



# Sheffield Resources Limited

## Thunderbird Mineral Sands Project

---

### Technical Report

### Product Transport and Derby Port Air Quality Assessment



**6 October 2016**

### Disclaimer

This report may not be copied or reproduced without the consent of Atmospheric Solutions or Sheffield Resources Limited.

This report has been prepared on behalf of and for the exclusive use of Sheffield Resources Limited, in accordance with the terms of agreement between Atmospheric Solutions and Sheffield Resources Limited.

This report is based upon the information provided at the time of preparation and issue.

Atmospheric Solutions accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

### Document Status

Document Number: AS-16-1108-RPT-01 Rev 2

Client: Sheffield Resources Limited

Job Number: AS-16-1108

Prepared by		6 October 2016	Robert Kennedy
Reviewed by		6 October 2016	Jacqueline Burgin
Approved by		6 October 2016	Robert Kennedy

### Revision Status

Revision A	Issued for Internal Review	17 August 2016	Robert Kennedy
Revision 0	Issued for Use	19 August 2016	Robert Kennedy
Revision 1	Re-issued for Use	23 September 2016	Robert Kennedy
Revision 2	Re-issued for Use	6 October 2016	Robert Kennedy

### Distribution Status

Copy Number	Distributed To	PDF Copy	Hard Copy
Copy 1	Atmospheric Solutions Document Control	Yes	Yes
Copy 2	Sheffield Resources Limited - Sheffield	Yes	No

This document is uncontrolled when printed.

---

## Contents

Executive Summary.....	1
1. Introduction.....	3
2. Objectives and Scope of Work.....	3
3. Emissions Inventory .....	4
4. Pollutant Information .....	6
5. Emissions Modelling.....	7
6. Conclusions .....	14
7. References .....	15

## EXECUTIVE SUMMARY

This air quality assessment has been prepared for the Derby Port component of the Thunderbird Mineral Sands Project (Thunderbird Project), proposed by Sheffield Resources Limited (Sheffield Resources), as part of the overall environmental approvals process.

The Thunderbird Project involves the extraction and processing of mineral sands from the Thunderbird mine site, located approximately 98 km northeast of Broome and 72 km west of Derby, in Western Australia. The minerals will be mined using conventional earth moving machinery and mobile equipment, such as dozers, and passed through screening prior to wet concentration and further processing before being prepared for transport and export. The final products, comprising zircon, leucoxene and ilmenite, will be transported by road trains to the Port of Derby, where they will be stockpiled inside a warehouse (up to 60,000 t). The products will subsequently be conveyed out to barges at the port jetty for subsequent transfer to an oceangoing vessel located in deeper water, off Point Torment.

This report focuses on the air quality aspects associated with the Derby Port activities. Air quality impacts at the Thunderbird mine site are covered in a separate report (Reference 14). The proposed activities have the potential to generate dust emissions at the Derby Port and Derby Town Centre, and as such have been addressed in this report. The main emission sources include road trains, truck unloading, stockpiling and conveyor loading activities. Combustion emissions for the road trains and port mobile equipment (i.e. the loader used to manage the stockpiles) are not considered to be significant sources; as such the focus will be on their potential for dust generation.

The product transport corridor traverses the Derby townsite via Loch Street. A restaurant and amenities are located at the port and a number of commercial fishing operators use the wharf facilities. The nearest residences are located within the Derby townsite, which is located just under 2 km southeast from the port. There are no other industrial activities at the port at present, with the Thunderbird Project to utilise the existing conveying system.

The emissions from the project have been estimated using current design data and operating conditions, in combination with emissions estimation factors from the National Pollutant Inventory handbooks. The AERMOD dispersion model has been utilised for the modelling, which is considered suitable given the lack of complicated terrain and significant features which, if present, would warrant the use of a more advanced dispersion model. AERMOD's meteorological pre-processor AERMET has been used to prepare input meteorological data files based on 2015 MM5 inputs.

Dust emissions have been modelled for the total suspended particulates (TSP) emitted, as well as particles with an aerodynamic diameter less than 10 microns (PM<sub>10</sub>) and 2.5 microns (PM<sub>2.5</sub>). In addition, dust deposition has been modelled. PM<sub>10</sub> and PM<sub>2.5</sub> emissions have been compared against the National Environment Protection Measure for Ambient Air Quality (NEPM AAQ) criteria (the advisory reporting threshold for PM<sub>2.5</sub>),

whilst TSP and dust deposition have been compared to the New South Wales Environmental Protection Agency (NSW EPA) criteria in the absence of NEPM criteria.

