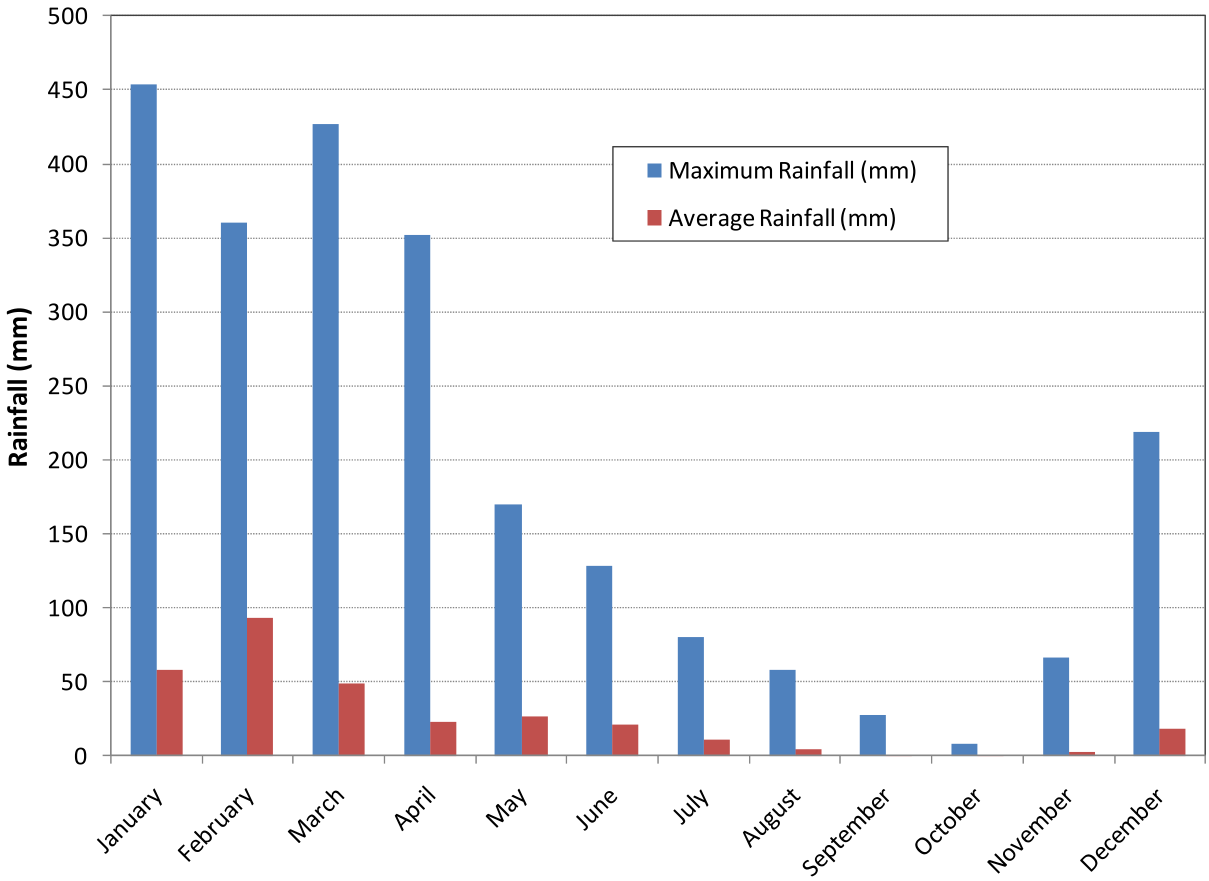
■ **Figure 3-3 Winter Wind Rose (2004/2005)**



■ **Figure 3-4 Spring Wind Rose (2004/2005)**

3.1.2. Rainfall

Rainfall in Port Hedland is predominantly 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. This is illustrated in **Figure 3-5**, which shows the mean rainfall and average days of rain per month measured between 1948 to present (BoM 2011).

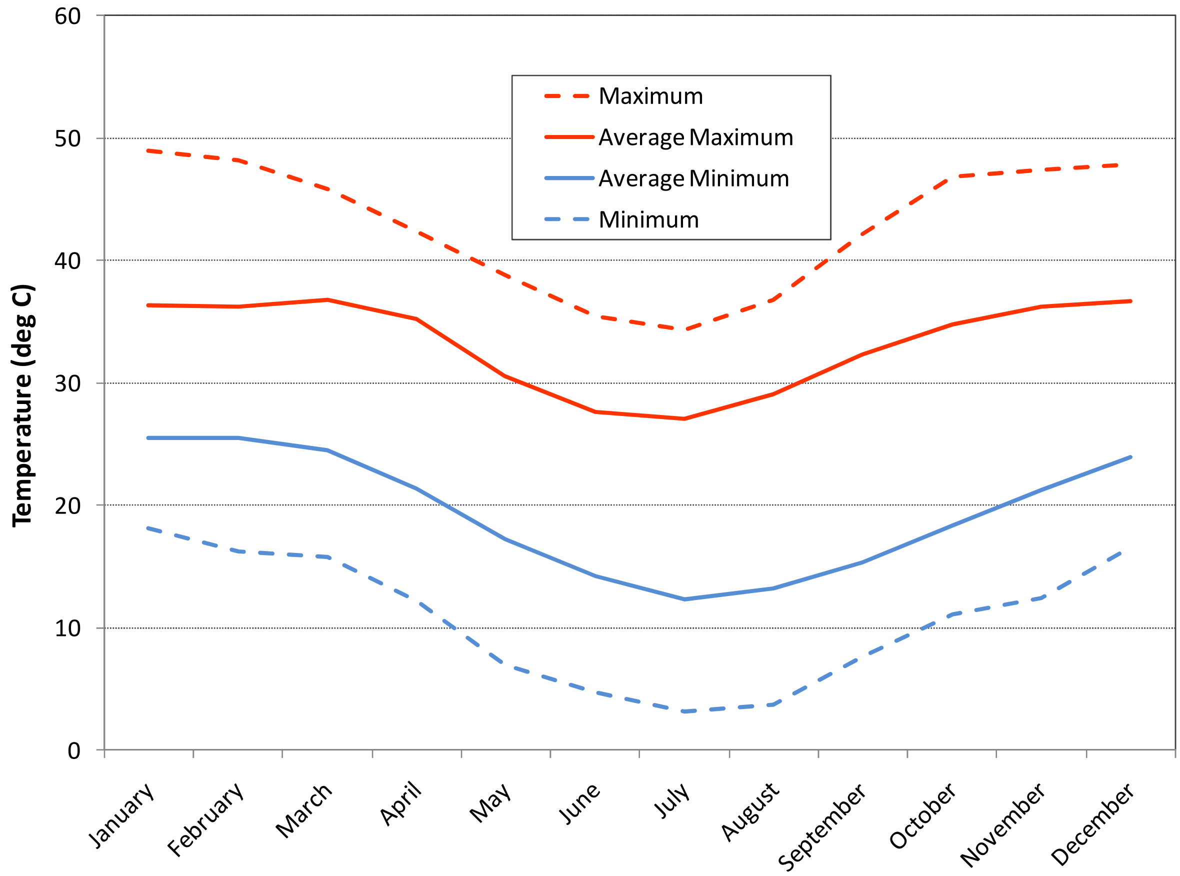


Source: BoM 2011.

▪ **Figure 3-5 Seasonal Rainfall Data for Port Hedland**

3.1.3. Temperature

The long term monthly temperature statistics for Port Hedland are presented in **Figure 3-6**. This figure contains the average monthly maxima and minima as well as the highest and lowest temperature recorded during this period. 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.

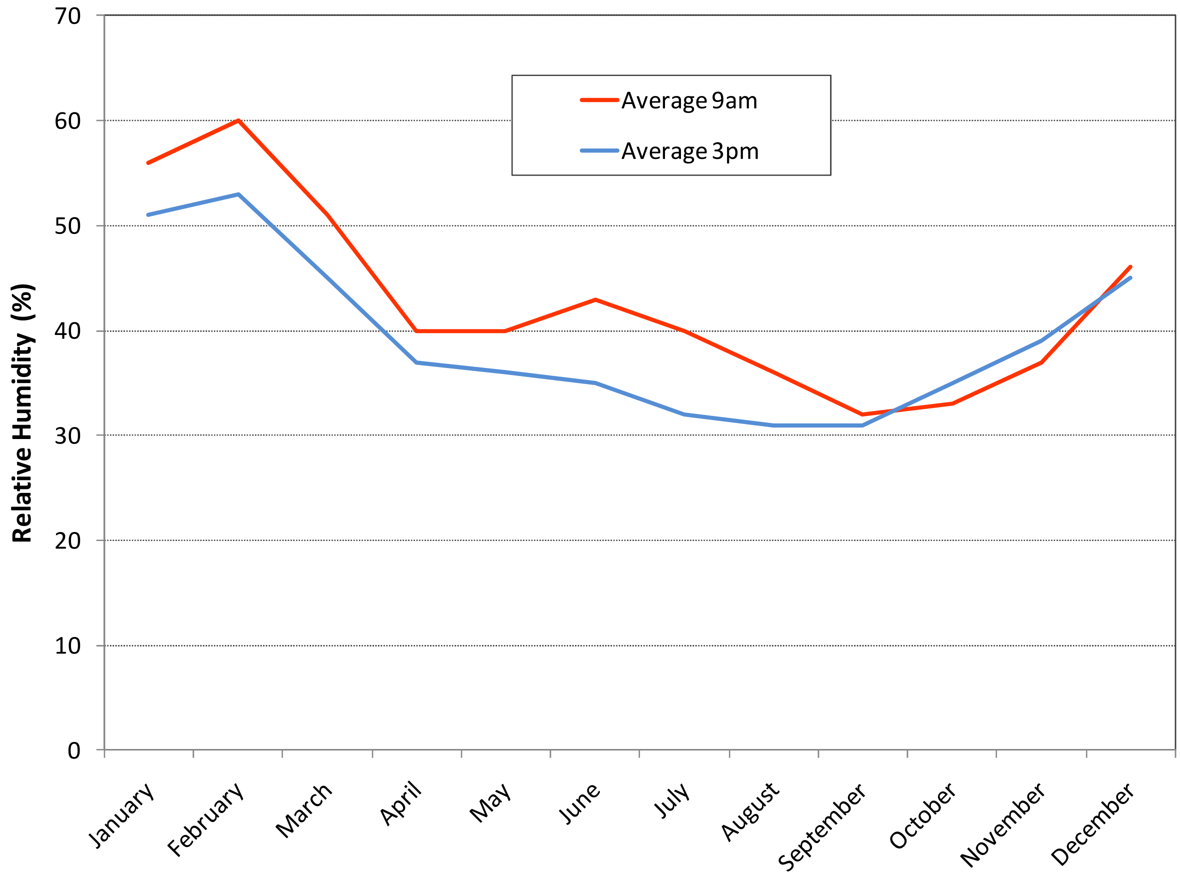


Source: BoM 2011.

■ **Figure 3-6 Seasonal Temperature Statistics for Port Hedland**

3.1.4. Humidity

The long term humidity statistics in Port Hedland at 9 am and 3 pm are presented in **Figure 3-7**. This figure shows that the humidity is typically high during the summer months and is generally low during the winter period, reflecting the effect of high rainfall during the hotter summer months.



Source: BoM 2011.

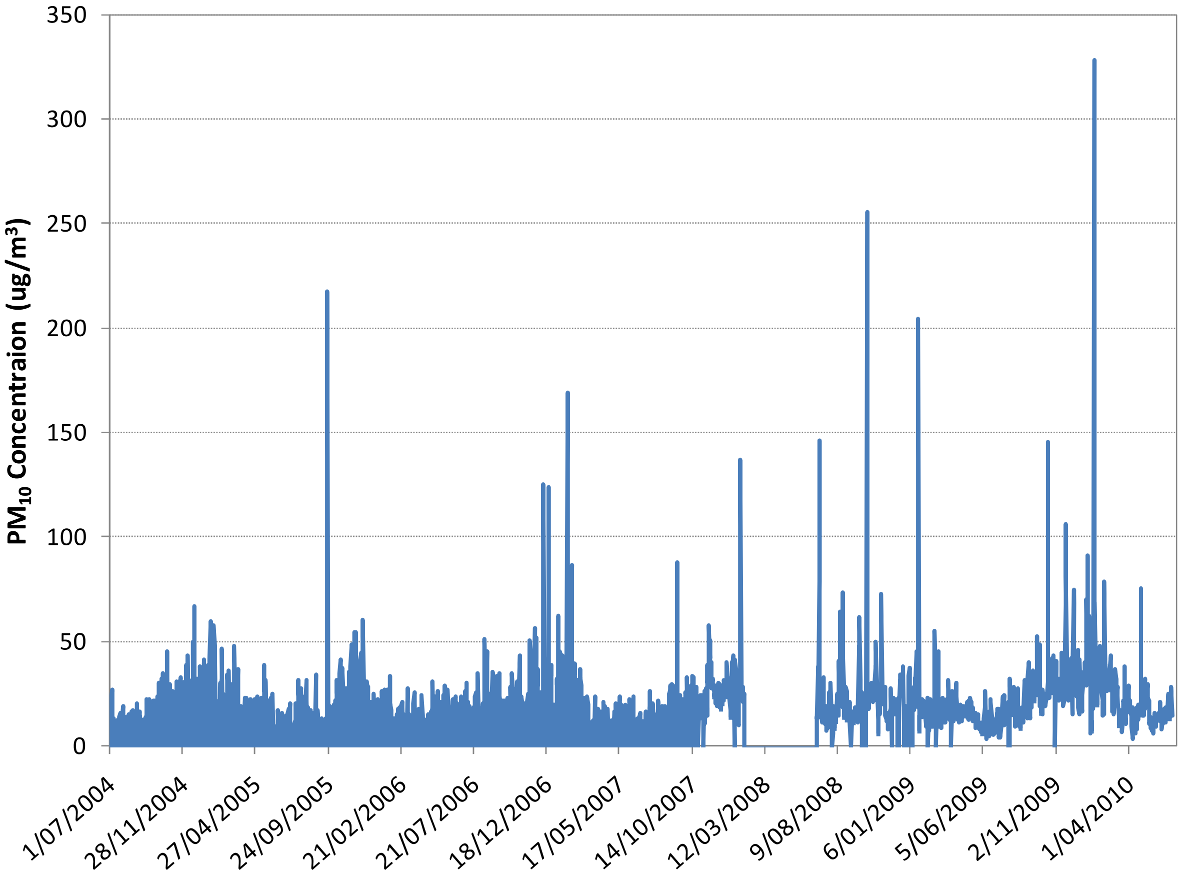
- **Figure 3-7 Mean Humidity Data for Port Hedland**

3.1.5. Existing Air Quality in Port Hedland

The semi-arid landscape of the Pilbara is a naturally dusty environment with wind-blown dust a significant contributor to ambient dust levels within the region. This was highlighted by the aggregated emission study that was conducted by SKM in 2000 (SKM 2003). This study found that the Pilbara region emitted around 170,000 t of windblown particulate matter in the 1998/1999 financial year.

The PM_{10} dust concentrations recorded by BHP Billiton Iron Ore at the Port Hedland Airport monitoring station from July 2004 through to June 2010 are presented in **Figure 3-8** and show that these high levels occur on an annual cycle with higher dust levels occurring predominately during the summer periods.

However, despite the naturally high background levels of PM_{10} in the Pilbara region, most of the PM_{10} in the town of Port Hedland is locally generated (DoE 2004) with the primary sources of dust being port operations. Background dust levels over a year have been compiled for model input, consistent with the meteorological year used in the model. The background file was derived by determining the minimum PM_{10} concentration, on a daily basis, recorded at either the Harbour, Hospital or BoM High Volume Air Samplers monitoring locations.



- **Figure 3-8 Background PM_{10} Concentration in Port Hedland Region (BoM - Port Hedland Airport)**

4. Dust Mitigation Options

As noted in **Section 1**, BHP Billiton Iron Ore has implemented a series of expansion and capacity enhancing projects at Port Hedland to increase iron ore throughput to meet the growing demand for iron ore from overseas customers.

As part of these expansion projects, BHP Billiton Iron Ore, is committed to reducing emissions of particulates from their operations to meet ambient targets as agreed with the Environmental Protection Authority (EPA). To assist in reducing emissions from the Port Hedland operations a series of research and development (R&D) projects has been implemented to investigate and trial alternative abatement technologies. The following sections contain a summary of the results of the dust abatement R&D projects that are applicable to this project.

4.1. Chemical Surfactants

An R&D project was conducted with the chemical surfactant 'Gluon 500', manufactured by Rainstorm (a Perth based company), to determine its effectiveness at reducing dust generated by wind erosion from stockpiles and open areas within operational areas.

To determine the effectiveness of this product a field trial was conducted in the Eastern and Western Stockyards on Finucane Island from 17–30 November 2009. During this period three material stockpiles (, two MAC fines stockpiles and one Yandi fines stockpile) were treated with the Gluon 500 product along with the open areas between the stockpiles. The automated water cannons along the treated stockpiles were isolated to prevent the water from eroding the stockpile surface (SKM 2010).

PM_{10} emissions were sampled, utilising a TSI model 8520 DustTrak aerosol monitoring unit, for both treated and untreated stockpiles and open areas. Visually, the chemical surfactant was observed to significantly reduce wind erosion. Results of the monitoring data show the chemical surfactant is capable of:

- capping the wind erosion emission rate from stockpiles at 1.3 g/s, regardless of the wind speed, for at least three days; and
- reducing wind erosion from non trafficked open areas by up to 98% (SKM 2010).

4.2. Fogging Systems

A field trial was conducted from October to November 2009 to investigate the effectiveness of a TRC (The Raring Company) dust reduction fogging system installed at the P118 conveyor on the shiploading jetty at the BHP Billiton Iron Ore Nelson Point operations. During this period, a TSI model 8520 DustTrak was operated on the downwind side of the P118 conveyor aligned to face into the wind and measurements were taken from Newman high grade lump and Yandi Lump products. Control samples were taken with the fogging system off and compared to the experimental sample with the system on (SKM 2010a).

Visually, the fogging system was observed to improve visibility in the immediate area. Results of the monitoring data show the fogging system, in its current design, is capable of producing:

- a reduction in emissions of 41% for Yandi Lump with a standard deviation of 13 percentage points; and
- a reduction in emissions of 36% for NHG Lump with a standard deviation of 15 percentage points.

These reductions are comparable to that of the wet scrubbers used on site which have previously recorded emission reductions varying from 17% to 52% (SKM 2010a). Further reductions would be achieveable by ensuring that the dust hoods were at the height specified by MARC Technologies and ensuring that the skirts are correctly adjusted. This would increase the effectiveness of the fogging and further reduce particulate emissions from transfer stations (SKM 2010a).

4.3. Conveyor Belt Wash Stations

From 7–10 April 2010, a field trial was conducted at the BHP Billiton Iron Ore operations in Port Hedland to determine the effectiveness of conveyor belt wash stations in reducing fugitive dust emissions from conveyors. Monitoring was conducted at two transfer stations namely TS810 on Finucane Island and TS505 at Nelson Point. TS810 is effectively a dual transfer station in that it has two incoming and two outgoing conveyors which feed shiploaders 3 and 4, while TS505 is a single transfer station that has a belt rollover arrangement. The sampling methodology used in this assessment was identical to that used in previous assessments of emissions at the BHP Billiton Iron Ore operations in Port Hedland (SKM 2006).

The results of the sampling indicate that by having an operational belt wash station:

- an average emission reduction of approximately 40% with MAC and Yandi fines can be achieved at a dual transfer station;
- an average emission reduction of 61% when a dual transfer station has both conveyors handling Yandi fines, potentially due to the greater propensity of this material to adhere to conveyors resulting in a higher than normal emission rate from the return conveyor; and
- an emission reduction of 72% for any conveyor that has a belt rollover arrangement (SKM 2010b).

4.4. Wind Fences

During November 2010 SKM investigated the potential of using wind fences as a dust abatement measure at the Port Hedland operations on behalf of BHP Billiton Iron Ore. This investigation consisted of a desktop literature review with indicative dispersion modelling.

The literature review determined that wind fences have the capability of reducing the wind speed by up to 50% immediately downwind of the fence with the wind speed gradually increasing with distance from the fence. The dispersion modelling determined that by reducing the wind speed resulted in decreased emissions from sources with a corresponding decrease in the predicted ground level concentrations at receptors (SKM 2010c).

Further work is required, predominately by computational fluid dynamic (CFD) modelling, to determine the exact reduction that can be achieved by various wind fence configurations and their corresponding reduction at receptors within Port Hedland. There is also the potential for dust reductions above that reported in the literature if deposition from sources immediately upwind of the wind fences is taken into consideration.

4.5. Dust Abatement used in this Assessment

For the purposes of supporting the environmental impact assessment the following dust abatement techniques will be integrated into the emission calculations to reduce dust emissions from the existing and proposed infrastructure at the BHP Billiton Iron Ore operations in Port Hedland:

- An emission reduction of 40% to account for the installation of belt wash stations at selected transfer stations.
- An emission reduction of 40% to account for the installation of fogging systems at selected transfer stations.
- An emission rate capped at 1.5 g/s to account for the use of chemical surfactants on stockpiles and open areas.
- A variable emission reduction, based on a 50% reduction in wind speed, to account for wind fences located within all stockyards. This reduction is only valid for emission sources that are located in the first two stockpile rows downwind of the proposed fences. As noted in **Section 4.4** further studies are required to ensure compliance with the dust management program.

To account for the possibility of either the belt wash stations or the fogging system not been available for dust abatement at any given time (due to breakage or servicing) the modelling has only assumed an availability of 75%.

5. Emission Estimation

5.1. Validated Emission Estimation in Port Hedland

As part of the Product and Capacity Expansion (PACE) project, an intensive dust measurement program was conducted at BHP Billiton Iron Ore's Port Hedland operations over the months September to November 2001 (SKM 2002). Field investigations included the measurement and ranking of dust emissions from:

- operational plant such as transfer stations, screening and crushing plant and shiploaders;
- stockpile operations such as stackers, reclaimers, dozers and haulpacks;
- wind erosion off stockpiles and open areas; and
- vehicle movements.

Dust emissions were measured under various meteorological conditions for the full range of ore types being handled by the operations and various ore moistures. Empirical relationships were determined for the dust generated for each source as a function of ore type, moisture content and wind speed.

Further dust measurement programs were undertaken in 2004 (SKM 2004a and 2004b) and 2005 (SKM 2006) to ensure that emission estimates and assumptions made in previous assessments were still valid and that the empirical relationships were also still valid.