Based on the results of the modelling, the product transport and port activities are not predicted to result in any exceedances of the pollutant criteria specified above at any sensitive receivers or at nearby residences, and as such the Project is not expected to have any adverse impact on air quality in the area.

## 1. INTRODUCTION

Sheffield Resources Limited (Sheffield Resources) are seeking environmental approvals to develop the Thunderbird Mineral Sands Project (Thunderbird Project).

The Thunderbird Project involves the extraction and processing of mineral sands from the Thunderbird mine site located approximately 98 km northeast of Broome and 72 km west of Derby in the west Kimberley region of Western Australia. The minerals will be mined using conventional machinery and mobile equipment, such as dozers, and passed through screening prior to wet concentration and further processing. The final products, comprising zircon, leucoxene and ilmenite, will then be transported by road trains to the Port of Derby, where they will be stockpiled inside a purpose built storage facility (up to 60,000 t).

The final products will be exported by ship. Due to the extreme tidal conditions experienced in the Kimberley, ocean going vessels are unable to berth at the port. Products will therefore be loaded onto barges via the existing conveyor system (refurbished) and transferred to the ocean going vessel located in deeper water off Point Torment.

This air quality assessment has been prepared for the Derby Port component of the Thunderbird Project, as part of the overall environmental approvals process. The Thunderbird mine site is covered in a separate report (Reference 14).

## 2. OBJECTIVES AND SCOPE OF WORK

The primary objective of this study was to characterise air quality impacts on sensitive receptors associated with the Thunderbird Project product transport and Derby Port operations. The scope of work involved the following:

- Identify the emission sources associated with the Thunderbird Project Port Operations;
- Characterise and inventory the emission sources;
- Characterise the baseline air quality in the Derby area via desktop assessment; and
- Perform atmospheric dispersion modelling to assess the potential for air quality impacts on sensitive receptors along the transport route and at the Derby town site.

### 3. EMISSIONS INVENTORY

The emissions for the Thunderbird Project can be split up between two main areas, the mine site and the port. The two are linked by road, with road trains taking the product in bulk from the mine site and delivering it to the port storage facility, prior to conveying out to barges for shipment.

This report focuses on the emissions associated with the port activities, which includes assessing the impact of the road trains carrying product through the town of Derby.

The existing facilities at the Derby Port will be utilised for the Thunderbird Project, with minor upgrades and refurbishment including the conveyor system for transferring product to barges. A storage facility will be constructed on the port grounds to house and contain the product, which will be delivered by 5 quad road trains (each carrying a 115 t payload). Each road train will make approximately 2 return trips every 24 hour period, totalling 10 return truck movements per day between the mine site and port. The road trains will unload the products to stockpiles within the storage facility which will be managed by a loader before being fed to the conveying system, where load-out will occur. As such, at peak production, 2,300 tonnes per day will arrive at the port storage facility, prior to being conveyed out to the ship loading area. The stockpiled product is not expected to exceed 60,000 tonnes at the port and will be housed inside the warehouse.

Based on the above, the primary emission for the port will be dust in the form of airborne particulates (TSP, PM<sub>10</sub> and PM<sub>2.5</sub>), as well as deposited dust (considered for the purposes of amenity). The only other emissions considered are related to the combustion of fuel associated with the loader at the warehouse, the 5 road trains and the ships and barges, all of which are not considered significant enough to warrant investigation in respect to the air quality limits for combustion products. Similarly, the loading of the ships themselves, located off Point Torment, has not been included due to the large distance between the activity and the port.

The emission factors for the dust generated by the port activities have been based on the National Pollutant Inventory (NPI) Emissions Estimation Handbook (EEH) for Mining (Reference 4, as recommended by the NPI EEH for Mineral Sands, Reference 3). As recommended in the NPI EEH Mining guide, a 70% control factor has been applied to the emissions generated within the storage facility due to the mitigating effect of the enclosure. It should be noted that where PM<sub>2.5</sub> emission factors are not present in the NPI EEHs, a conservative factor of 50% of the PM<sub>10</sub> rate has been used.

The dust emissions generated by the road trains on the paved roads through the town of Derby have been based upon the unpaved road emissions factors from the NPI EEH for Mining, corrected for the size and weight of the road trucks proposed to be used, however with a 99% control factor applied, highlighting the effectiveness of paving to mitigate dust from transportation (Reference 6). Road train dust emissions have been calculated based on the NPI EEH for Mining factors, using their average weight of 171 t empty with a 115 t payload, giving an average weight for their return journey of 228.5 t.

Emissions factors for the port activities are summarised in Table 1 and port emissions are summarised in Table 2.