The dust emission fluxes (g/s) for the various plants and operations at Port Hedland are dependent on the ore type being handled, moisture content and prevailing meteorological conditions. The hourly modelled emission estimates have been calculated from the dust emission flux values by applying a factor representing the frequency of occurrence of that particular activity throughout the 2004/2005 financial year, with due consideration of the ore type being handled, its moisture content and the wind speed.

Validation of the model was undertaken against the observed dust concentrations in Port Hedland, and this is reported in **Appendix A**.

The emission calculations used to simulate the BHP Billiton Iron Ore growth are consistent with previous validation work conducted by SKM (2002; 2004a; 2004b; and 2006).

Modelling of the future growth scenarios were conducted using time series files which contained information on the tonnages through the ore dumpers, stackers, reclaimers and shiploaders by ore type and moisture, supplied by The Simulation Group. These files were converted into source emissions by using the flux emission calculations developed during 2001, 2004 and 2005 and used in the 2004/2005 validation studies.

5.2. Emission Estimates from Current and Proposed Facilities

For the Outer Harbour Development assessment, the following prospective operational configurations were modelled:

- BHP Billiton Iron Ore's RGP5 with an Inner Harbour capacity up to 215 Mtpa;
- BHP Billiton Iron Ore's proposed Inner Harbour capacity up to 255 Mtpa; and
- the proposed Outer Harbour Development at Boodarie with a capacity of 300 Mtpa.

Cumulative modelling was also conducted for both existing and future operations including:

- 21 Mtpa from the Port Hedland Port Authority (PHPA) Utah Point operations;
- 1 Mtpa from the existing PHPA operations at Nelson Point;
- 120 Mtpa from the Fortescue Metals Group (FMG) operations at Anderson Point;
- 55 Mtpa from the proposed Roy Hill operations in South West Creek; and
- 50 Mtpa from the proposed North West Iron Ore Alliance (NWIOA) in South West Creek.

5.3. Emission Estimates from BHP Billiton Iron Ore's Inner Harbour Development (RGP5)

Estimates of emissions from the stockyards and export infrastructure associated with the proposed Outer Harbour Development were based on an emission file received from The Simulation Group (TSG) on 5 November 2010 (File ID: CPOv10h_Case002cNoRSFNewJBF_1PBlend_4DSO_215_s2_dust). The total incoming tonnage for this scenario is presented in **Table 5-1** and the total outgoing ore is presented in **Table 5-2**. From these tables it is evident that BHP Billiton Iron Ore is proposing to blend the incoming material from six mines to create four outgoing. It is important to note that there will be no bulking conducted and that blending will be accomplished during the normal stacking and and reclaiming operations. It is currently planned that Yandi fines will be exported as a stand alone product (not blended).

- **Table 5-1 Approximate incoming tonnage for RGP5 Development (Mtpa)**

Product	Car Dumpers	Stackers
Returned screened fines		8,684,000
Newman Lump	20,511,000	20,511,000
Newman Fines	42,555,000	22,029,000
Yandi Fines	75,012,000	33,083,000
MAC Lump	17,749,000	16,749,000
MAC Fines	29,845,000	16,960,000
Jimblerbar Lump	10,256,000	10,256,000
Jimblebar Fines	11,006,000	6,313,000
OB25 Lump	3,359,000	3,359,000
Goldsworthy Lump	712,000	712,000
Central Pilbara Lump	6,378,000	6,378,000

- **Table 5-2 Approximate outgoing tonnage for proposed Outer Harbour Development Stockyards (Mtpa)**

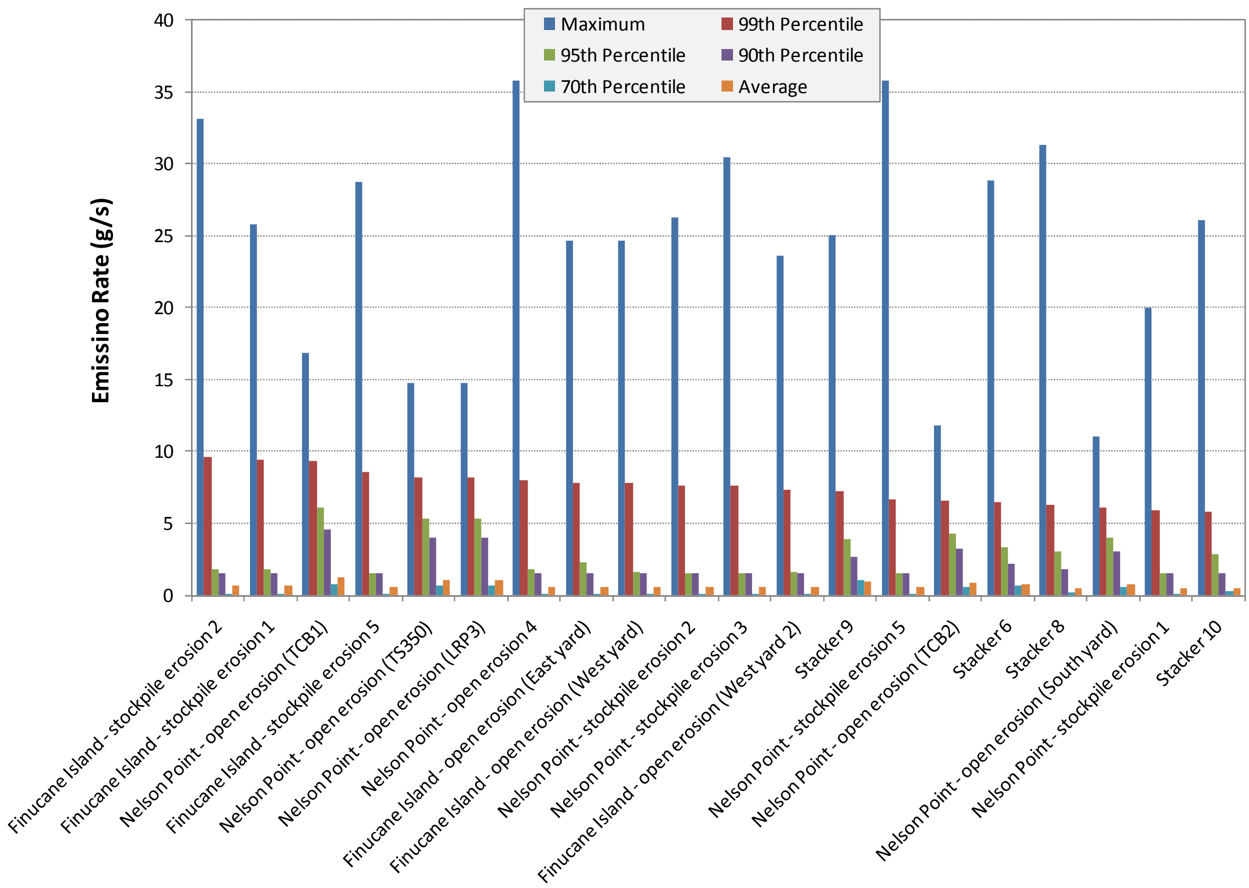
Product	Reclaimers	Shiploaders
Pilbara Blend Lump	57,895,000	49,210,000
Yandi fines	32,809,000	74,738,000
Central Pilbara fines	19,990,000	32,874,000
Eastern Pilbara fines	25,674,000	46,200,000
Jimblebar fines	6,807,000	11,500,000

The calculated emission rates for the operations during RGP5 are presented in **Figure 5-3** and are independant of other sources in the region. The primary emission sources predicted to occur during this phase of development are predominantly associated with wind erosion from stockpiles, though it should be noted that the 99th percentile emission rate is significantly lower than the maximum indicating that the predicted high emission rates from these sources occur very infrequently. The next series of high emissions are derived from the stackers though it should be noted that these high emissions are not a factor of the stackers but of product with a low moisture content been stacked during high winds (>6 m/s).

In addition to the extensive dust abatement strategies already implemented by BHP Billiton Iron Ore at their Nelson Point and Finucane Island operation the following dust reduction measures have been considered as part of the RGP5 development are:

- installation of either wet scrubbers or fogging systems on selected transfer stations;
- belt wash stations on all new transfer stations;
- use of a predictive meteorological system to predict adverse meteorological conditions to ensure that appropriate dust reductions are undertaken; and
- use of chemical surfactants on the stockpiles and open areas, as directed by the predictive meteorological system, to reduce emissions associated with wind erosion.

Existing dust controls implemented under the BHP Billiton Iron Ore Dust Management Plan will continue to be applied.



▪ **Figure 5-1 Top 20 Calculated PM_{10} Emission Rates for RGP5**

5.4. Emission Estimates from BHP Billiton Iron Ore's Inner Harbour Development (RGP6)

Estimates of emissions from the stockyards and export infrastructure associated with the proposed Outer Harbour Development were based on an emission file received from The Simulation Group (TSG) on 3 December 2010 (File ID: CPOv11v_6B_Opt1_2Blend1DSO_250_s13_DustFiles). The total incoming tonnage for the proposed Outer Harbour Development is presented in **Table 5-3** and the total outgoing ore is presented in **Table 5-4** From these tables it is evident that BHP Billiton Iron Ore is proposing to blend the incoming material from seven mines to create two outgoing products classified as Pilbara Blend (lump and fines). As previously noted (**Section 5.3**) there will be no bulking conducted and that blending will be accomplished during the normal stacking and and reclaiming operations. It is currently planned that there will be a third outgoing product, Yandi fine, which will be exported as a stand alone product (not blended) though it has not been modelling in this scenario. This ensures that the the modelling remains conservative as Yandi fines have a lower emission rate than other products handled at the port (SKM 2006)

- **Table 5-3 Approximate incoming tonnage for proposed RGP6 Inner Harbour Development (Mtpa)**

Product	Car Dumpers	Stackers
Nammuldi Lump	20,329,000	20,329,000
Nammuldi Fines	41,357,000	41,357,000
Yandi Fines	66,038,000	66,038,000
MAC Lump	17,920,651	17,920,651
MAC Fines	32,934,000	32,934,000
Jimblerbar Lump	10,065,000	10,065,000
Jimblebar Fines	19,108,000	19,108,000
OB25 Lump	3,917,000	3,917,000
OB25 Fines	6,325,000	6,325,000
Goldsworthy Lump	672,000	672,000
Goldsworthy Fines	1,403,000	1,403,000
Central Pilbara Lump	5,910,000	5,910,000
Central Pilbara Fines	11,649,000	11,649,000

- **Table 5-4 Approximate outgoing tonnage for proposed RGP6 Inner Harbour Development (Mtpa)**

Product	Reclaimers	Shiploaders
Pilbara Blend Lump	93,208,000	93,208,000
Pilbara Blend Fines	148,157,000	148,157,000

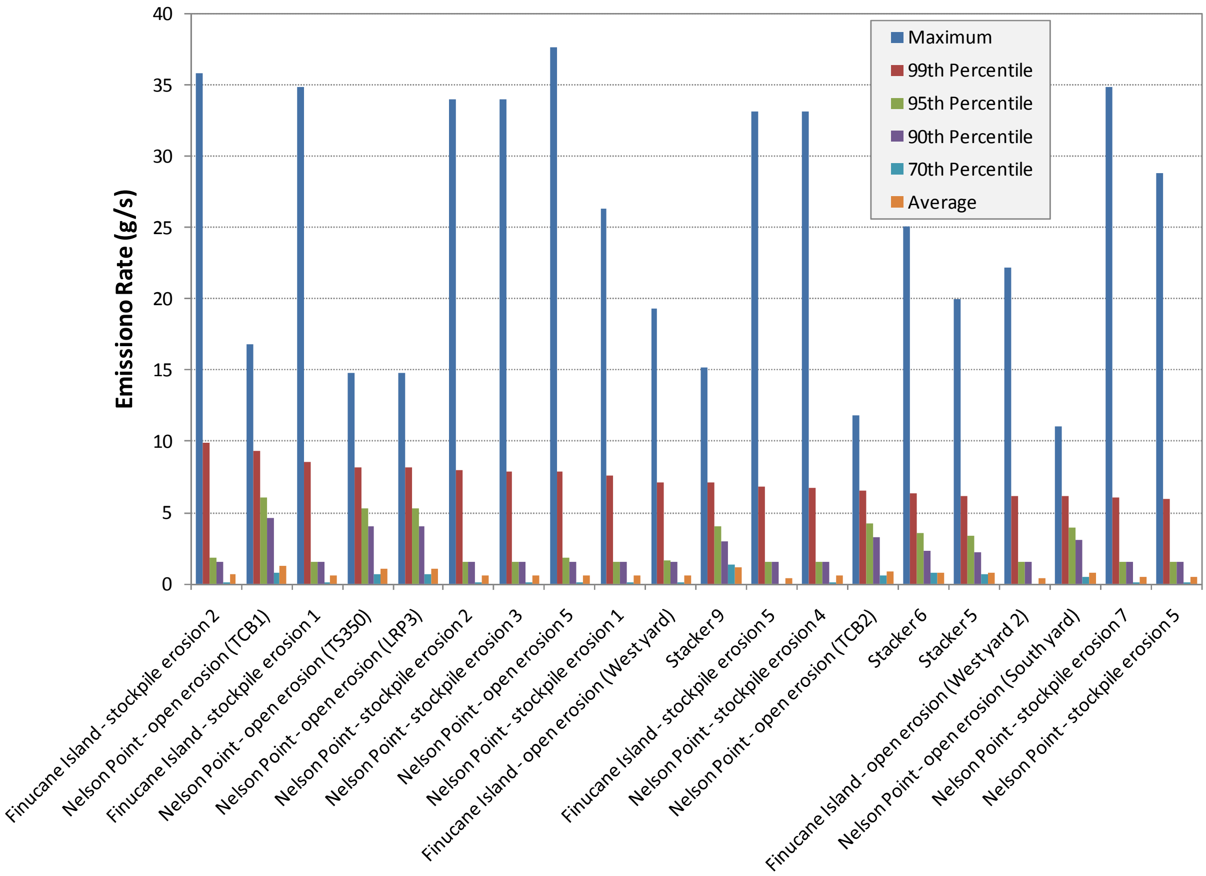
The calculated emission rates for the operations during RGP6 are presented in **Figure 5-2** and are independant of other sources in the region. The primary emission sources predicted to occur are similar to that predicted to occur for RGP5 (**Section 5.3**) in that the main emissions are associated with wind erosion from stockpiles and open areas. Again it should be noted that the 99th percentile emission rate is significantly lower than the maximum indicating that the predicted high emission rates from these sources occur very infrequently.

In addition to the extensive dust abatement strategies already implemented by BHP Billiton Iron Ore at their Nelson Point and Finucane Island operation the following dust reduction measures have been considered as part of the RGP6 development are:

- installation of either wet scrubbers or fogging systems on selected transfer stations;
- belt wash stations on all new transfer stations;
- use of a predictive meteorological system to predict adverse meteorological conditions to ensure that appropriate dust reductions are undertaken; and
- use of chemical surfactants on the stockpiles and open areas, as directed by the predictive meteorological system, to reduce emissions associated with wind erosion.

In addition to these dust abatement strategies BHP Billiton Iron Ore will continue to investigate additional dust abatement measures to ensure compliance with the dust management program.

Existing dust controls implemented under the BHP Billiton Iron Ore Dust Management Plan will continue to be applied.



▪ **Figure 5-2 Top 20 Calculated TSP Emission Rates for RGP6**

5.5. Emission Estimates from BHP Billiton Iron Ore's Proposed Outer Harbour Development

Estimates of emissions from the stockyards and export infrastructure associated with the proposed Outer Harbour Development were based on an emission file received from The Simulation Group (TSG) on 3 December 2010 (File ID: CPOv11v_6B_Opt1_2Blend1DSO_250_s13_DustFiles). The total incoming tonnage for the proposed Outer Harbour Development is presented in **Table 5-5** and the total outgoing ore is presented in **Table 5-6**. From these tables it is evident that BHP Billiton Iron Ore is proposing to blend the incoming material from seven mines to create two outgoing products classified as Pilbara Blend (lump and fines). As previously noted (**Section 5.3**) there will be no bulking operations conducted and that blending will be accomplished during the normal stacking and and reclaiming operations. It is currently planned that there will be a third outgoing product, Yandi fine, which will be exported as a stand alone product (not blended) though it has not been modelling in this scenario to ensure that the modelling remains conservative.

- **Table 5-5 Approximate incoming tonnage for the proposed Outer Harbour Development Stockyards (Mtpa)**

Product	Car Dumpers	Stackers
Nammuldi Lump	20,329,000	20,329,000
Nammuldi Fines	41,357,000	41,357,000
Yandi Fines	66,038,000	66,038,000
MAC Lump	17,920,651	17,920,651
MAC Fines	32,934,000	32,934,000
Jimblerbar Lump	10,065,000	10,065,000
Jimblebar Fines	19,108,000	19,108,000
OB25 Lump	3,917,000	3,917,000
OB25 Fines	6,325,000	6,325,000
Goldsworthy Lump	672,000	672,000
Goldsworthy Fines	1,403,000	1,403,000
Central Pilbara Lump	5,910,000	5,910,000
Central Pilbara Fines	11,649,000	11,649,000

- **Table 5-6 Approximate outgoing tonnage for the proposed Outer Harbour Development Stockyards (Mtpa)**

Product	Reclaimers	Shiploaders
Pilbara Blend Lump	93,208,000	93,208,000
Pilbara Blend Fines	148,157,000	148,157,000

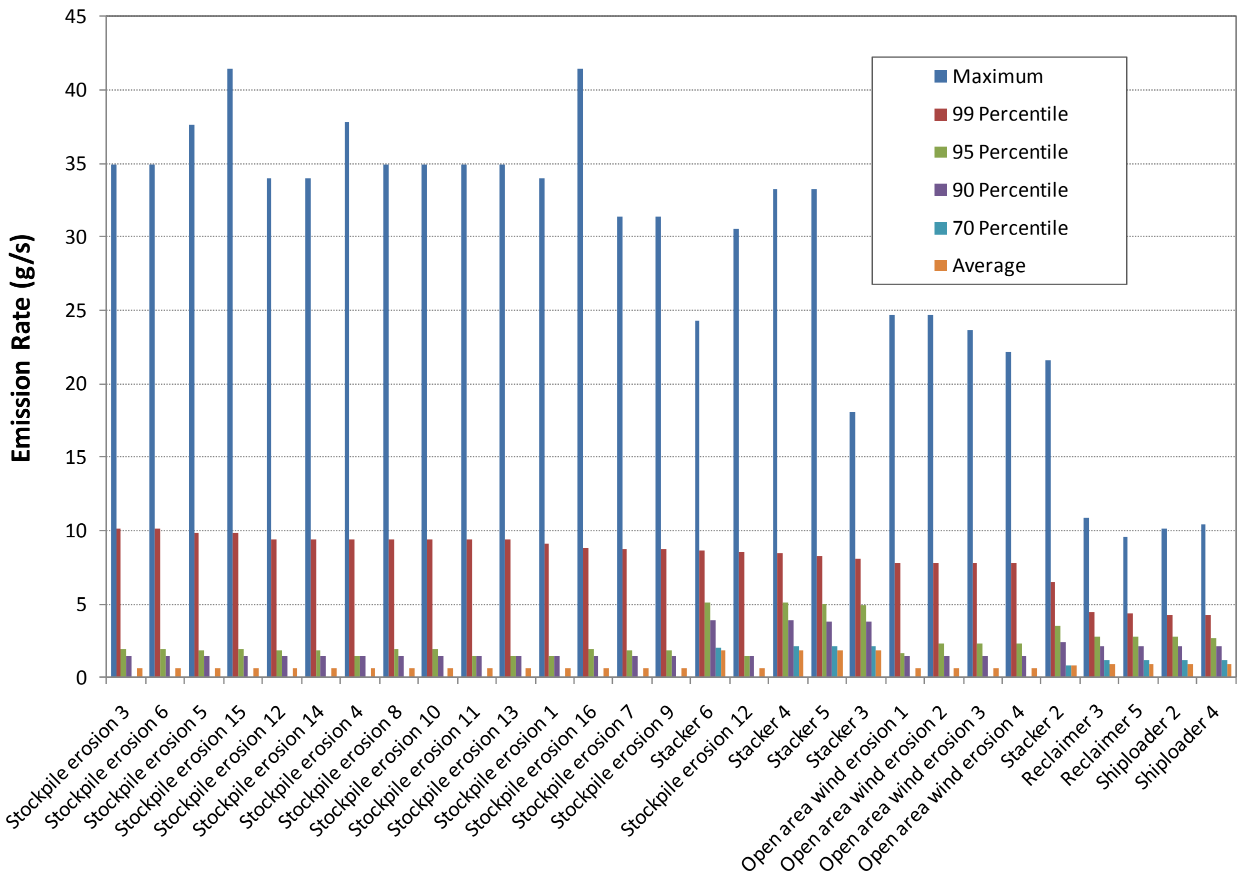
The calculated emission rates for the proposed Outer Harbour Development operations are presented in **Figure 5-3** and are independant of other sources in the region. The primary emission sources predicted to occur from the proposed Outer Harbour Development are predominantly associated with wind erosion from stockpiles, though it should be noted that the 99th percentile emission rate is significantly lower than the maximum indicating that the predicted high emission rates from these sources occur very infrequently. The next series of high emissions are derived from the stackers though it should be noted that these high emissions are not a factor of the stackers but of product with a low moisture content been stacked during high winds (>6 m/s). The next series of high emissions are associated with wind erosion from both the stockpiles and open areas.

In addition to the extensive dust abatement strategies already implemented by BHP Billiton Iron Ore at their Nelson Point and Finucane Island operation the following dust reduction measures have been considered for the proposed Outer Harbour Development:

- stockyard cannons utilising the algorithms currently used by the BHP Billiton Iron Ore operations at Nelson Point and Finucane Island;
- enclosure and dust extraction on all proposed car dumpers;
- enclosure and dust extraction on the new transfer station on Finucane Island;

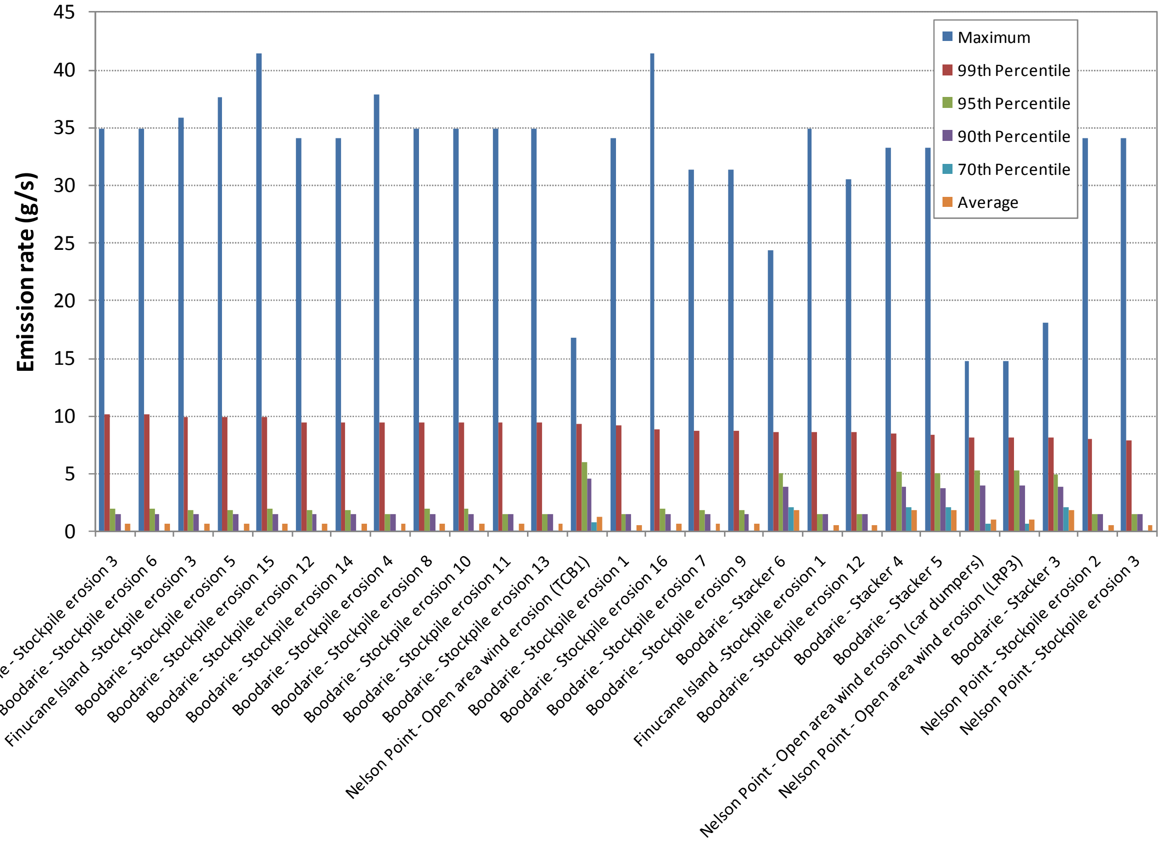
- belt wash station at the new transfer station on the shiploader wharf to clean the overwater conveyor;
- belt wash station at the new transfer station on Finucane Island to clean the overland conveyor;
- belt wash stations on all new transfer stations;
- use of a predictive meteorological system to predict adverse meteorological conditions to ensure that appropriate dust reductions are undertaken; and
- use of chemical surfactants on the stockpiles and open areas, as directed by the predictive meteorological system, to reduce emissions associated with wind erosion.

Existing dust controls implemented under the Dust Management Plan will be applied for the Outer Harbour Development.



- **Figure 5-3 Calculated PM_{10} Emission Rates for the proposed Outer Harbour Development in Isolation (All Stages)**

The highest emission rates for all proposed BHP Billiton Iron Ore operations are presented in **Figure 5-4**. This shows the high emission sources from the Outer Harbour are comparable to the emission rates calculated for the inner harbour. In both the Outer Harbour Development and inner harbour, wind erosion and stacking feature as dominant emission sources.



- **Figure 5-4 Calculated PM_{10} Emission Rates for all proposed BHP Billiton Iron Ore Operations in Port Hedland**

5.6. Cumulative Emission Sources

The cumulative emission sources for this study are located around Port Hedland from current and planned export operations undertaken by PHPA, FMG, Roy Hills and NWIOA. Emission sources considered to be significant for inclusion in this Study are:

- car dumpers;
- transfer stations;
- stackers and reclaimers;
- lump rescreening plants;
- conveyors;
- shiploaders;
- wheel generated dust; and

- wind erosion (stockpile and open area).

Dust emissions from most sources vary with moisture content of product, size distribution of product, prevailing wind speed and direction as well as source dimensions.

Emissions for existing and future operations within Port Hedland were obtained from PHPA and are the same as those used in the Fatal Flaw study (SKM 2009). The emissions were calculated using the emission estimation equations listed in the NPI Emission Estimation technique Manual for Mining (NPI 2001). This manual provides empirical and default values for emissions from operational activities. These have generally been sourced from the USEPA and modified by factors determined from coal mining in NSW where data is available. For iron ore operations the only data publicly available is from Pitts (2000), which indicates that emission factors can be significantly different from those published elsewhere, most notably the lower emission factors for lump re-screening plants.

Emissions estimation graphs for the existing and future cumulative operations in the region are presented in **Appendix B**.

6. Modelling Methodology

This section describes the model used to predict ground level concentrations from the derived emission rates and meteorological data.

6.1. Modelling Approach

Air quality impacts from operations have been modelled using the Victorian EPA's AUSPLUME computer dispersion model (Version 6.0). It is a steady state model, and assumes that over time, the average concentration distribution of the plume is Gaussian. AUSPLUME has recently been upgraded to enable a more rigorous treatment of atmospheric dust dispersion than the previous versions. AUSPLUME is one of the primary models for assessing impacts from industrial sites in Australia.

6.2. AUSPLUME Modelling

The AUSPLUME (Version 6.0) dispersion model was used, along with site representative meteorological data for the year July 2004 to June 2005, to predict the dispersion of PM_{10} at eight representative receptors within the region. An AUSPLUME output file typical of those used in this assessment is presented in **Appendix C**. The main model options and assumptions used are listed below:

- meteorological data from an annual file of hourly observations from Port Hedland Airport;
- rural dispersion options;
- assumption of no terrain;
- dry deposition included; and
- average roughness length of 0.1 m to simulate the average over sea and land.

6.3. 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 restrict the duration of model runs while using the particle deposition algorithms. This grid system was chosen for this assessment as it is identical to that used in the PHPA fatal flaw investigation (SKM 2009) and the PHDMT report (DSD 2010).

6.4. Discrete Receptors

Dust concentrations were modelled at thirteen discrete receptors within the region, the names of which and locations of which are presented in **Table 6-1** and **Figure 6-1**. 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 (**Appendix A**). The Hospital site is also used as the site to demonstrate achievement of performance criteria established in the existing environmental approvals.

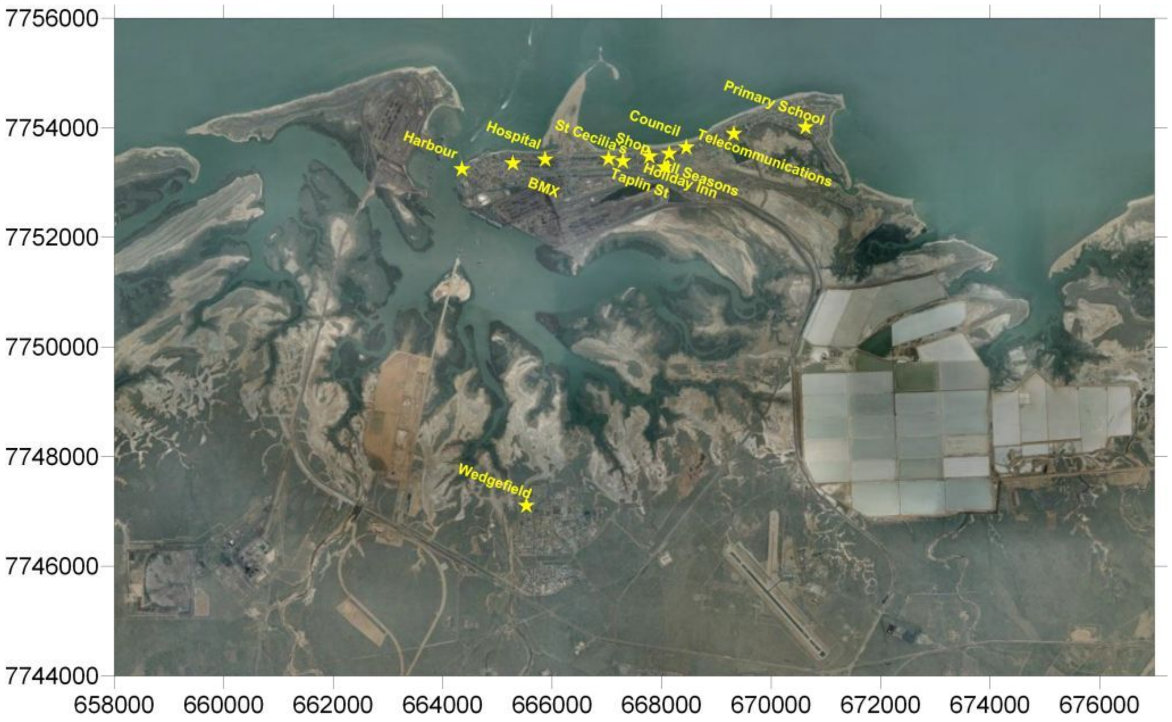
The site labelled Taplin Street represents the location at which the PHDMT recommended interim air quality management target (DSD 2010) is to be met.

The sites labelled BMX, St Cecilia's, Holiday Inn, Port Hedland Shop, All Seasons Hotel, Council Offices and Telecommunication Tower are conceptual locations that are used to determine the change in ground level concentrations throughout Port Hedland.

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. 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 was also assigned to Wedgefield because, although this area is classified as a light industrial area, there are residents within this precinct and previous air quality studies within the Port Hedland region have also assigned a receptor at this location (SKM 2009).

- **Table 6-1 Sensitive Receptor Locations for Model Interpretation**

Location	Sensitive Receptor	
	Easting	Northing
Harbour Monitor	664350	7753240
BMX	665281	7753352
Hospital Monitor	665870	7753420
Taplin St	667030	7753435
St Cecilia's	667292	7753390
Holiday Inn	667780	7753480
Port Hedland Shop	668050	7753280
All Seasons Hotel	668140	7753530
Council Offices	668450	7753640
Telecommunications Tower	669320	7753890
Port Hedland Primary School	670631	7754008
Port Hedland Senior High School	666600	7743439
Wedgefield	665526	7747107



- **Figure 6-1 Receptor locations**

6.5. Outer Harbour Development Proposed Layout

The layout of the proposed stockyards at Boodarie is shown in **Figure 6-2**. Each stockyard has a single row of five 200 kt stockpiles and is serviced by a luffing and slewing stacker and luffing and slewing bucket wheel reclaimer. The RSF yard has two 200 kt stockpiles and is serviced by a luffing and slewing stacker and a portal scraper reclaimer. The layout of the proposed wharf facilities are presented in **Figure 6-3**.

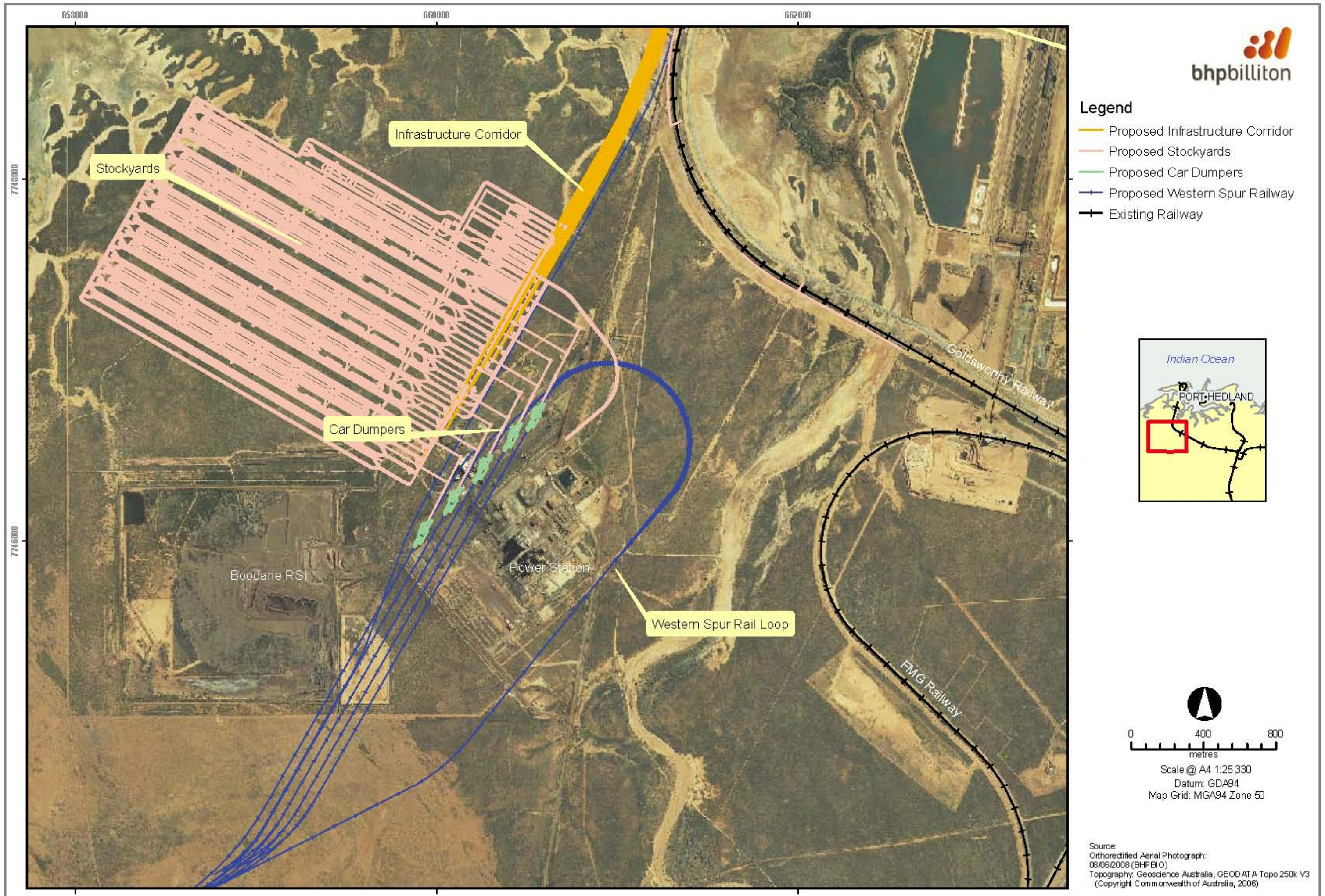
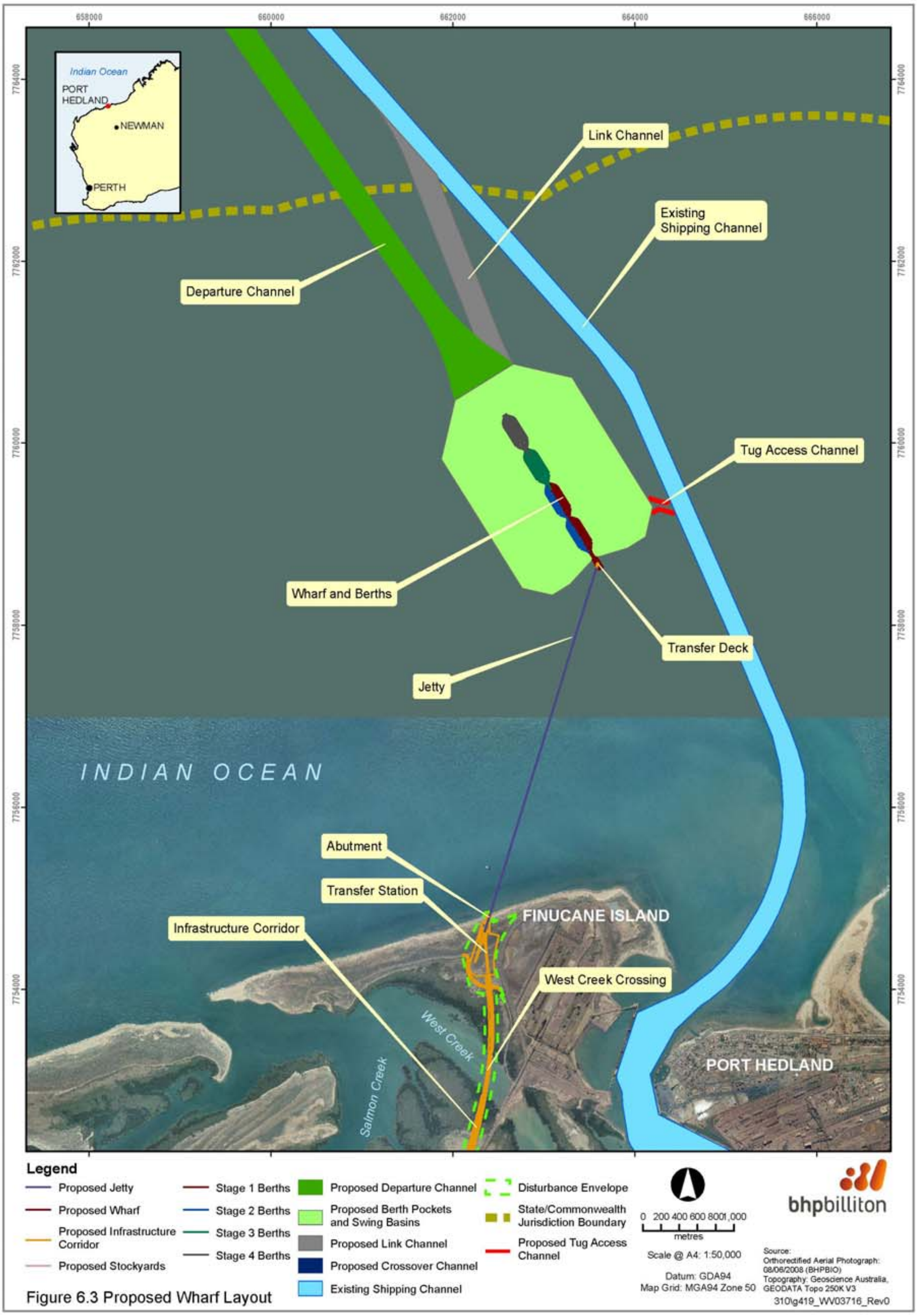


Figure 6.2 Proposed Stockyard Layout

- **Figure 6-2 Proposed Stockyard Layout**



- **Figure 6-3 Proposed Wharf Layout**

7. Model Results

This section presents the results of atmospheric dispersion modelling for the proposed Outer Harbour Development. The modelling results are presented for the 13 sensitive receptor locations identified (**Section 6.4**) and are compared to the the dust performance targets described in Ministerial Statement 740 and DSD (2010) (see **Section 2**).

7.1. Overview of Modelling

Modelling was conducted and results developed for four operational scenarios as presented in **Table 7-1**. The first two represent the gradual increase in tonnage by BHP Billiton Iron Ore operations while the final scenario incorporates the cumulative impact from existing and future operations including:

- 21 Mtpa from the PHPA Utah Point operations;
- 1 Mtpa from the existing PHPA operations at Nelson Point;
- 120 Mtpa from the FMG operations at Anderson Point;
- 55 Mtpa from the proposed Roy Hill operations in South West Creek; and
- 50 Mtpa from the proposed NWIOA in South West Creek.

The analysis of these results is presented in **Appendix E** and the results summarised below.

Table 7-1 Modelled Scenarios

	RGP5 (Inner Harbour)	Proposed Inner Harbour project	Outer Harbour Development	Additional Facilities	Total tonnage (Mtpa)
	215	255	240	247	
BHP Billiton Iron Ore					
1	✓				215
2		✓			255
3		✓	✓		495
Cumulative					
4		✓	✓	✓	742

7.2. BHP Billiton Iron Ore Future Dust Impact

7.2.1. PM_{10}

The predicted 24-hour PM_{10} statistics at the Hospital monitoring station and the proposed Taplin Street locality from the proposed Outer Harbour Development, with and without background concentrations, are displayed in **Table 7-2**. For reference, the background concentrations (**Section 3.1.5**) are also presented in this table. The results indicate that the proposed Outer Harbour Development, as a stand alone operation, is predicted to have minimal impact at the Hospital and Taplin Street receptors.

The proposed Outer Harbour Development is predicted to have no impact on the either the maximum or the 99th percentile predicted concentration and only relatively minor impacts on the remaining statistics, including the annual average.

- **Table 7-2 Statistics for Predicted PM_{10} Ground Level Hospital Concentrations from the proposed Outer Harbour Development ($\mu g/m^3$)**

Operation	Receptor	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Annual Average	Annual Exceedences of 70 $\mu g/m^3$
Background concentration								
Outer Habour Development (240 Mtpa)	Hospital	5	4	3	2	1	0.8	0
	Taplin St	5	3	3	2	1	0.7	0
Outer Habour Development (240 Mtpa) With background data	Hospital	71	57	40	33	23	21.0	1
	Taplin St	71	57	40	33	23	20.9	1

Note: The single annual exceedance that occurs in all scenarios is a function of a 'natural' background exceedance.

The predicted 24-hour PM_{10} statistics at the Hospital and Taplin Street locations from the proposed BHP Billiton Iron Ore developments (including background concentrations) and cumulative operations are displayed in **Table 7-3**. The results demonstrate that the short term target is exceeded in the background file and that the proposed Outer Harbour Development does not contribute to an increase in the number exceedances of the target. The number of exceedences falls below the limit of 10, thus meeting the short term PM_{10} criteria (**Section 2.3**).

The annual average PM_{10} criteria is exceeded by 1 $\mu g/m^3$ at the Hospital location with the introduction of the Outer Harbour Development. BHP Billiton Iron Ore is continuing to investigate additional dust abatement measures to ensure that all ministerial conditions (**Section 2.1**) and dust reduction targets (**Section** Error! Reference source not found.) are met.

The annual average criteria at the Hospital is also exceeded with the introduction of the cumulative modelling however it is important to note that the annual average target is only applicable to the contribution from BHP Billiton Iron Ore's operations (**Section 2.3**).

- **Table 7-3 Cumulative Statistics for Predicted PM_{10} Ground Level Hospital Concentrations (μg/m³)**

Operation	Receptor	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Annual Average	Annual Exceedences of 70 μg/m³
Background concentration		71	57	39	32	22	20	1
RGP5	Hospital	75	63	49	44	34	30	1
	Taplin St	73	61	47	40	300	26	1
RGP6	Hospital	76	64	49	44	34	30	1
	Taplin St	74	62	47	41	31	26	1
Outer Harbour Development (240 Mtpa) + RGP6	Hospital	76	65	51	45	35	31	1
	Taplin St	74	65	53	48	35	30	1
Outer Harbour Development (240 Mtpa) + RGP6 (CD5) + cumulative impact	Hospital	77	67	58	50	40	35	2
	Taplin St	74	65	53	48	35	30	1

The predicted 24-hour PM_{10} statistics at South Hedland and Wedgefield for the proposed Outer Harbour Development (including background concentrations) are displayed in **Table 7-4**. For reference, the background concentrations are also presented in this table. The results show that the proposed BHP Billiton Iron Ore expansions, including the Outer Harbour Development will have a relatively minor impact on dust concentrations at South Hedland and Wedgefield, and is predicted to result in no additional exceedances of the 70μg/m³ target. The largest increase in the predicted ground level concentrations occurred with the introduction of the cumulative sources, particularly at the Wedgefield receptor due to its close proximity to the proposed operations in the cumulative scenario.