**Table 1: Emissions Factors for the Port Activities**

Port Operations:	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	Units
Road Trains <sup>1</sup>	0.082	0.025	0.013	kg/VKT
Truck Unloading <sup>2</sup>	0.012	0.0043	0.0022	kg/t
Loader Operations <sup>3</sup>	0.025	0.012	0.0060	kg/t
Wind Erosion <sup>3</sup>	0.40	0.20	0.10	kg/ha/h
Conveyor Transport	0.00032	0.00015	0.000075	kg/t/transfer point

- Notes: 1. Emission factors from the NPI EEH for Mining, Tables 2 and 3.  
 2. Based on an average weight of 228.5 t, with a 99% control factor due to sealed roads.  
 3. A control factor of 70% has been applied to activities within the warehouse enclosure, as per NPI EEH for Mining, Table 4.  
 4. Where PM<sub>2.5</sub> emission factors are not present in the NPI EEHs, a conservative factor of 50% of the PM<sub>10</sub> rate has been used.

**Table 2: Dust Emissions from the Port Area**

Port Operations:	TSP		PM <sub>10</sub>		PM <sub>2.5</sub>	
	g/s	kg/y	g/s	kg/y	g/s	kg/y
Road Trains	0.073	1,968	0.022	602	0.011	301
Truck Unloading	0.096	2,569	0.034	921	0.017	460
Loader Operations	0.200	5,352	0.096	2,569	0.048	1,284
Conveyor Transport	0.017	457	0.008	214	0.004	107
Wind Erosion	0.017	447	0.008	223	0.004	112
<b>Total from Port</b>	<b>0.403</b>	<b>10,792</b>	<b>0.169</b>	<b>4,529</b>	<b>0.084</b>	<b>2,265</b>

- Notes: 1. Road train emissions for the journey from the Derby town centre to the Port only.  
 2. Annual emissions are based on the planned operating hours of 7,446 per annum.

## 4. POLLUTANT INFORMATION

The primary pollutants which will be generated by the Thunderbird Project have been identified as dust / particulate emissions, as discussed in the previous chapter.

Total suspended particulates (TSP) consist of coarse and fine particles. In the atmosphere particles range in size from 0.1 to 50  $\mu\text{m}$ . Even without human activity, the atmosphere contains particles from sources such as wind-blown dust, fires, sea salt, pollens, and bacteria. From human activity, industry is by far the largest producer of TSPs.

Respirable particles, defined as those with a diameter of less than 10  $\mu\text{m}$  ( $\text{PM}_{10}$ ), are a particular health concern as they are easily inhaled and retained in the lungs, and may potentially pass into the blood stream. Respirable particles may also adsorb potentially health threatening organic "air toxics" (such as benzene, 1,3-butadiene, acetaldehyde and formaldehyde).

The size of the particles determines how far into the respiratory system the particles penetrate. Particles with an aerodynamic diameter greater than 10  $\mu\text{m}$  are screened out in the upper respiratory tract, while particles smaller than 10  $\mu\text{m}$  ( $\text{PM}_{10}$ ) may penetrate into the lower respiratory tract in humans. There is increasing evidence that the adverse health effects of particulates are more closely associated with the  $\text{PM}_{2.5}$  size fraction (particulate matter with a diameter less than 2.5  $\mu\text{m}$ ). Their small size increases the likelihood that the  $\text{PM}_{2.5}$  particles will carry irritants and potentially toxic compounds deep into the lungs.