- **Table 7-4 Statistics for Predicted PM_{10} Ground Level South Hedland and Wedgefield Concentrations from the Proposed Outer Harbour Development (μg/m³)**

Operation	Receptor	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Annual Average	Annual Exceedences of 70 μg/m³
Background Concentration	-	71	57	39	32	22	20	1
RGP5	South Hedland	71	57	40	33	23	21	1
	Wedgefield	71	58	40	34	23	21	1
RGP6	South Hedland	71	58	40	33	23	21	1
	Wedgefield	71	59	41	34	24	22	1
Outer Harbour Development (240 Mtpa) + RGP6 (CD5)	South Hedland	71	62	42	35	24	22	1
	Wedgefield	71	62	46	36	26	24	1
Outer Harbour Development (240 Mtpa) + RGP6 (CD5) + cumulative impact	South Hedland	72	67	45	38	27	24	2
	Wedgefield	82	72	55	47	35	30	6

7.2.2. Total Suspended Particulates

The predicted 24-hour TSP statistics at the Hospital monitoring station and the proposed Taplin Street locality from the proposed Outer Harbour Development, with and without background concentrations, are displayed in **Table 7-5**. For reference, the background concentrations are also presented in this table. From the results presented in this table, it is evident that the proposed Outer Harbour Development, as a stand alone operation, is predicted to have minimal impact at the Hospital and Taplin Street receptors. The proposed Outer Harbour Development is predicted to have no impact on the maximum concentration and only relatively minor impacts on the remaining statistics, including the annual average.

- **Table 7-5 Statistics for Predicted TSP Ground Level Hospital Concentrations from the proposed Outer Harbour Development (μg/m³)**

Operation	Receptor	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Annual Average
Background concentration		151	83	60	50	33	33.3
Outer Habour Development (240 Mtpa)	Hospital	6	5	3	3	1	1.0
	Taplin St	6	5	4	3	1	0.9
Outer Habour Development (240 Mtpa) With background data	Hospital	151	84	62	51	36	34.4
	Taplin St	151	84	61	51	36	34.3

The predicted 24-hour PM_{10} statistics at the Hospital and Taplin Street locations from the proposed BHP Billiton Iron Ore developments (including background concentrations) and cumulative operations are displayed in **Table 7-6**. The model predicts an annual average concentration which is less than the target of 65 μg/m³ (**Section 2.3**) from operations associated with the proposed developments.

- **Table 7-6 Cumulative Statistics for TSP Ground Level Hospital Concentrations (μg/m³)**

Operation	Receptor	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Annual Average
Background concentration		151	83	60	50	33	33.3
RGP5	Hospital	158	99	79	70	55	50.5
	Taplin St	154	88	71	63	49	43.1
RGP6	Hospital	167	95	81	71	56	51.1
	Taplin St	156	87	73	66	49	43.5
Outer Harbour Development (240 Mtpa) + RGP6	Hospital	167	97	83	73	58	52.2
	Taplin St	156	88	75	68	50	44.4
Outer Harbour Development (240 Mtpa) + RGP6 (CD5) + cumulative impact	Hospital	167	113	94	83	66	58.1
	Taplin St	156	94	83	76	56	48.6

The predicted 24-hour TSP statistics at South Hedland and Wedgefield for the proposed Outer Harbour Development (including background concentrations) are displayed in **Table 7-7**

For reference, the background concentrations are also presented in this table. The results show that the proposed BHP Billiton Iron Ore expansions, including the Outer Harbour Development, will have a relatively minor impact on dust concentrations at South Hedland and Wedgefield. The largest increase in the predicted ground level concentrations occurred with the introduction of the cumulative sources particularly at the Wedgefield receptor due to its close proximity to the proposed operations in the cumulative scenario.

- **Table 7-7 Statistics for Predicted TSP Ground Level South Hedland and Wedgefield Concentrations from the proposed Outer Harbour Development (μg/m³)**

Operation	Receptor	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Annual Average
Background concentration		151	83	60	50	33	33.3
RGP5	South Hedland	151	84	61	51	35	34.0
	Wedgefield	151	85	62	52	37	34.9
RGP6	South Hedland	151	84	61	52	36	34.3
	Wedgefield	151	85	62	53	37	35.4
Outer Harbour Development (240 Mtpa) + RGP6	South Hedland	151	84	65	54	39	36.6
	Wedgefield	151	86	67	58	42	38.6
Outer Harbour Development (240 Mtpa) + RGP6 (CD5) + cumulative impact	South Hedland	151	84	69	57	43	39.1
	Wedgefield	152	110	83	75	56	48.9

8. Conclusion

8.1. Overview

Using the Gaussian dispersion model AUSPLUME, a numerical dispersion-modelling package was developed for proposed stockyards located adjacent to the decommissioned Boodarie Plant.

The model was validated for operations using:

- operational data on throughput tonnages, ore type and ore moisture determined from BHP Billiton Iron Ore on-site records;
- time series input data file containing meteorological data for 2004/05 recorded by the Bureau of Meteorology at the Port Hedland Airport;
- source emissions determined by field investigations conducted during 2001, 2004 and 2005; and
- TSP and PM_{10} concentrations recorded at the Harbour and Hospital dust monitors within the town of Port Hedland.

Comparison of the predicted concentration distributions to the measured concentration distributions demonstrated that the model over-predicts for PM_{10} at the town of Port Hedland and the Hospital monitor sites but under-predicts for TSP at the same locations (**Appendix A**).

The emissions were re-calculated using the same methodology as that used in the 2004/2005 model validation (SKM 2006). It should be noted that this estimation technique has been utilised to obtain an emission file to allow for conceptual model runs to be conducted.

Modelling of the proposed Outer Harbour Development in isolation (including engineering controls) indicates minimal impact at the Hospital receptor. The modelling of current and proposed BHP Billiton Iron Ore operations indicates that at the Hospital monitoring station:

- the number of exceedences of the PM_{10} 24-hour short term concentration target at both the Hospital and Taplin Street receptors are within the specified criteria;
- the annual average PM_{10} criteria will potentially be exceeded though further investigations are currently been conducted to determine the effectiveness of additional dust abatement measures within the existing stockyards at Nelson Point and Finucane Island, to ensure that the required dust targets are met;
- the TSP annual average will be achieved; and
- using the Hospital criteria as comparison, the dust impact at South Hedland and Wedgefield meet criteria limits.

9. References

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Appendix A Model Calibration/Validation

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 for estimating dispersion range from simple empirical expressions to very complex numerical solutions of the conservation equations governing pollutant concentration. Due to the complexity of atmospheric transport processes, practical or operational dispersion models rely heavily on empiricism.

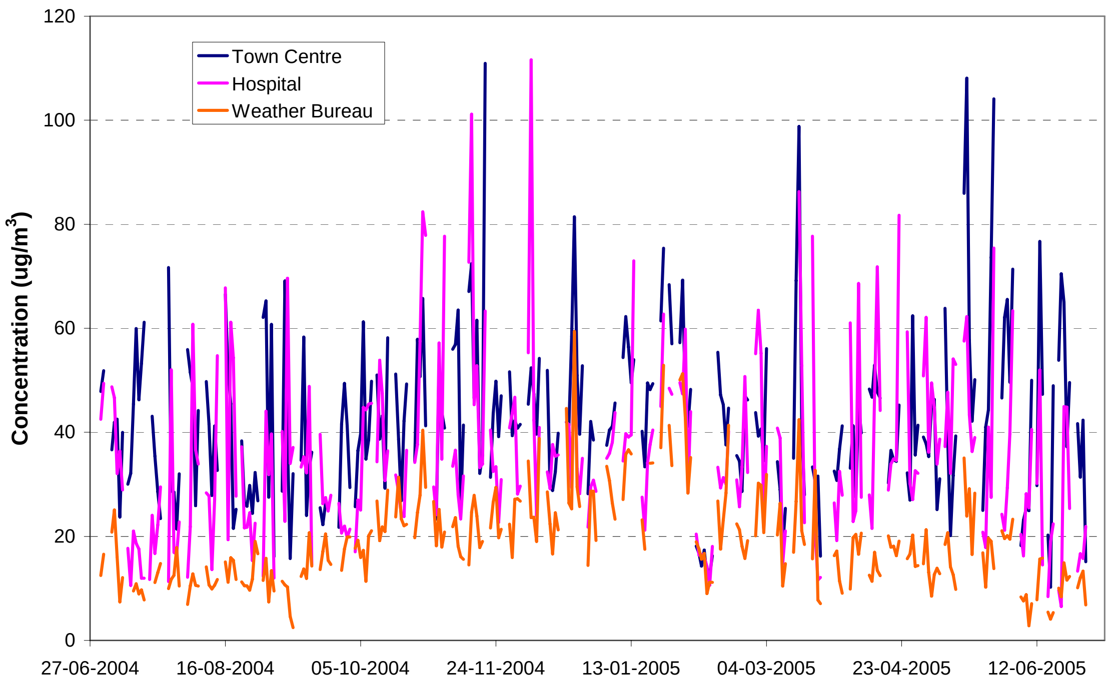
It is generally accepted that errors in air pollution modelling results can be large (Hanna et al, 1982). This, in conjunction with the large uncertainty of many of the model inputs for fugitive dust emissions, means that results should be closely examined and used cautiously. Verification of models with practical impact data becomes an essential part of any overall impact prediction/assessment process.

9.1. Model Validation

Fundamental to the development of confidence in the model is a comparison of the calculated ambient concentrations with available monitored values. It is now recognised that model predictions are poorly correlated with hourly observations paired in time and space. The predicted absolute maximum is typically accurate within a factor of two, and the observed and predicted values are within a factor of two of each other only about 30-50% of the time. However, models can simulate the ground-level patterns of concentration fairly well.

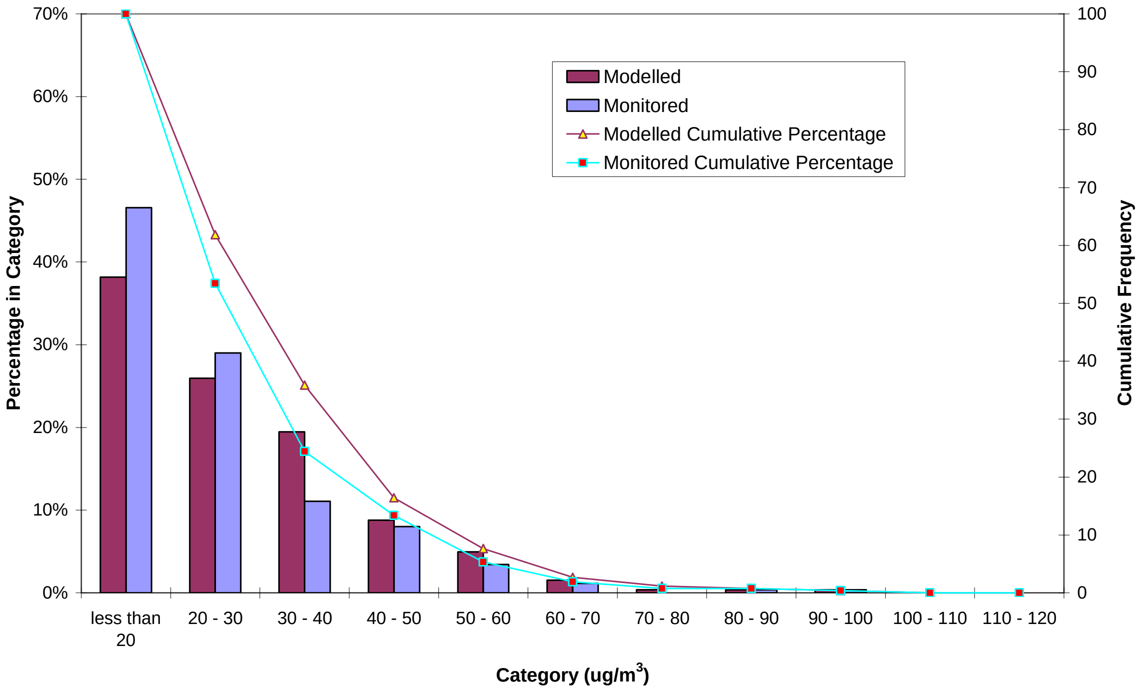
Uncertainties in monitored data, such as local sources (for example dirt roads adjacent to monitoring sites) mean monitored values may not be truly representative of the scale of variability of dust levels in the Port Hedland as a whole. Therefore, error analyses that relate model results to monitoring stations may reflect as much uncertainty in the monitoring data as in the model data. A better criterion for the evaluation of model results is the comparison of the frequency distribution for high values.

To validate the AUSPLUME model and confirm its effectiveness as a predictor of present and future ground level concentrations, frequency distributions of estimates of PM_{10} and TSP ground level concentrations were compared with fugitive dust levels at current monitoring locations within the town of Port Hedland. The daily average PM_{10} concentrations measured at the Harbour and Hospital monitors during 2004 and 2005 are shown in **Figure A -** 1 . As input for validation, the model simulated the operations that occurred during 2004/05, with actual ore tonnages and ore moisture used to estimate the dust generated from the various plant, stockpiles and vehicles. The strength, frequency and location of the various on- and off-site sources were "fine-tuned" in the validation process.

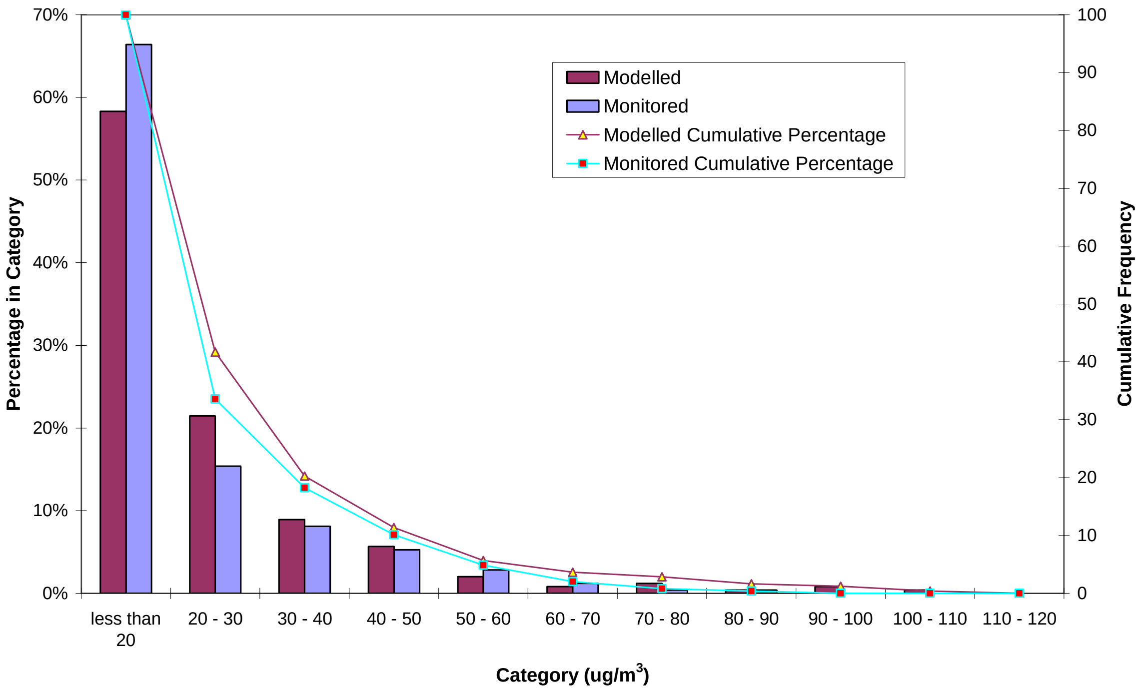


- **Figure A - 1 Daily Average PM_{10} Concentrations as Measured at Port Hedland during 2004/05**

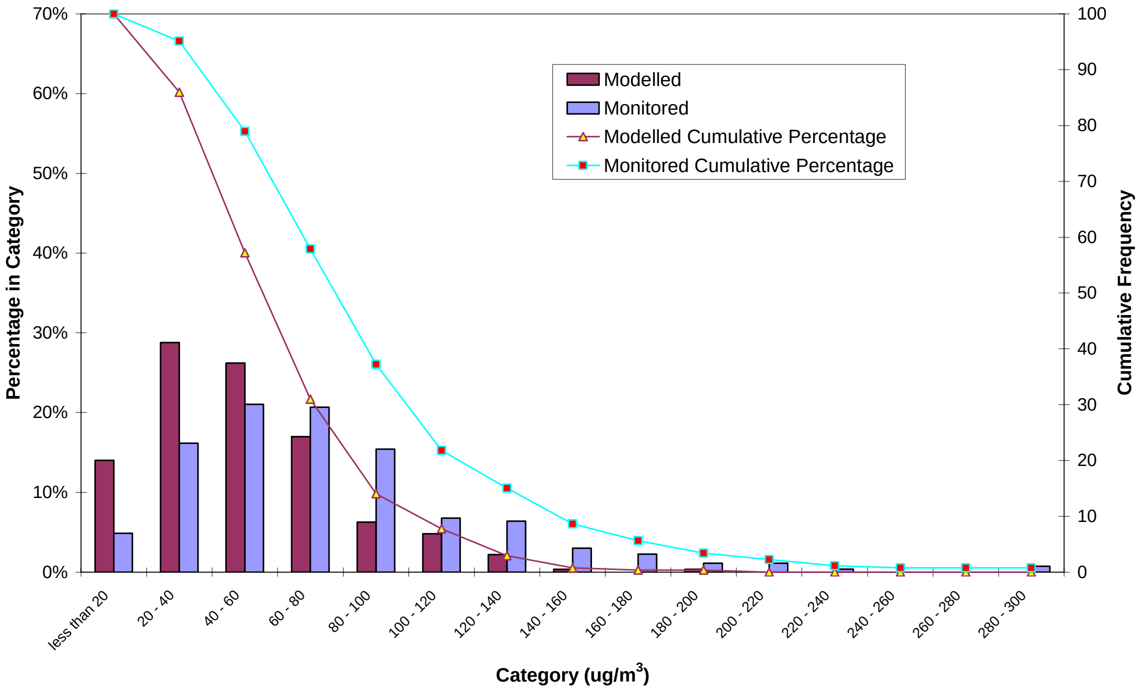
The ability of the modelling package to predict dust concentrations within the town of Port Hedland is evidenced from **Figure A-2** to **Figure A-5.** These graphs compare the frequency distributions of PM_{10} concentrations predicted by the model for the year 2004/2005 with those concentrations recorded at the residential monitors over the same period. From these figures it can be seen that the model has a tendency for over-prediction at both the Harbour and the Hospital monitoring stations for PM_{10} while there is a tendency for under-prediction for TSP.