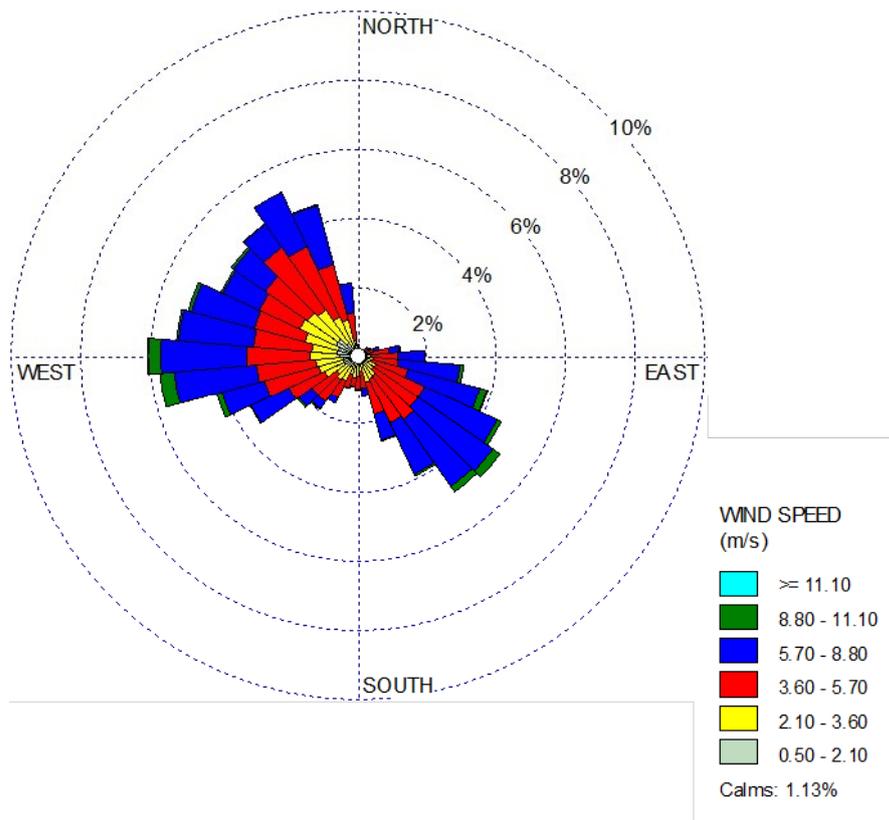
The National Environment Protection Measure for Ambient Air Quality (NEPM AAQ) includes a limit for  $\text{PM}_{10}$  of 50  $\mu\text{g}/\text{m}^3$  over a 24 hour period (with the initial NEPM AAQ criteria allowing for 5 exceedances in a year), as well as an advisory standard for  $\text{PM}_{2.5}$  of 25  $\mu\text{g}/\text{m}^3$  over a 24 hour period, and 8  $\mu\text{g}/\text{m}^3$  averaged over one year (Reference 1). Whilst not included in the NEPM AAQ, a common limit for dust deposition is set at 4  $\text{g}/\text{m}^2/\text{month}$ , and for TSP is 90  $\mu\text{g}/\text{m}^3$  on an annual average (e.g. NSW, Reference 12).

The following dispersion modelling will include comparisons against the above-mentioned criteria at the maximum model result output, as well as the 6<sup>th</sup> highest for  $\text{PM}_{10}$  to take into consideration the allowable exceedances.

## 5. EMISSIONS MODELLING

Dispersion modelling has been carried out in accordance with the principles of the Air Quality Guidance Notes (Reference 2) and in line with previous studies within the region.

The emissions modelling program AERMOD has been chosen to perform the dispersion modelling for the project, which is seen as a more advanced model to the previous standard model AUSPLUME, and is now the preferred model of the Victoria EPA (the creators of AUSPLUME). However, given the lack of significant topographical features and the character of the sources, either model would be expected to perform adequately. AERMOD's meteorological pre-processor AERMET has been used to prepare input meteorological data files based on MM5 inputs from Lakes Environmental, which provide the upper air data otherwise unavailable onsite. The annual wind rose for the meteorological data used is shown in Figure 5-1, for the year 2015, which is the most recent complete year of meteorological data available for the area.



**Figure 5-1: 2015 Annual Wind Rose for the Derby Area.**

The modelling has included the port and the Derby Town Centre in order to assess the impact of the port operations on the nearby sensitive receptors. To assess the road train emissions, a segment of the road leading from the port to the centre of the town of Derby has been included (the entire road route has not been included for both simplicity and to reduce the computer modelling calculation time; however an ample section has

been included to show direct and cumulative impacts from the road train operations, which is seen to adequately evaluate the emissions potential for this source).

There are no significant emissions sources within the Derby region, as such the main contributors to dust levels are ambient wind-borne dust and smoke from dry season bush fires. The Derby Port and conveyor system have been unused for export activities since 2008, when it was used by Western Metals and no other industrial activities exist in the region. As such, background and cumulative emissions from other industrial activities are expected to be negligible, and naturally occurring background particulate concentrations are expected to be minor. However, in order to be conservative, the average ambient dust concentrations found in north-west Western Australia have been used to ensure the worst-case scenario is considered. The background concentrations used are  $40 \mu\text{g}/\text{m}^3$  for TSP,  $20 \mu\text{g}/\text{m}^3$  for  $\text{PM}_{10}$  and  $7 \mu\text{g}/\text{m}^3$  for  $\text{PM}_{2.5}$ , averaged over 24 hours, which are based on a number of studies based on ambient monitoring of the Kimberley and Pilbara areas, which both experience a higher level of activity than Derby and as such are seen to be a conservative choice in lieu of local data (Reference 15, 16).

Given the relatively low activity rate of the operations, the enclosure of the stockpiles, and the lack of contributing sources, the dust emissions modelled are consequently low and well within guidelines at the nearest sensitive receptors, as shown in the following figures.



**Figure 5-2: Maximum Ambient TSP Concentrations, Annual Average ( $\mu\text{g}/\text{m}^3$ )**

The ambient TSP ground level concentrations are shown in the above figure, which show that TSP levels are expected to be substantially below the criteria of  $90 \mu\text{g}/\text{m}^3$  on an annual average at the boundary of the port and at the nearby sensitive receptors.

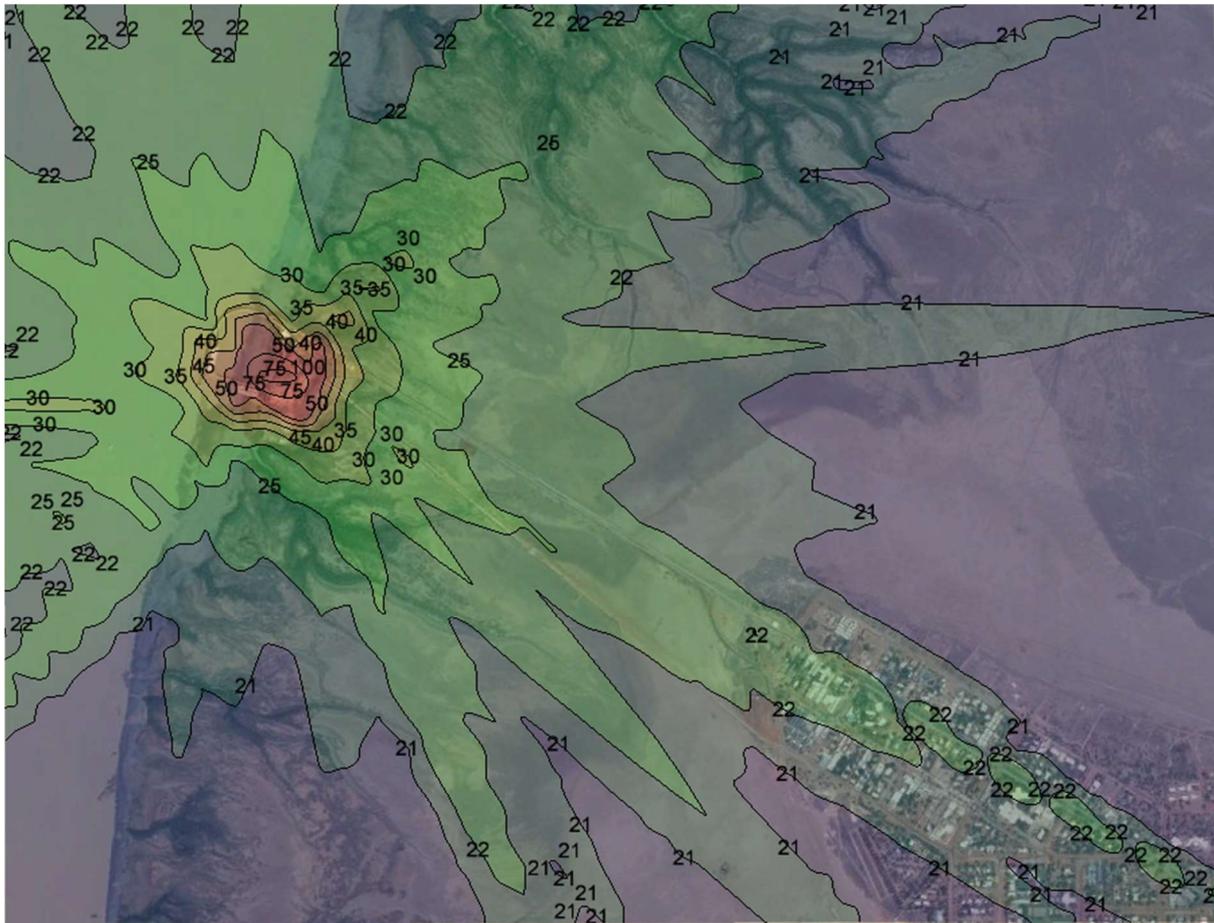
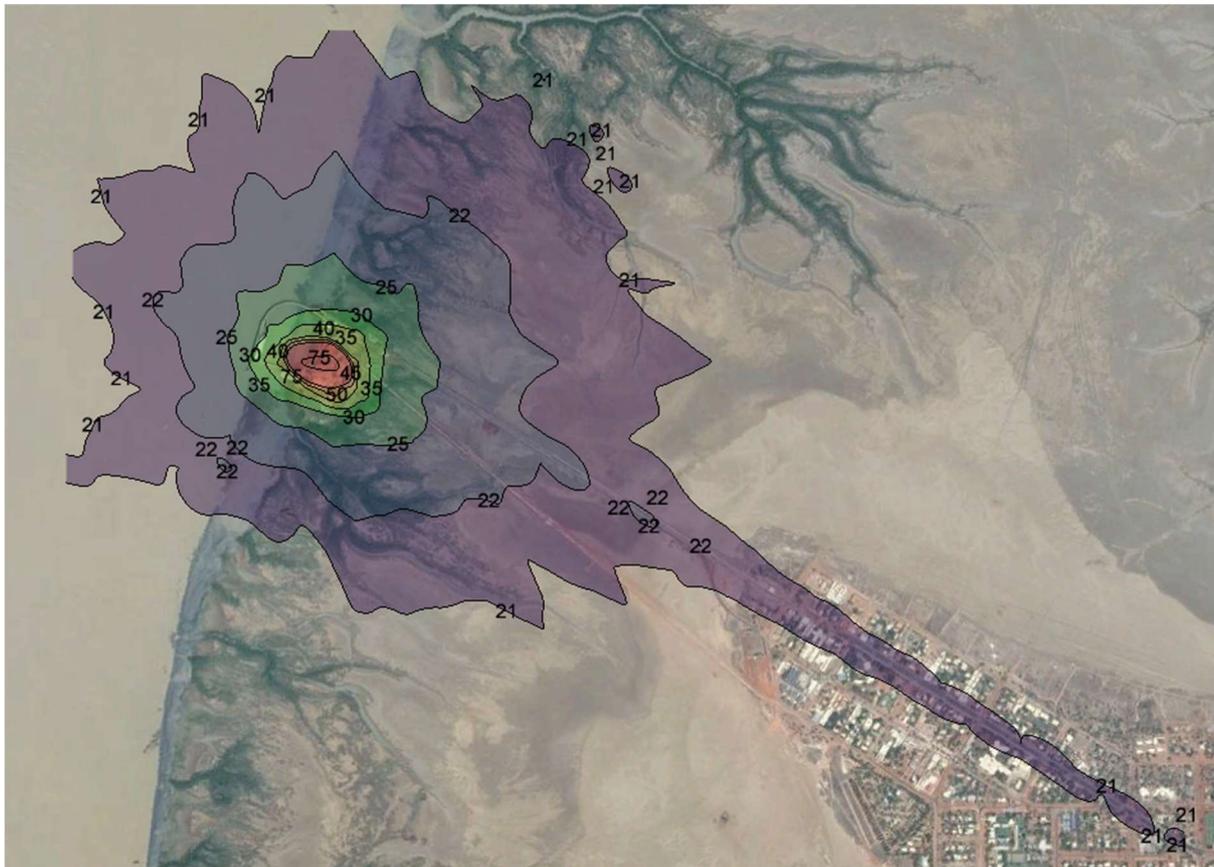
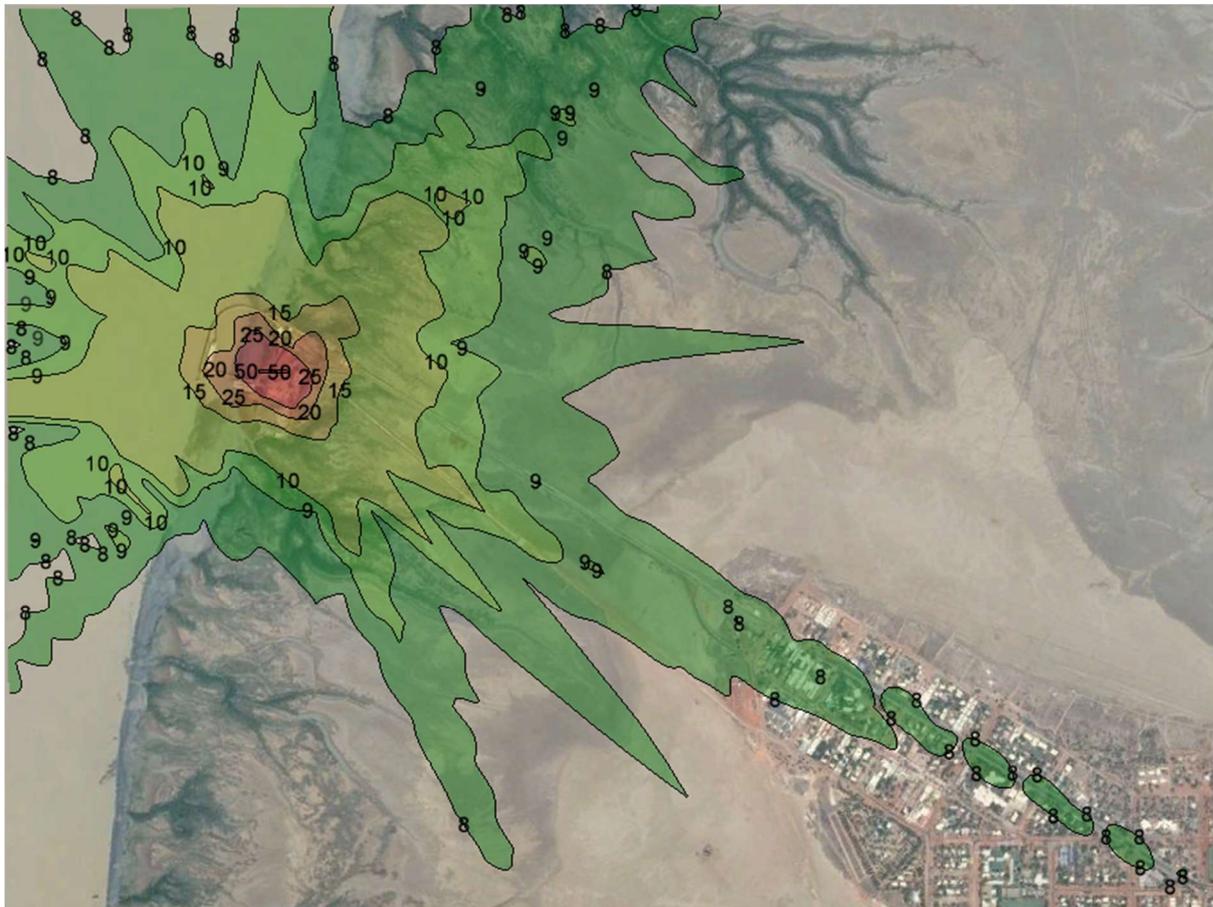