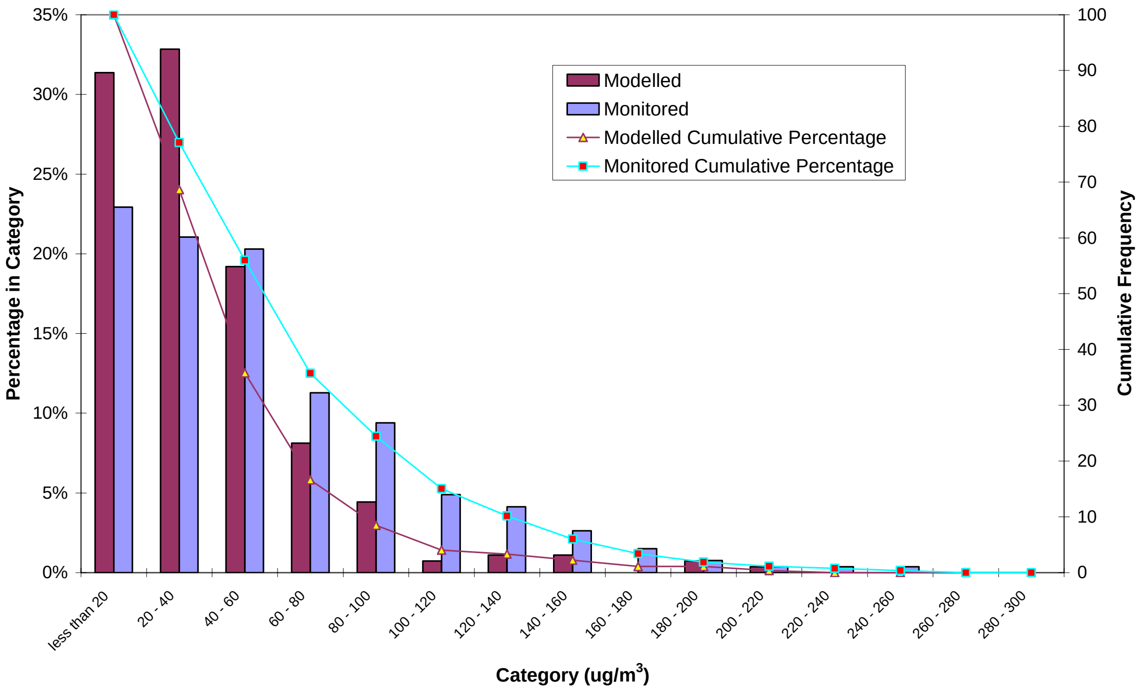
- **Figure A - 2 PM_{10} Calibration for 2004/05 at the Harbour Monitor**



- **Figure A - 3 PM_{10} Calibration for 2004/05 at the Hospital Monitor**



- **Figure A - 4 TSP Calibration for 2004/05 at the Harbour Monitor**

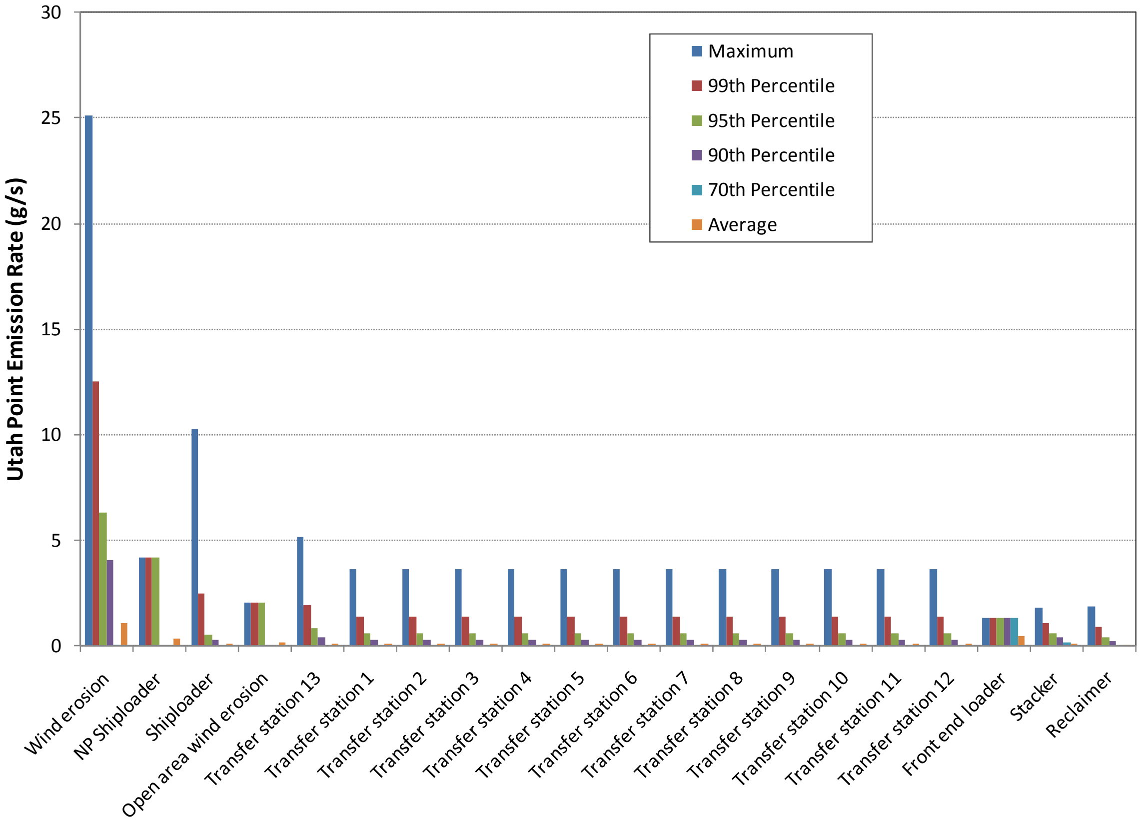


- **Figure A - 5 TSP Calibration for 2004/05 at the Hospital Monitor**

Appendix B Emission Estimation

B.1 Emission Estimates from Port Hedland Port Authority (Utah Point)

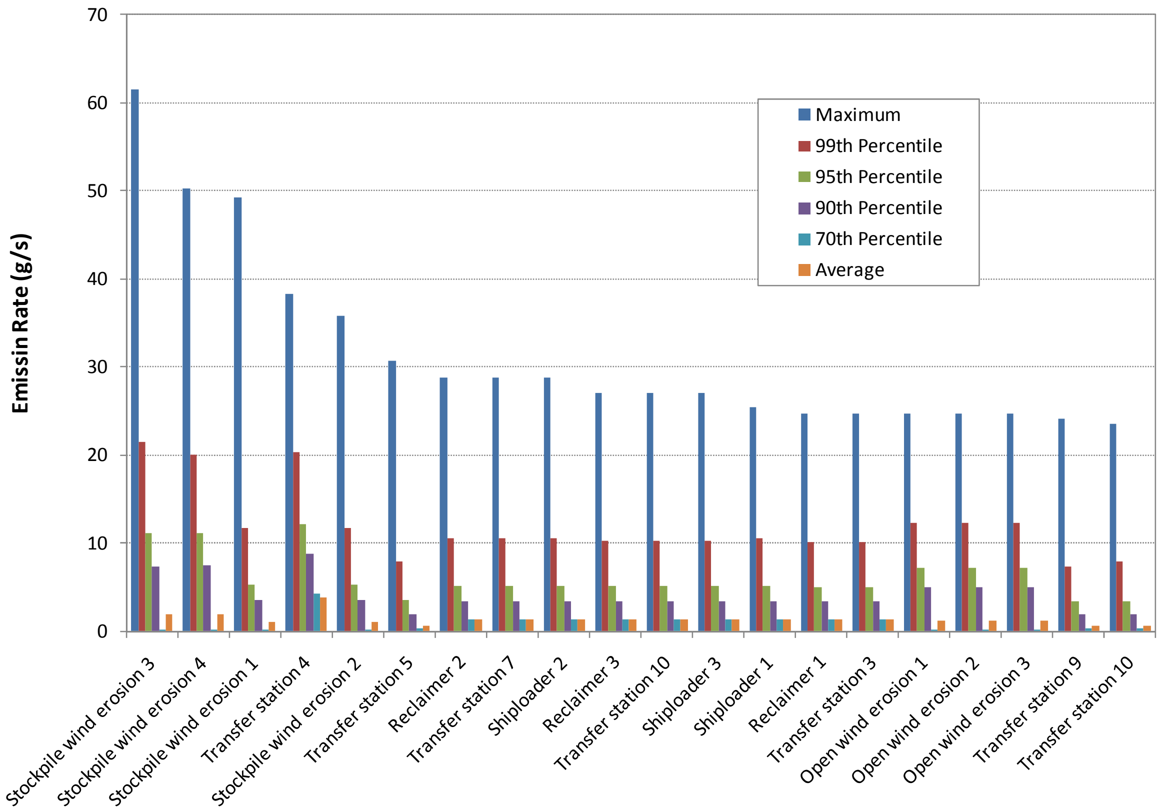
The emission file for the PHPA Utah Point operations at 21 Mtpa was obtained from the PHPA and is identical to that used in the Fatal Flaw study (SKM 2009). Emission rankings for Utah Point operations are presented in **Figure B - 1** and show a relatively uniform emission rate derived predominantly from wind erosion, shiploaders and transfer stations located at Utah Point.



- **Figure B - 1 Top 20 Calculated PM_{10} Emission Rates for the Proposed Utah Point Development (21 Mtpa)**

B.2 Emission Estimates from Fortescue Metals Group (Anderson Point)

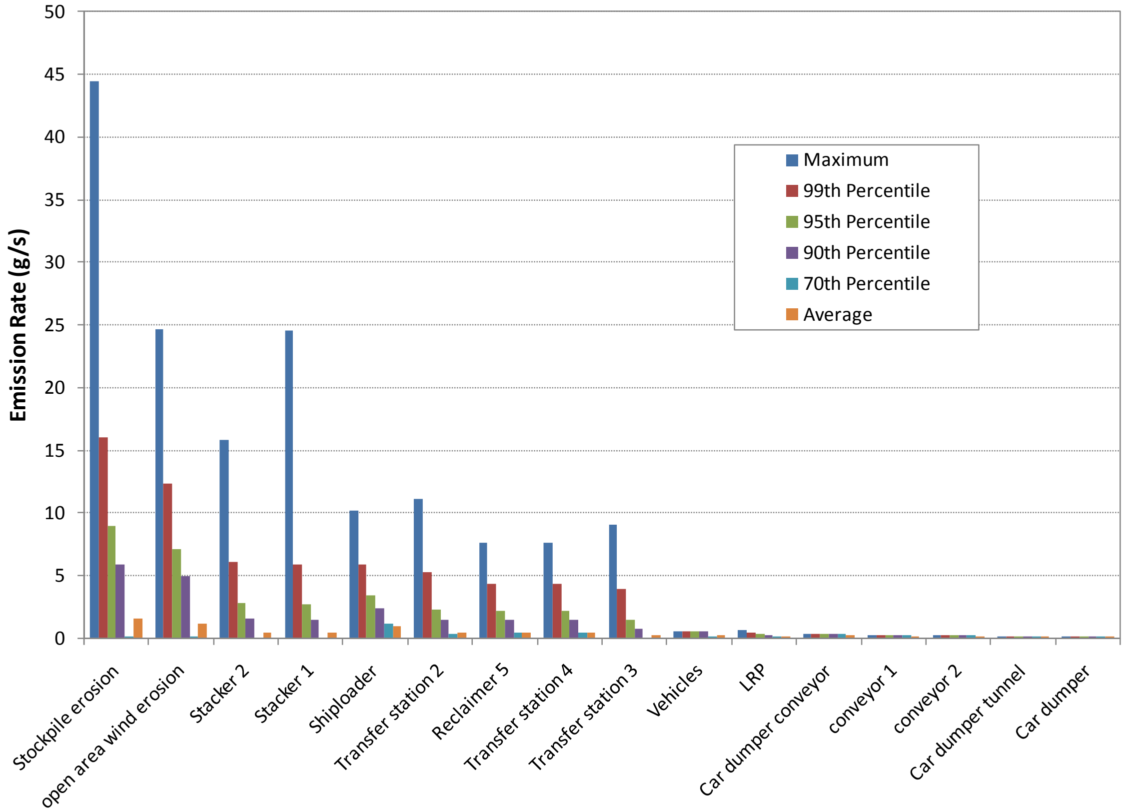
The emission file for the FMG operations at 120 Mtpa was obtained from the PHPA and is identical to that used in the Fatal Flaw study (SKM 2009). Emission rankings for FMG operations are presented in **Figure B - 2** and show that the highest emissions are associated with wind erosion from stockpiles.



- **Figure B - 2 Calculated PM_{10} Emission Rates from FMG at 120 Mtpa**

B.3 Emission Estimates from Roy Hills (South West Creek)

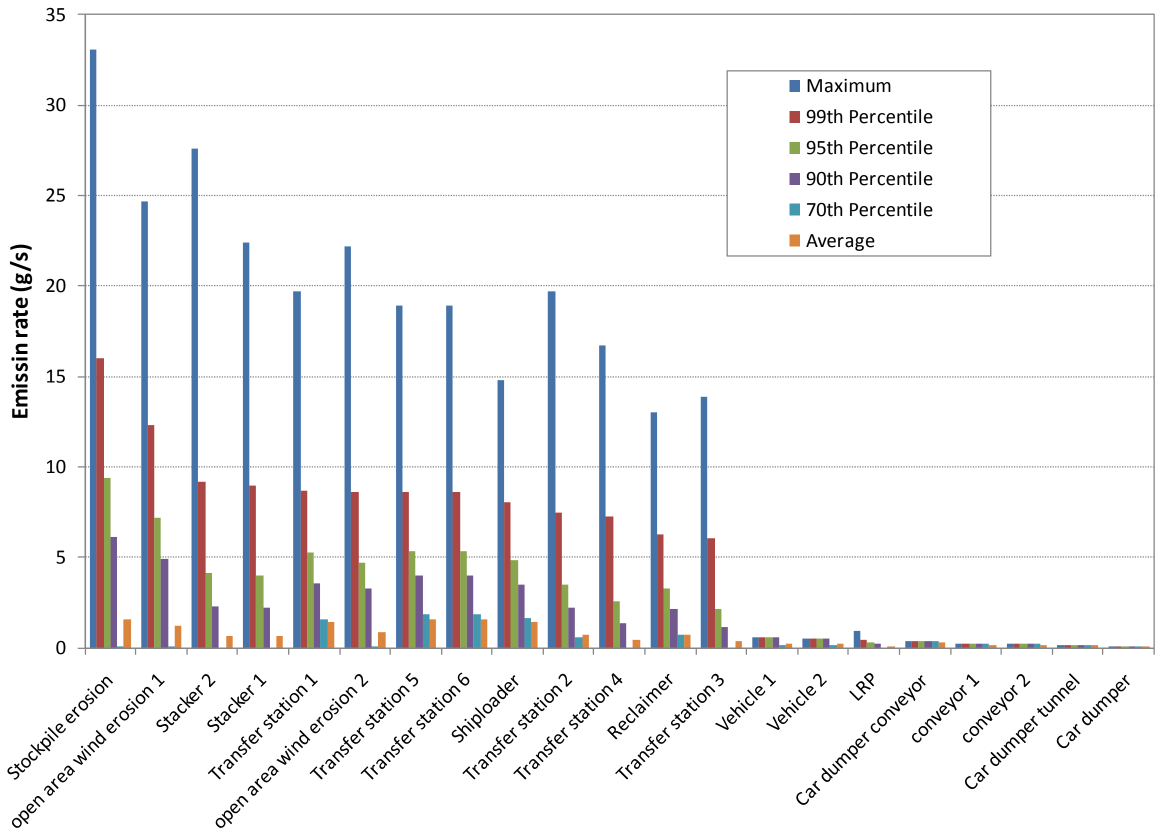
The emission file for the Roy Hills operations at 55 Mtpa was obtained from the PHPA and is identical to that used in the Fatal Flaw study (SKM 2009). Emission rankings for Roy Hills operations are presented in **Figure B – 3** and show that the highest emissions are associated with wind erosion from stockpiles and stackers.



■ **Figure B - 3 Calculated PM_{10} Emission Rates from Roy Hills at 55 Mtpa**

B.4 Emission Estimates from North West Iron Ore Alliance (South West Creek)

The emission file for the proposed NWIOA operations at 50 Mtpa was obtained from the PHPA and is identical to that used in the Fatal Flaw study (SKM 2009). Emission rankings for NWIOA operations are presented in **Figure B – 4** and show that the highest emissions are associated with wind erosion from stockpiles.



- **Figure B - 4 Calculated PM_{10} Emission Rates from Roy Hills at 55 Mtpa**

Appendix C AUSPLUME Configuration File

```
1            _______________________________________________________

                ESY CaerusCase3 RGP6b, PM10, Receptor, 7Jan2011, JDH

             _______________________________________________________

 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

                   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           ________________________________________________________

              ESY CaerusCase3 RGP6b, PM10, Receptor, 7Jan2011, JDH

                             SOURCE CHARACTERISTICS

            ________________________________________________________


                    VOLUME SOURCE: CD4SD

   X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
 663310  7754160            0m             3m          3m            2m

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

        Hourly multiplicative factors will be used with
        this emission factor.

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


                    VOLUME SOURCE: CD4-T

   X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
 663250  7753910            0m             2m          2m            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: CD4-C

  X(m)     Y(m)     Ground Elevation     Height   Hor. spread   Vert. spread
663190  7753810            0m              5m          8m            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: TS865

  X(m)     Y(m)     Ground Elevation     Height   Hor. spread   Vert. spread
662950  7753490            0m             10m          3m            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: EY-S11

  X(m)     Y(m)     Ground Elevation     Height   Hor. spread   Vert. spread
663260  7753455            0m              5m         50m            5m

           (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: EY-R8

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread    Vert. spread
663310  7753605             0m             5m         30m            4m

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

     Hourly multiplicative factors will be used with
     this emission factor.

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


                VOLUME SOURCE: EY-S12

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread    Vert. spread
663340  7753870             0m            10m         28m            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: EY-SW1

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread    Vert. spread
663450  7753690             0m            10m         28m            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: EY-SW2

   X(m)     Y(m)      Ground Elevation     Height    Hor. spread    Vert. spread
  663150  7753450             0m             10m         28m             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: EY-A1

   X(m)     Y(m)      Ground Elevation     Height    Hor. spread    Vert. spread
  663150  7753310             0m              1m         50m             0m

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

        Hourly multiplicative factors will be used with
        this emission factor.

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


                  VOLUME SOURCE: EY-VEH

   X(m)     Y(m)      Ground Elevation     Height    Hor. spread    Vert. spread
  663190  7753390             0m              1m         40m             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: EYBROL

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663495	7754150	0m	1m	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: EY-SL2

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663910	7752190	0m	10m	40m	6m

(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: TS890

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663090	7753385	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: TS809

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663520	7752930	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: TS901

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663815	7752735	0m	7m	3m	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: CD5

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663355	7754145	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: CD5-T

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663260	7753995	0m	2m	2m	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: CD5-C

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663195	7753876	0m	5m	8m	3m

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

Hourly multiplicative factors will be used with this emission factor.

Particle Mass	Particle Size	Particle 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: TS910

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
662965	7753420	0m	10m	3m	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: TS911

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663260	7753265	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: CD6

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663420	7754185	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: CD6-T

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663390	7754110	0m	2m	2m	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: CD6-C

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663220	7753800	0m	5m	8m	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: CD6TS

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663020	7753430	0m	10m	3m	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
```

```
1          _______________________________________________________

        ESY CaerusCase3 RGP6b, PM10, Receptor, 7Jan2011, JDH

                        RECEPTOR LOCATIONS

           _______________________________________________________


 DISCRETE RECEPTOR LOCATIONS (in metres)

 No.     X       Y     ELEVN  HEIGHT       No.     X       Y     ELEVN  HEIGHT
  1  664350 7753240     0.0    2.0          8  668140 7753530     0.0    2.0
  2  665281 7753352     0.0    2.0          9  668450 7753640     0.0    2.0
  3  665870 7753420     0.0    2.0         10  669320 7753890     0.0    2.0
  4  667030 7753435     0.0    2.0         11  670631 7754008     0.0    2.0
  5  667292 7753390     0.0    2.0         12  666600 7743439     0.0    2.0
  6  667780 7753480     0.0    2.0         13  665526 7747107     0.0    2.0
  7  668050 7753280     0.0    2.0
```

```
 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:
 C:\AUSPLUME\Quantum\RGP6b\ESYEmissions_CaerusCase3_RGP6b_4Jan11.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:
 ESY CaerusCase3 RGP6b 4Jan2011, JDH, PAEHolmes
```

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

Prefix CD4SD  allocated: CD4SD
Prefix CD4-T  allocated: CD4-T
Prefix CD4-C  allocated: CD4-C
Prefix TS865  allocated: TS865
Prefix EY-S11 allocated: EY-S11
Prefix EY-R8  allocated: EY-R8
Prefix EY-S12 allocated: EY-S12
Prefix EY-SW1 allocated: EY-SW1
Prefix EY-SW2 allocated: EY-SW2
Prefix EY-A1  allocated: EY-A1
Prefix EY-VEH allocated: EY-VEH
Prefix EYBROL allocated: EYBROL
Prefix EY-SL2 allocated: EY-SL2
Prefix TS890  allocated: TS890
Prefix TS809  allocated: TS809
Prefix TS901  allocated: TS901
Prefix CD5    allocated: CD5
Prefix CD5-T  allocated: CD5-T
Prefix CD5-C  allocated: CD5-C
Prefix TS910  allocated: TS910
Prefix TS911  allocated: TS911
Prefix CD6    allocated: CD6
Prefix CD6-T  allocated: CD6-T
Prefix CD6-C  allocated: CD6-C
Prefix CD6TS  allocated: CD6TS
```

Appendix D 2004/2005 Meteorological File

Stability Classes

	A	B	C	D	E	F	Total
Number	48	534	1445	5040	1301	248	8616
Percent	0.56	6.20	16.77	58.50	15.10	2.88	

Stability Class by Wind direction

	A	B	C	D	E	F
N	0.5	6.7	21.1	59.3	9.6	2.8
NE	1.9	14.1	31.3	36.8	13.3	2.5
E	0.8	7.3	22.0	59.1	8.3	2.4
SE	0.6	6.4	19.0	59.9	11.3	2.7
S	0.8	8.0	14.3	50.9	22.2	3.7
SW	0.8	7.7	16.0	39.5	31.3	4.8
W	0.1	2.2	7.4	67.8	19.6	2.9
NW	0.3	5.3	16.0	65.6	10.8	2.1

Stabilty Class by Hour of Day

Hour	A	B	C	D	E	F
1	0	0	0	239	104	16
2	0	0	0	243	104	12
3	0	0	0	233	101	25
4	0	0	0	222	113	24
5	0	0	0	205	128	26
6	0	0	0	205	122	32
7	0	21	124	143	58	13
8	0	36	225	98	0	0
9	3	101	137	118	0	0
10	14	111	125	109	0	0
11	19	98	159	83	0	0
12	9	74	203	73	0	0
13	2	52	217	88	0	0
14	1	33	168	157	0	0
15	0	7	55	297	0	0
16	0	1	29	329	0	0
17	0	0	3	356	0	0
18	0	0	0	344	13	2
19	0	0	0	311	44	4
20	0	0	0	265	79	15
21	0	0	0	239	95	25
22	0	0	0	217	118	24
23	0	0	0	231	109	19
24	0	0	0	235	113	11

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	103	97	80	43	24	9	5	6	3
1800 to 2000 m	10	4	8	2	1	1	5	7	24	27	35	39	59	76	85	71	76	61	40	28	12	7	9	12
1600 to 1800 m	10	6	5	11	8	9	7	8	29	29	34	40	56	51	46	56	57	55	48	23	26	18	8	10
1400 to 1600 m	14	9	9	8	11	11	11	15	21	24	36	44	53	62	52	50	46	41	41	38	23	25	14	9
1200 to 1400 m	41	44	40	37	28	28	30	43	40	51	45	62	56	56	46	41	39	57	50	38	45	46	57	35
1000 to 1200 m	64	69	74	68	76	71	55	49	52	52	65	60	50	27	27	20	26	32	47	56	59	44	54	65
800 to 1000 m	99	106	94	93	80	83	74	61	70	49	39	30	21	18	10	9	12	16	42	58	65	72	83	100
600 to 800 m	0	0	0	1	0	0	46	87	47	38	22	17	8	6	8	4	4	1	0	0	0	0	0	0
400 to 600 m	0	1	0	1	0	0	36	56	33	14	12	7	6	1	3	4	2	1	0	0	0	0	0	0
200 to 400 m	0	0	1	0	0	0	16	19	22	12	6	4	2	3	1	1	0	7	8	11	12	10	1	0
0 to 200 m	120	116	126	137	154	154	77	11	5	1	2	0	0	1	0	0	0	8	40	83	108	132	127	125

Wind Occurence Matrix

Speed (m/s)	N	NE	E	SE	S	SW	W	NW	Total
<0.5 (calm)									0.00
0.5 - 1.9	0.59	0.28	0.55	0.70	0.87	0.80	0.92	0.62	5.32
2.0 - 3.9	2.33	1.18	2.10	4.63	4.65	5.30	5.49	3.97	29.67
4.0 - 5.9	4.04	1.20	3.01	5.44	3.62	2.43	6.78	5.51	32.02
6.0 - 7.9	3.95	0.84	2.34	2.26	0.63	0.51	2.45	5.54	18.51
8.0 - 9.9	2.54	0.58	1.89	1.18	0.16	0.16	1.18	4.49	12.20
10.0 - 11.9	0.31	0.10	0.53	0.34	0.03	0.02	0.21	0.62	2.17
12.0 - 13.9	0.00	0.01	0.02	0.02	0.00	0.00	0.03	0.02	0.12
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	13.77	4.19	10.45	14.58	9.97	9.23	17.06	20.76	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)																	0.0
0.5 - 1.9	0.4	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.5	0.4	0.4	0.4	0.6	0.3	0.4	0.2	5.3
2.0 - 3.9	1.4	0.6	0.6	0.7	1.1	1.4	2.5	2.5	2.4	2.1	3.0	2.6	3.0	2.4	2.1	1.3	29.7
4.0 - 5.9	2.1	1.3	0.6	0.5	1.3	2.7	3.0	2.1	2.1	0.9	1.2	2.0	4.3	2.3	3.4	2.2	32.0
6.0 - 7.9	2.2	0.9	0.5	0.4	1.3	1.9	1.0	0.4	0.4	0.2	0.3	0.5	1.4	1.7	3.6	1.9	18.5
8.0 - 9.9	1.6	0.5	0.4	0.2	1.1	1.3	0.6	0.1	0.1	0.0	0.1	0.1	0.5	1.9	3.0	0.7	12.2
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	2.2
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	7.9	3.6	2.3	1.9	5.4	7.7	7.7	5.6	5.4	3.6	5.0	5.6	9.8	9.3	12.7	6.4	100.0

Ave wind speed = 5.17

Wind Speed range (m/s)	Count	Percentage (%)
0.00 - 0.99	0	0.00
1.00 - 1.99	458	5.32
2.00 - 2.99	838	9.73
3.00 - 3.99	1718	19.94
4.00 - 4.99	1423	16.52
5.00 - 5.99	1336	15.51
6.00 - 6.99	943	10.94
7.00 - 7.99	652	7.57
8.00 - 8.99	740	8.59
9.00 - 9.99	311	3.61
10.00 - 10.99	142	1.65
11.00 - 11.99	45	0.52
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 E Scenario Analysis

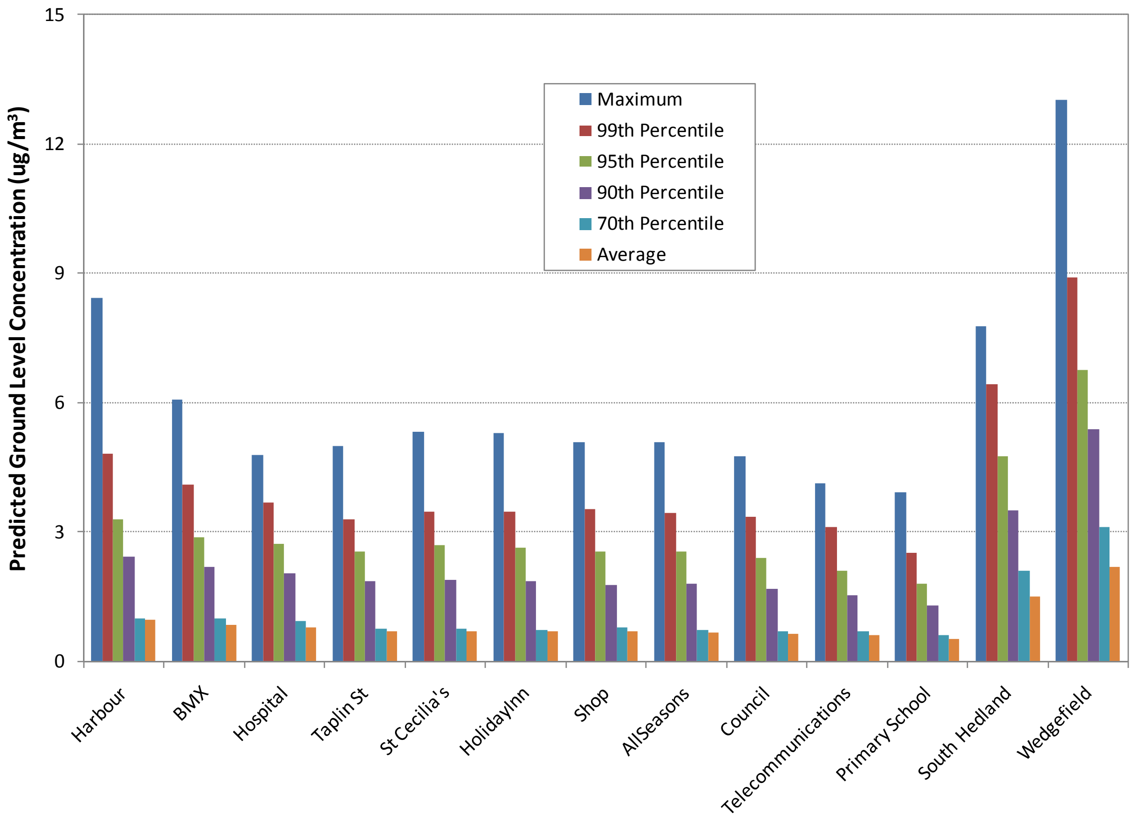
This Appendix details the results of all modelled scenarios outlined in **Section** 7.1 of the main body of the report. PM_{10} and TSP results for all four scenarios are described and compared to the relevant criteria.

E.1 Outer Harbour Development (standalone)

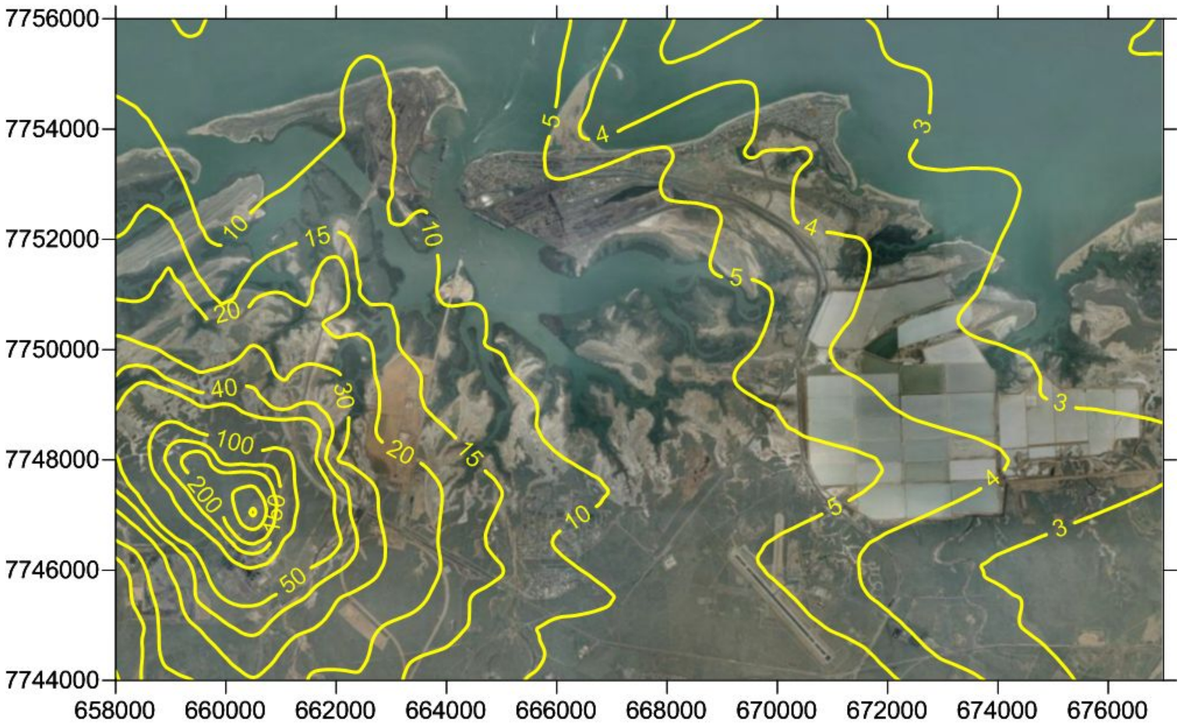
The first case modelled examines the potential impact of the proposed Outer Harbour Development as a standalone operation. The ground level PM_{10} concentrations predicted to occur at the thirteen sensitive receptor sites (see **Figure 6-1**) as a result of the proposed operations are presented in **Figure E-1**. For this figure it is evident that Wedgefield will experience a maximum predicted 24 hour average PM_{10} concentration of 13 $\mu g/m^3$ and a predicted increase in the annual average concentration of 2.2 $\mu g/m^3$ due to its proximity to the proposed operations.

The Hospital monitor is predicted to have an increase in the annual average concentration of 0.8 $\mu g/m^3$ while the maximum 24 hour average PM_{10} concentration is predicted to be 5 $\mu g/m^3$. The maximums at receptors within Port Hedland are attributable to high emissions from stackers under poor meteorological conditions. However, the concentrations at these receptors are low on average, making these maximums isolated events. Background is not included in these results.

The impact of the Outer Harbour Development, as a standalone operation without background concentrations, is represented as a contour plot in **Figure E-2**.