Figure 5-3: Maximum Ambient PM<sub>10</sub> Concentrations, 24-Hour Average (µg/m<sup>3</sup>)



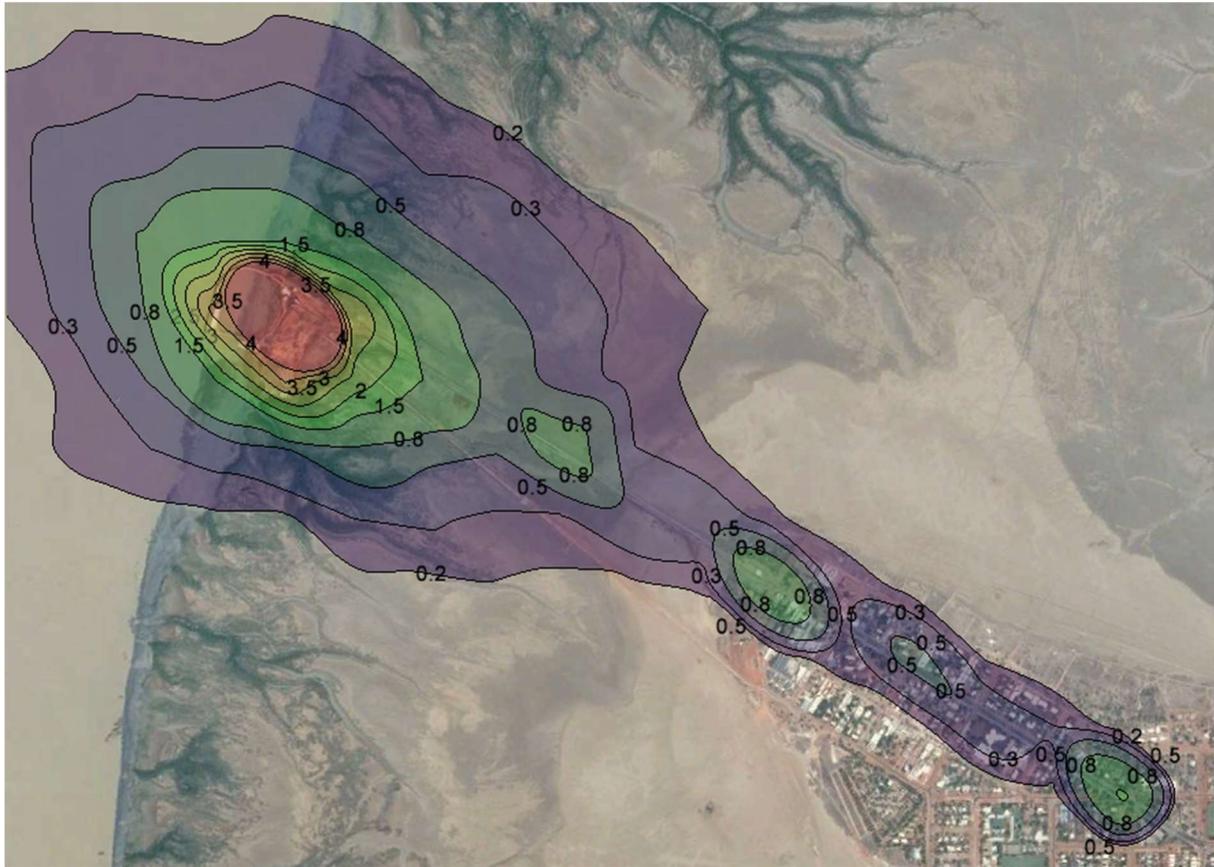
**Figure 5-4: 6<sup>th</sup> Highest Ambient PM<sub>10</sub> Concentrations, 24-Hour Average (µg/m<sup>3</sup>)**