- **Figure E-1 Statistics of Predicted 24-hour PM_{10} Ground Level Concentrations from the Proposed Outer Harbour Development (standalone with no background)**

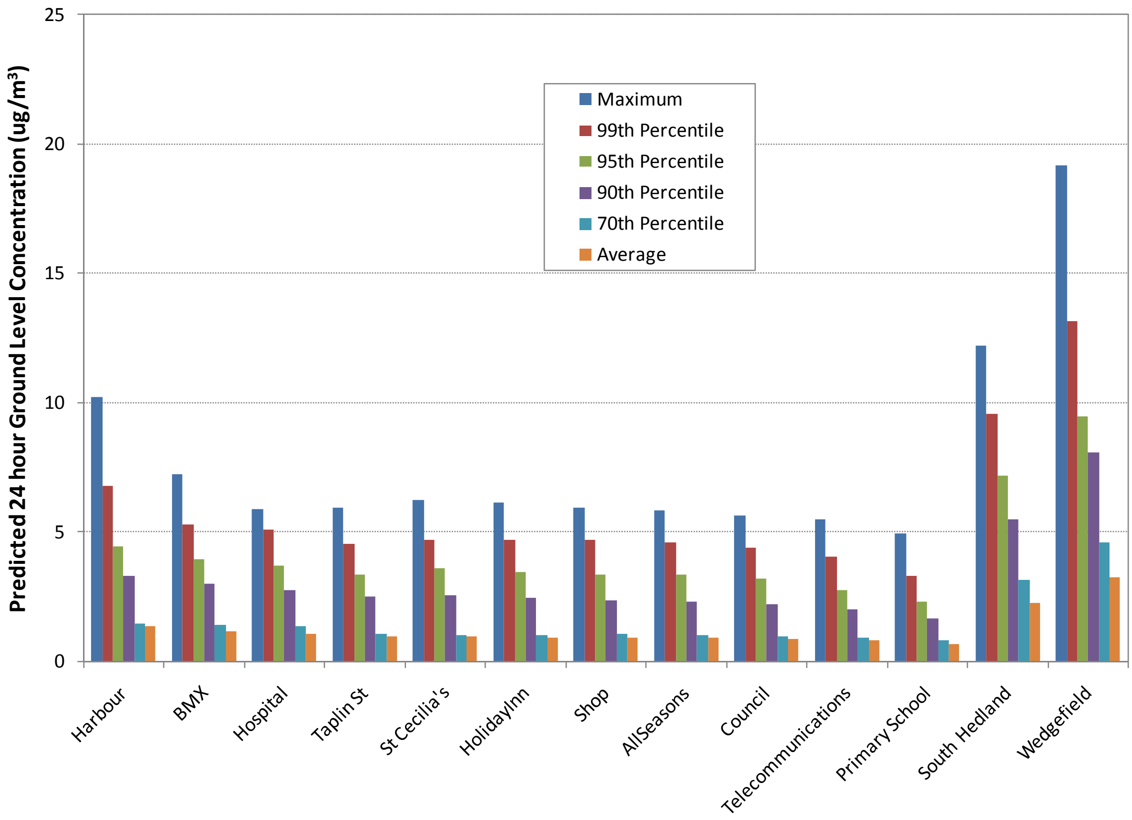


- **Figure E-2 Maximum Predicted 24-hour PM_{10} Ground Level Concentrations from the Proposed Outer Harbour Development (no background)**

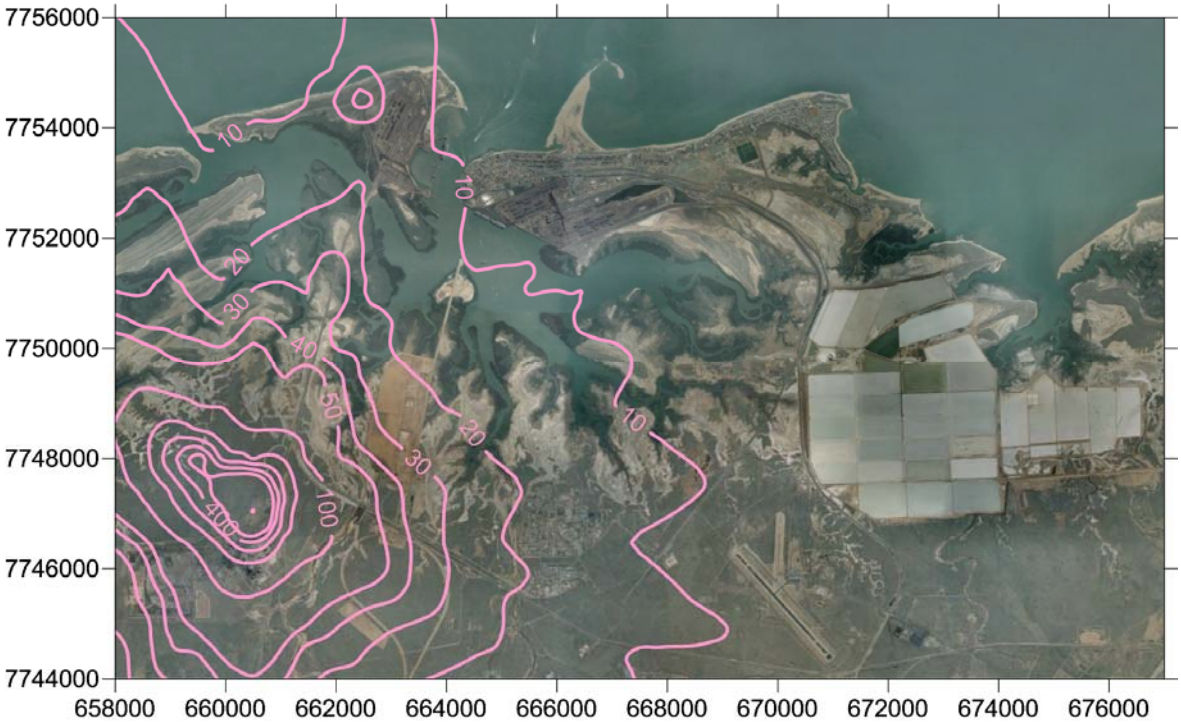
As mentined previously the first case modelled examines the potential impact of the proposed Outer Harbour Development as a standalone operation. The predicted ground level TSP concentrations at the thirteen sensitive receptor sites (see **Figure 6-1**) as a result of the proposed operations are presented in **Figure E-3**. For this figure it is evident that Wedgefield will experience a maximum predicted 24 hour average TSP concentration of 19 $\mu g/m^3$ and a predicted increase in the annual average concentration of 3.2 $\mu g/m^3$ due to its proximity to the proposed operations.

The Hospital monitor is predicted to have an increase in the annual average concentration of 1.1 $\mu g/m^3$ while the maximum 24 hour average TSP concentration is predicted to be 6 $\mu g/m^3$. The maximums at receptors within Port Hedland are attributable to high emissions from stackers under poor meteorological conditions. However, the concentrations at these receptors are low on average, making these maximums isolated events. Background is not included in these results.

The impact of the Outer Harbour Development, as a standalone operation without background concentrations, is represented as a contour plot in **Figure E-4**.



- **Figure E-3 Statistics of Predicted 24-hour TSP Ground Level Concentrations from the Proposed Outer Harbour Development (standalone with no background)**

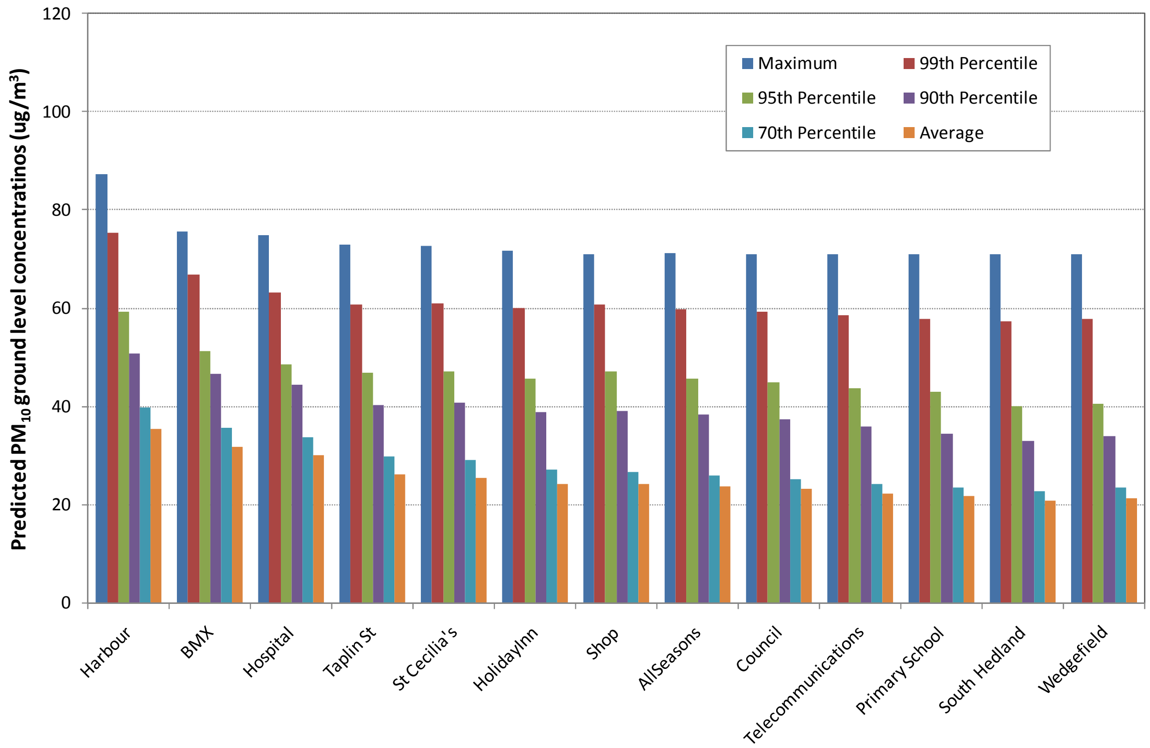


- **Figure E-4 Maximum Predicted 24-hour TSP Ground Level Concentrations from the Proposed Outer Harbour Development (no background)**

E.2 Scenario One – RGP5 (215 Mtpa)

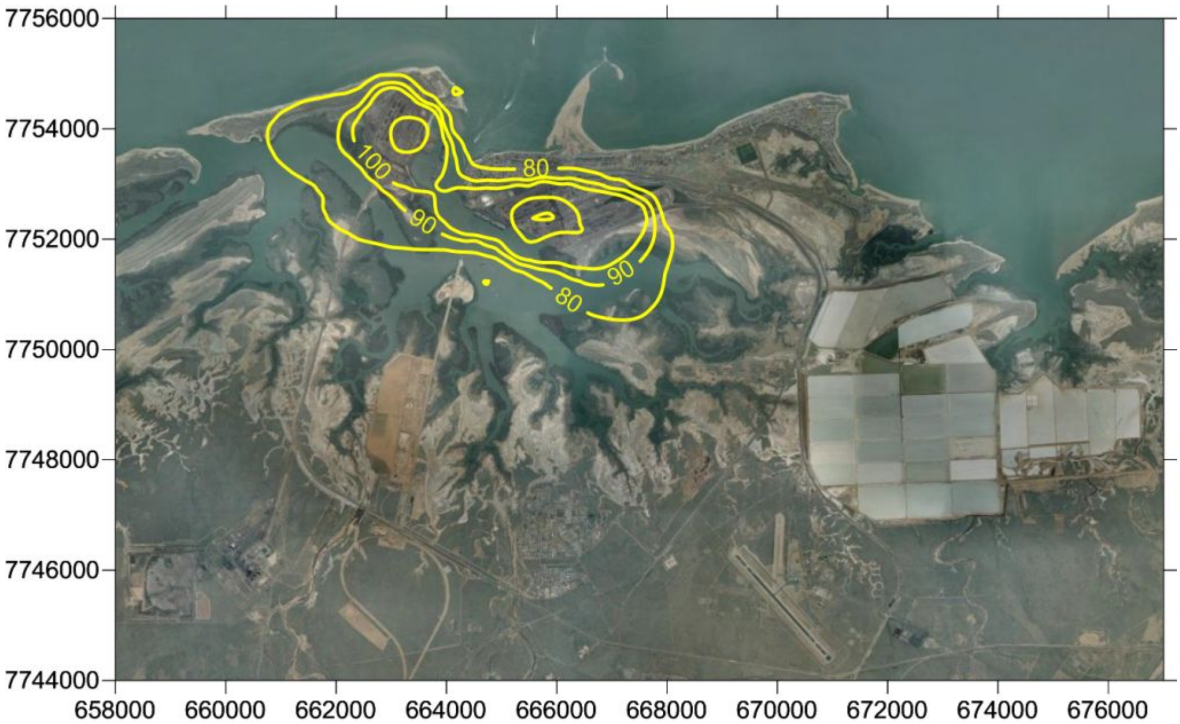
The first scenario modelled was RGP5 (215 Mtpa) and the predicted PM_{10} ground level concentrations at the thirteen sensitive receptor sites as a result of this scenario are presented in **Figure E-5**. From this figure it is evident that there is a single excursion above the short term target of 70 µg/m^3 at both the Hospital and Taplin Street receptors, however this excursion is a result of background influences.

The annual average target concentration of 30 µg/m^3 is predicted to be achieved at the Hospital receptor in this scenario.



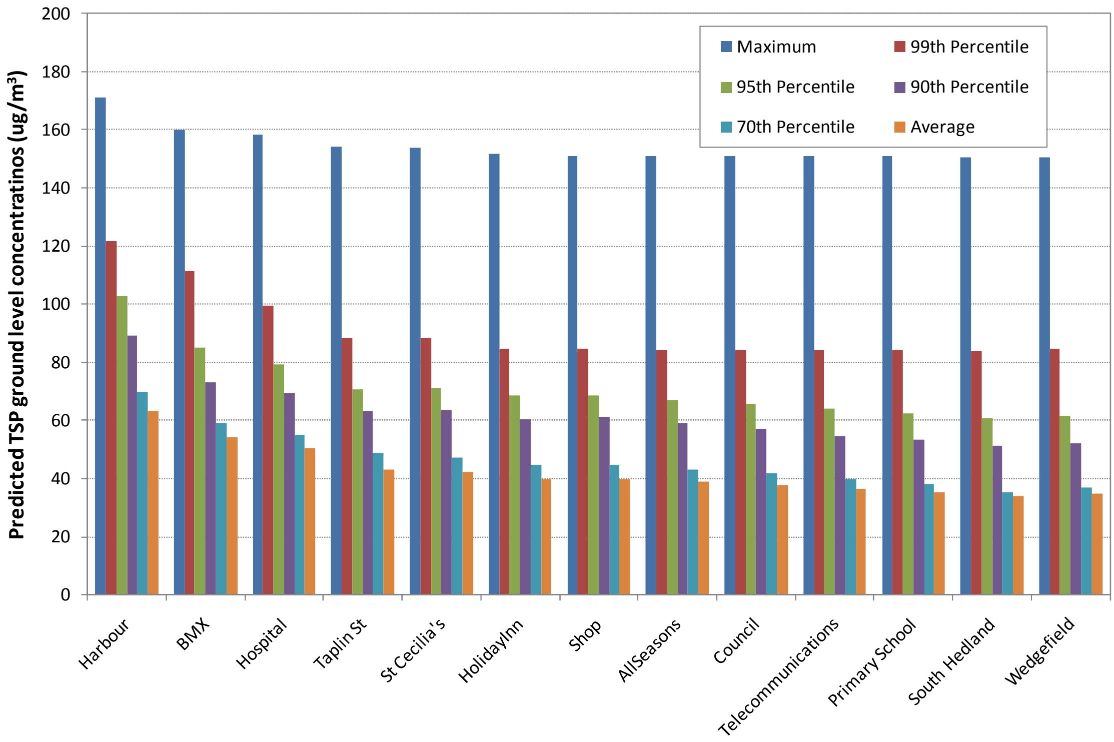
- **Figure E-5 Scenario 1 RGP5 - Statistics of predicted 24-hour PM_{10} ground level concentrations**

A contour plot of the maximum predicted PM_{10} ground level concentrations from this scenario are presented in **Figure E-6**. Note that the background concentrations are included in these results.

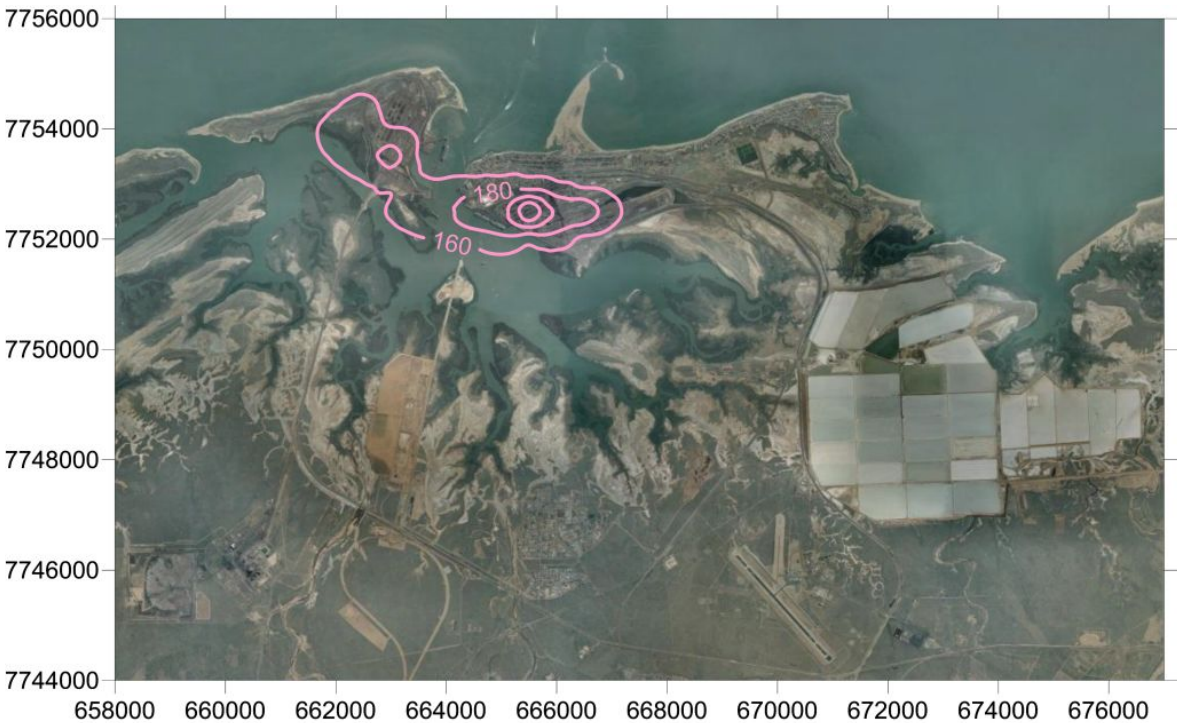


- **Figure E-6 Scenario 1 RGP5: Maximum predicted 24-hour PM_{10} ground level concentrations ($\mu g/m^3$)**

The predicted TSP ground level concentrations for the thirteen receptors are presented in **Figure E-7** and a contour plot of the maximum ground level concentrations is presented in **Figure E-8**. From these figures it is evident that the annual average target concentration of 65 $\mu g/m^3$ is predicted to be achieved at the Hospital receptor in this scenario.



- **Figure E-7 Scenario 1 RGP5 - Statistics of predicted 24-hour TSP ground level concentrations**

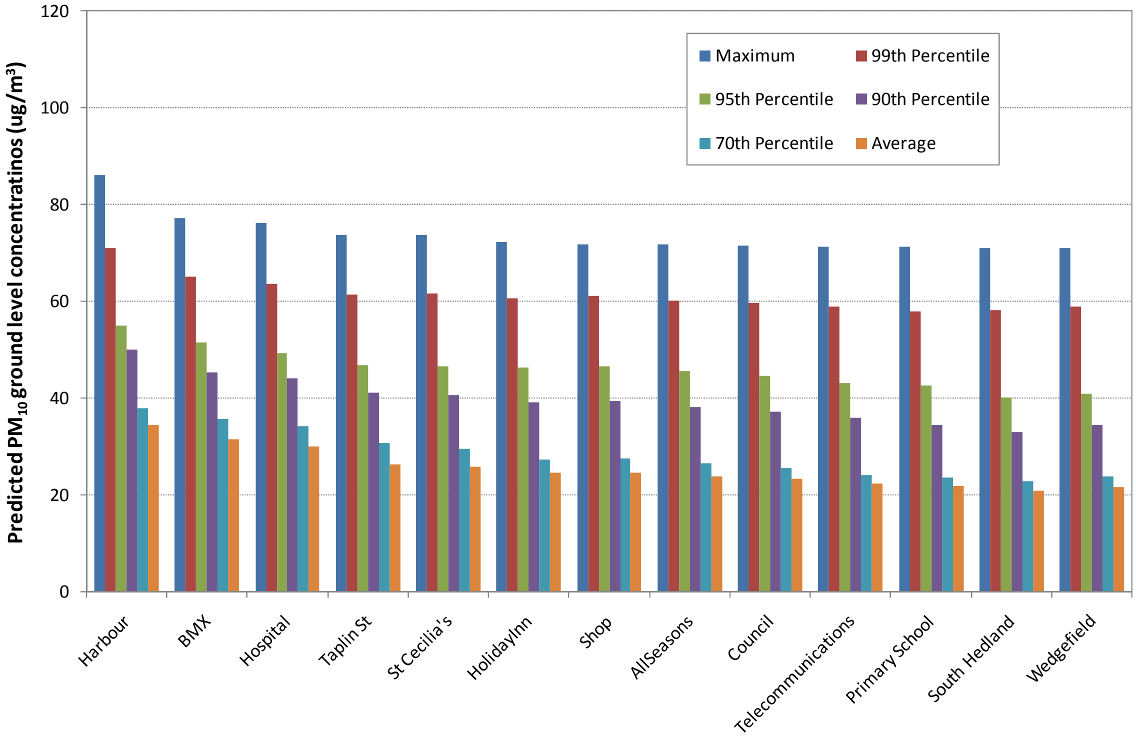


- **Figure E-8 Scenario 1 RGP5: Maximum predicted 24-hour TSP ground level concentrations (µg/m³)**

E.3 Scenario Two – RGP6 (255 Mtpa)

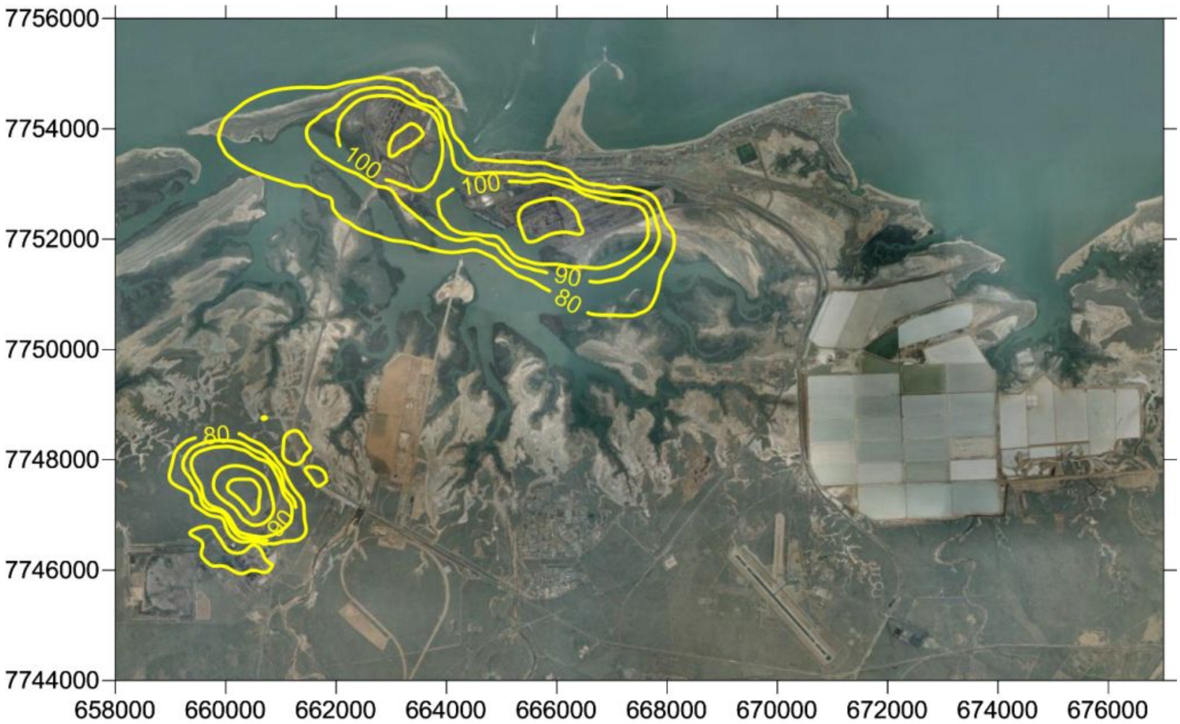
The predicted PM_{10} ground level concentrations at the thirteen sensitive receptor sites as a result of this scenario are presented in **Figure E-9**. As with the results from RGP5 (**Appendix E.2**) there is a single excursion above the short term target of 70 µg/m³ at both the Hospital and Taplin Street receptors however this excursion is a result of background influences.

The annual average target concentration of 30 µg/m³ is predicted to be achieved at the Hospital receptor in this scenario.



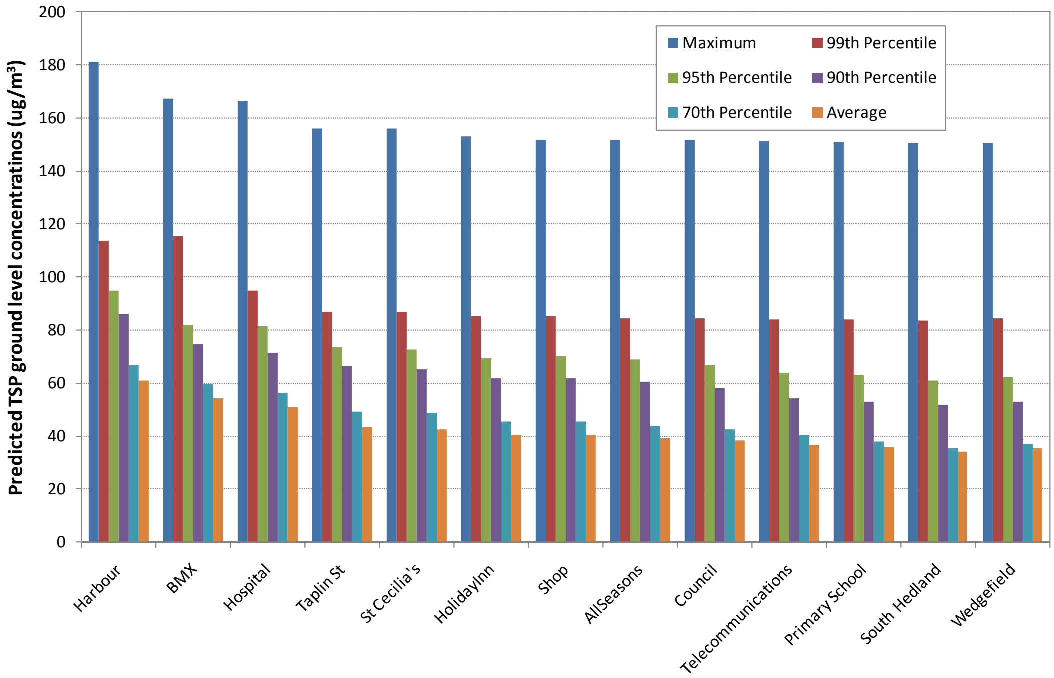
- **Figure E-9 Scenario 2 RGP6 - Statistics of predicted 24-hour PM_{10} ground level concentrations**

A contour plot of the maximum predicted PM_{10} ground level concentrations from this scenario are presented in **Figure E-10**. Note that the background concentrations are included in these results.

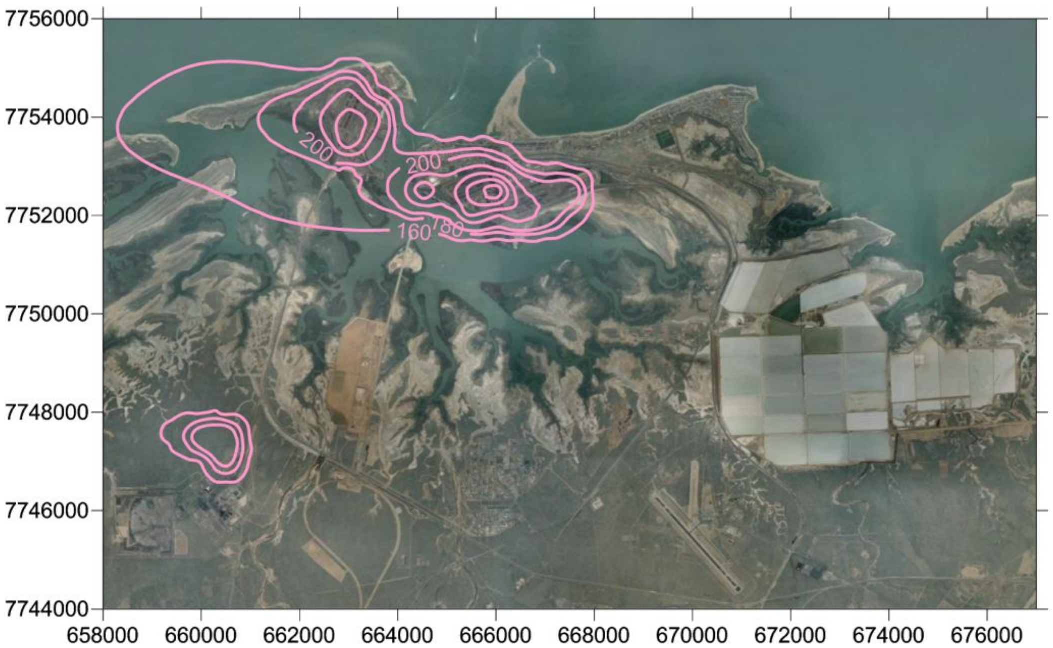


- **Figure E-10 Scenario 2 RGP6: Maximum predicted 24-hour PM_{10} ground level concentrations ($\mu g/m^3$)**

The predicted TSP ground level concentrations for the thirteen receptors are presented in **Figure E-11** and a contour plot of the maximum ground level concentrations is presented in **Figure E-12**. From these figures it is evident that the annual average target concentration of 65 $\mu g/m^3$ is predicted to be achieved at the Hospital receptor in this scenario.



- **Figure E-11 Scenario 2 RGP6 - Statistics of predicted 24-hour TSP ground level concentrations**

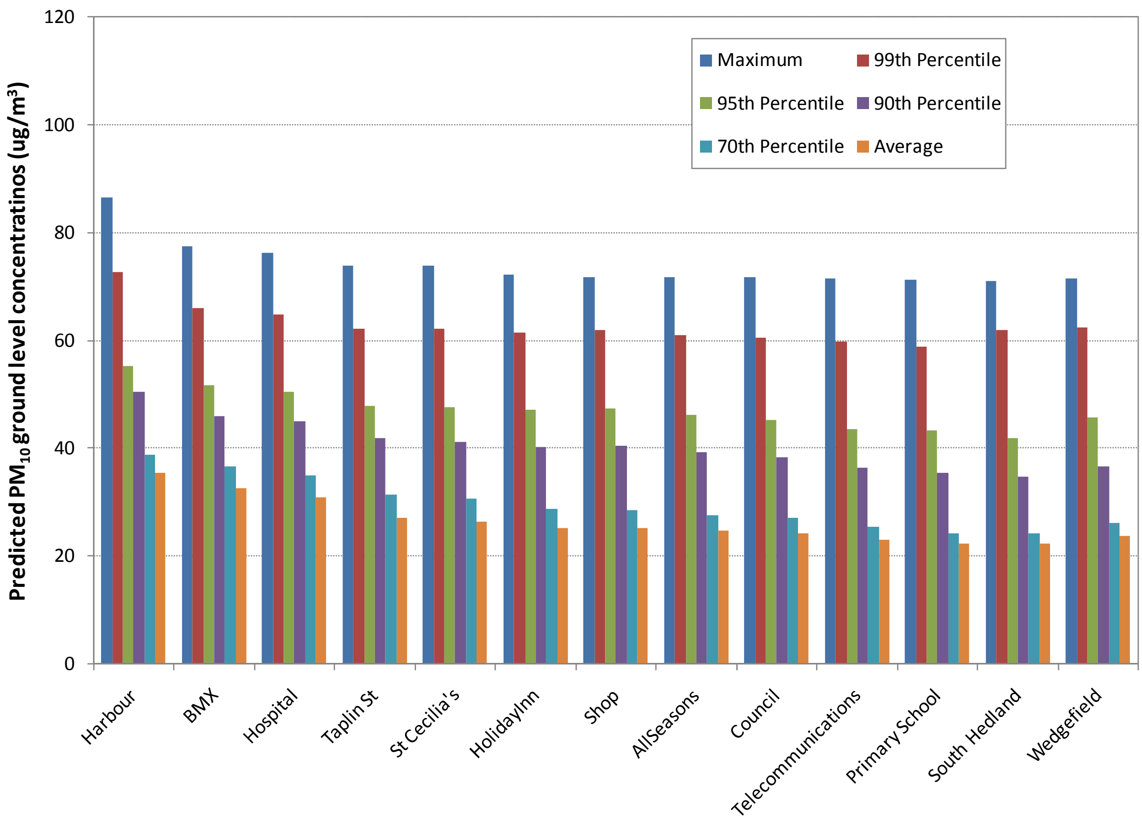


- **Figure E-12 Scenario 2 RGP6: Maximum predicted 24-hour TSP ground level concentrations (µg/m³)**

E.4 Scenario Three – Outer Harbour Development 240 Mtpa Boodarie

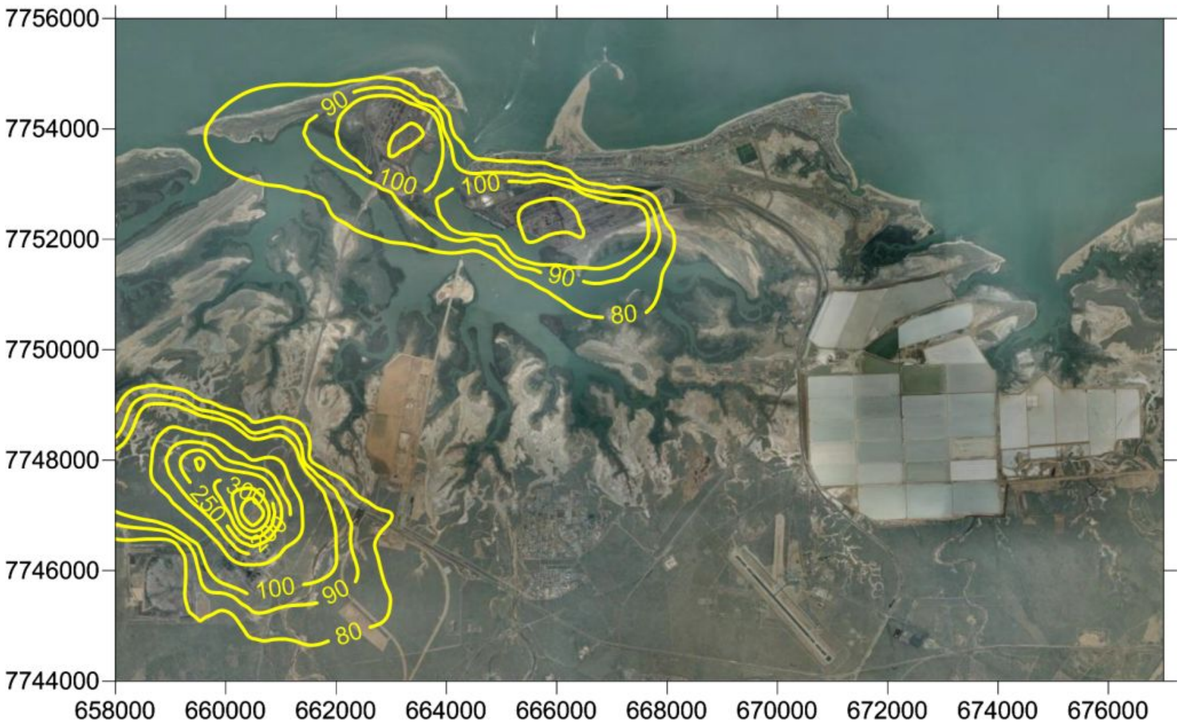
This scenario includes the proposed Outer Harbour Development and the proposed RGP6 scenario and the predicted PM_{10} ground level concentrations at the thirteen sensitive receptor sites as a result of this scenario are presented in **Figure E-13**. When the results presented in this figure are compared to that for Scenario two (**Figure E-9**) it is evident that the main receptors impacted with the introduction of the Outer Harbour Development are Wedgefield and South Hedland. This impact is primarily due to their close location to the proposed development. It should be noted that the predicted impact is well within the applicable criteria (**Section 2.3**). As with the results from RGP5 and RGP6 modelling there is a single excursion above the short term target of 70 µg/m^3 at both the Hospital and Taplin Street receptors however, as stated previously, this excursion is a result of background influences.

The annual average target concentration of 30 µg/m^3 is not predicted to be achieved at the Hospital receptor in this scenario. However further reductions should be achieved once further work has been conducted into the effectiveness of the proposed wind fences (**Section 4.4**).



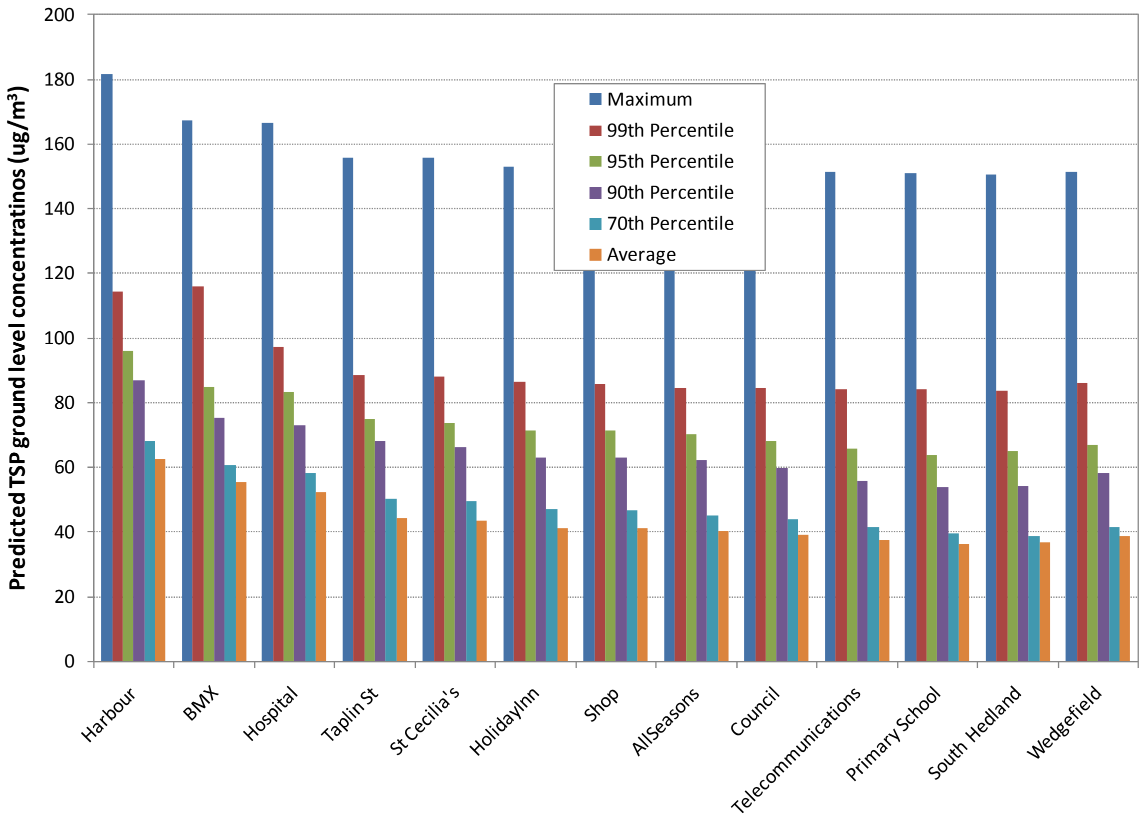
- **Figure E-13 Scenario 3 Outer Harbour Development - Statistics of predicted 24-hour PM_{10} ground level concentrations**

A contour plot of the maximum predicted PM_{10} ground level concentrations from this scenario are presented in **Figure E-14**. Note that the background concentrations are included in these results.



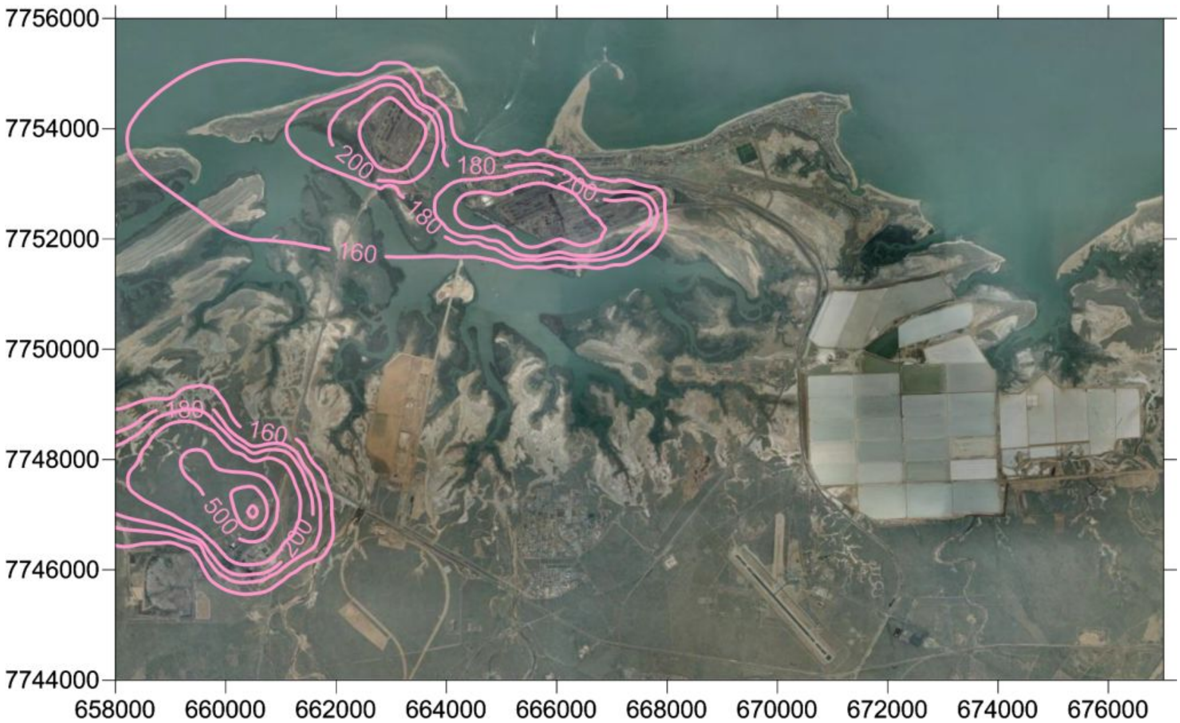
- **Figure E-14 Scenario 3 Outer Harbour Development: Maximum predicted 24-hour PM_{10} ground level concentrations (µg/m^3)**

The predicted TSP ground level concentrations at the thirteen sensitive receptor sites as a result of this scenario are presented in **Figure E-15**. As with the results for the predicted PM_{10} concentraions in this scenario the main receptors impacted with the introduction of the Outer Harbour Development are Wedgefield and South Hedland. This impact is primarily due to their close location to the proposed development. It should be noted that the predicted impact is well within the applicable criteria (**Section 2.3**).



▪ **Figure E-15 Scenario 3 Outer Harbour Development - Statistics of predicted 24-hour TSP ground level concentrations**

A contour plot of the maximum predicted 24-hour concentrations for TSP for this scenario is displayed in **Figure E-16**.



- **Figure E-16 Scenario 3 Outer Harbour Development: Maximum predicted 24-hour TSP ground level concentrations (μg/m^3)**

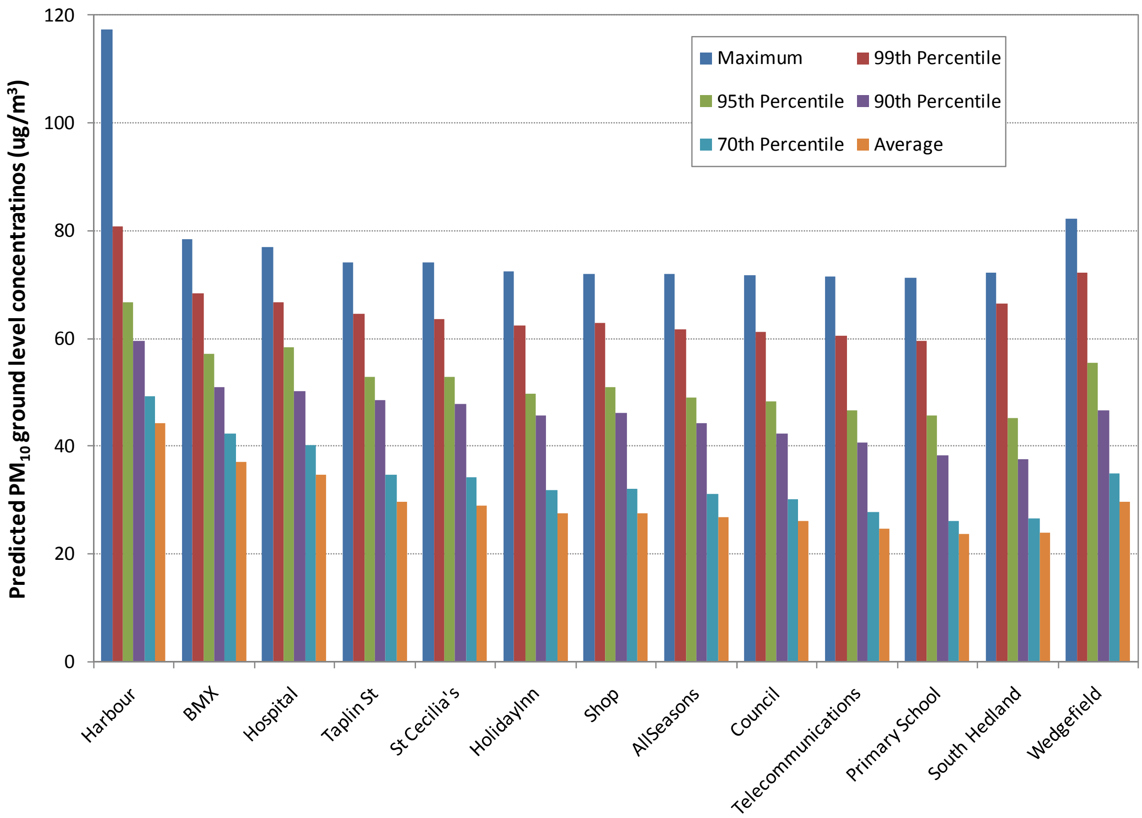
E.5 Scenario Four – Cumulative Modelling

This scenario combines all of the existing and proposed export facilities within the inner harbour at Port Hedland including the proposed BHP Billiton Iron Ore Outer Harbour Development. The facilities modelled in this scenario include:

- 255 Mtpa from the Inner Harbour from the proposed expansions by BHP Billiton Iron Ore
- 240 Mtpa from the proposed BHP Billiton Iron Ore Outer Harbour Development
- 21 Mtpa from the Port Hedland Port Authority (PHPA) Utah Point operations
- 1 Mtpa from the existing PHPA operations at Nelson Point
- 120 Mtpa from the Fortescue Metals Group (FMG) operations at Anderson Point
- 55 Mtpa from the proposed Roy Hill operations in South West Creek and
- 50 Mtpa from the proposed North West Iron Ore Alliance (NWIOA) in South West Creek

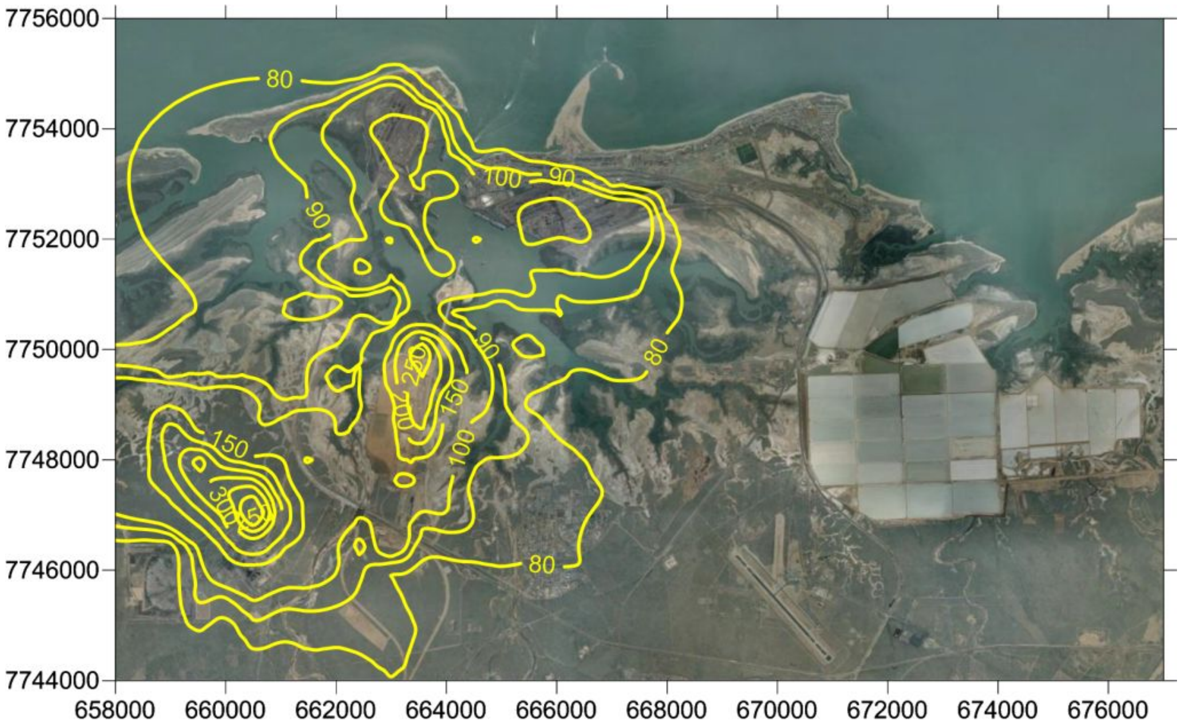
The ground level PM_{10} concentrations predicted to occur at the thirteen sensitive receptor sites as a result of this cumulative scenario are presented in **Figure E-17**. When the results for this scenario are compared to that predicted for the BHP Billiton Iron Ore proposed developments (**Figure E-13**) it is evident that incorporating all the proposed development within Port Hedland results in an increase in the predicted PM_{10} ground level concentrations across all receptors and statistics. The biggest increases occur at the Harbour receptor with a predicted increase of 31 µg/m³ in the maximum and 9 µg/m³ in the annual average. The second biggest increase occurs at the Wedgefield receptor with a predicted increase of 11 µg/m³ in the maximum and 6 µg/m³ in the annual average.

As noted in **Section 0** the PHDMT has recommended an interim air quality management target of 70 µg/m³ (24 hour average) with no more ten exceedances each calendar year to be met east of Taplin Street (DSD 2010). It is predicted that this interim target will be exceeded twice based on the results of this cumulative assessment which is within the number of allowable exceedances.



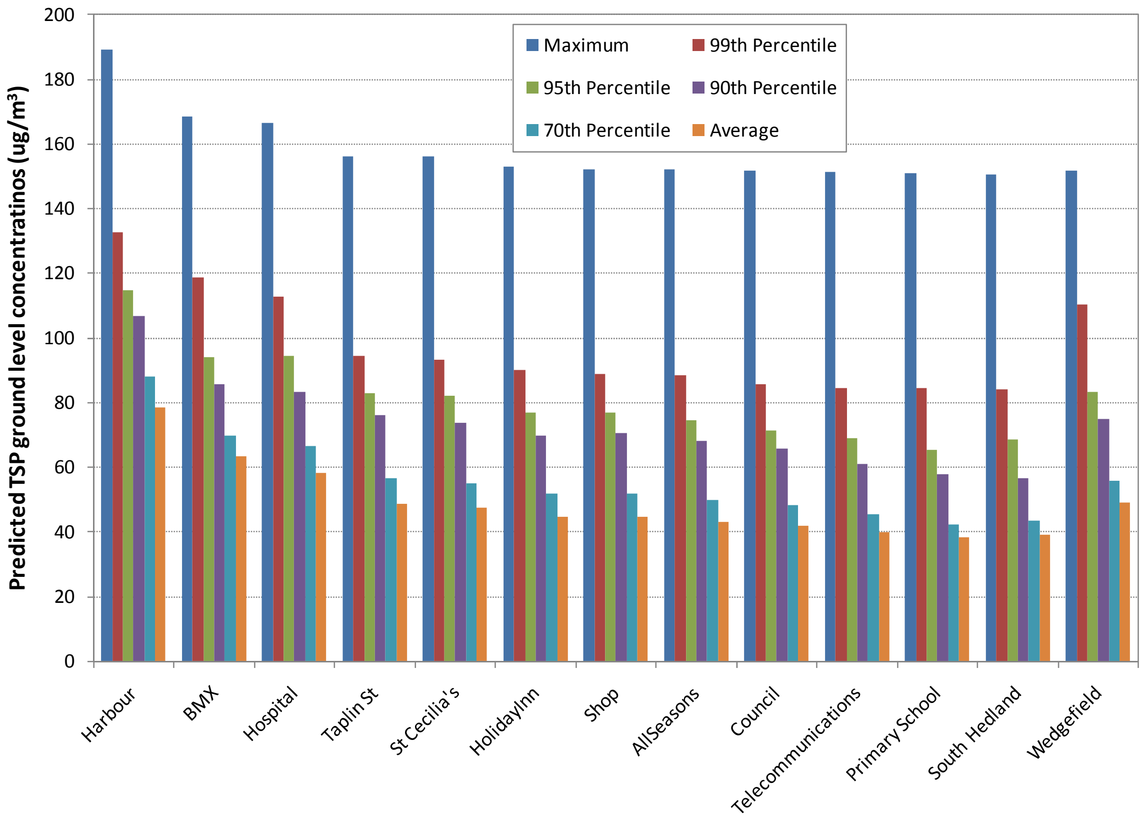
- **Figure E-17 Scenario 4 cumulative assessment - Statistics of predicted 24-hour PM_{10} ground level concentrations**

A contour plot of the maximum predicted PM_{10} ground level concentrations from this scenario are presented in **Figure E-18**. Note that the background concentrations are included in these results.



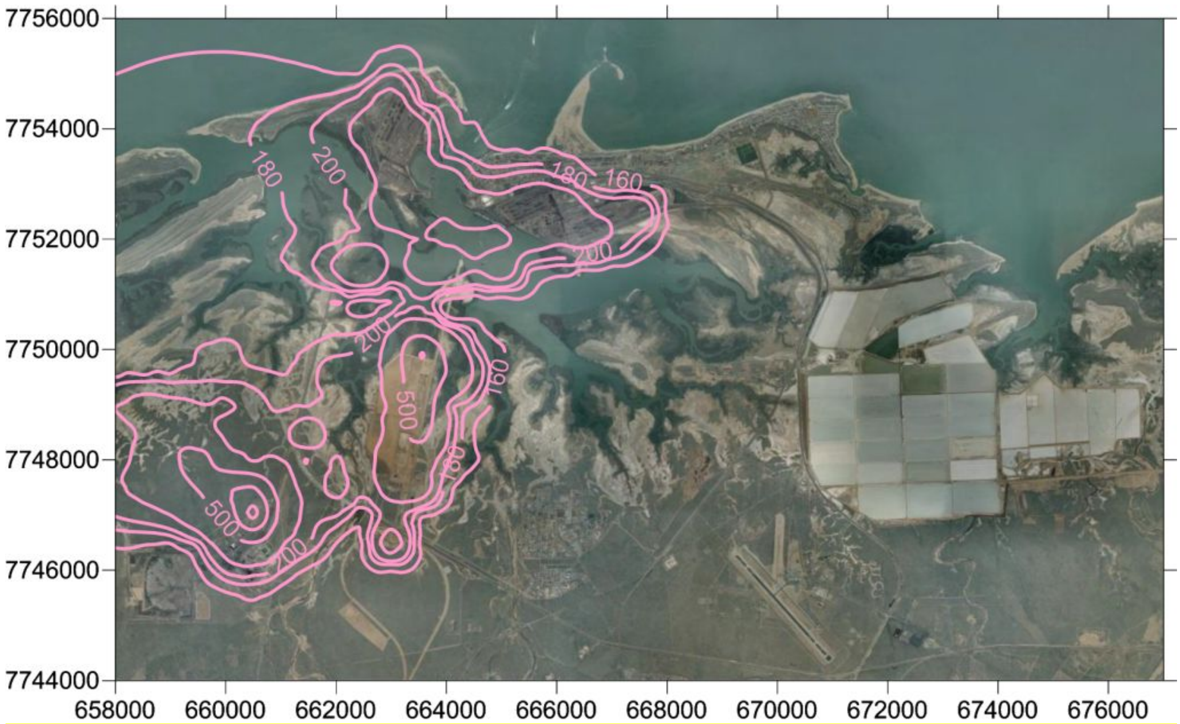
- **Figure E-18 Scenario 4 cumulative assessment: Maximum predicted 24-hour PM_{10} ground level concentrations (µg/m^3)**

The ground level TSP concentrations predicted to occur at the thirteen sensitive receptor sites as a result of this cumulative scenario are presented in **Figure E-19**. When the results for this scenario are compared to that predicted for the BHP Billiton Iron Ore proposed developments (**Figure E-15**) it is evident that incorporating all the proposed development within Port Hedland results in an increase in the predicted TSP ground level concentrations across all receptors and statistics. The biggest increases occur at the Harbour receptor with a predicted increase of 8 µg/m^3 in the maximum and 16 µg/m^3 in the annual average. The second biggest increase occurs at the Wedgefield receptor with a predicted increase of 10 µg/m^3 in the annual average.



- **Figure E-19 Scenario 4 cumulative assessment - Statistics of predicted 24-hour TSP ground level concentrations**

A contour plot of the maximum predicted PM_{10} ground level concentrations from this scenario are presented in **Figure E-20**. Note that the background concentrations are included in these results.



- **Figure E-20 Scenario 4 cumulative assessment: Maximum predicted 24-hour TSP ground level concentrations (µg/m³)**