The ambient PM<sub>10</sub> ground level concentrations are shown in the above figures (both the maximum and the 6<sup>th</sup> highest in order), which show that PM<sub>10</sub> levels are expected to be well below the criteria of 50 µg/m<sup>3</sup> on a 24 hour average at the nearby sensitive receptors and within the town of Derby, with elevated dust concentrations restricted to the immediate vicinity of the port, which is to be expected given the nature and scale of operations.



**Figure 5-5: Maximum Ambient PM<sub>2.5</sub> Concentrations, 24-Hour Average (µg/m<sup>3</sup>)**

The ambient PM<sub>2.5</sub> ground level concentrations are shown in the above figure, which show that PM<sub>2.5</sub> levels are expected to be significantly below the advisory standard of 25 µg/m<sup>3</sup> on a 24 hour average at the boundary of the port and at nearby sensitive receptors.



**Figure 5-6: Maximum Monthly Dust Deposition Contours (g/m<sup>2</sup>/month)**

The monthly dust deposition contours are shown in the above figure, which show that the level of dust deposition is expected to be significantly below the criteria of 4 g/m<sup>2</sup>/month at the nearby sensitive receptors and within the town of Derby, with elevated dust concentrations restricted to the immediate vicinity of the port, which is to be expected given the nature and scale of operations.

---

## 6. CONCLUSIONS

The air quality impacts of the product transport and port operations associated with the overall Thunderbird Project have been assessed. The air quality impacts have been found to be limited to dust impacts generated by the transport, unloading, conveying and shipping of the product at the port. These activities have been estimated using the emissions estimation methodologies of the NPI EEH Manuals for Mineral Sands (Reference 3) and Mining (Reference 4), and modelled in accordance with the Air Quality Modelling Guidance Notes (Reference 2).

The results of the modelling indicate that all pollutants (TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and dust deposition) will be well within the assessment levels discussed in Section 4 at the nearby sensitive receptors, both those closest to the port and those associated with the product transport corridor.

As such the port and transport activities are not expected to result in any adverse air quality impacts in the region.

## 7. REFERENCES

- Ref 1. National Environment Protection Measure for Ambient Air Quality (NEPM, <http://www.ephc.gov.au>).
- Ref 2. Air Quality Modelling Guidance Notes. Department of Environment, 2006.
- Ref 3. National Pollutant Inventory Emission Estimation Manual for Mineral Sands Mining and Processing. Version 1.0. Commonwealth of Australia, 2001. ISBN: 0642546924.
- Ref 4. National Pollutant Inventory Emission Estimation Manual for Mining. Version 3.1. Commonwealth of Australia, 2012. ISBN: 0642547009.
- Ref 5. National Pollutant Inventory Emission Estimation Manual for Combustion Emissions. Version 3.0. Commonwealth of Australia, 2008. ISBN: 0642548072.
- Ref 6. Emission Factor Documentation for AP-42 - Unpaved Roads. US Environmental Protection Agency, 1998.
- Ref 7. Dampier Mineral Sands Project - Thunderbird PFS Study. Sheffield Resources Limited, 2014. E5502-GRP-001.
- Ref 8. Thunderbird Mineral Sands Project Environmental Scoping Document. Sheffield Resources Limited, 2016. EPBC 2016/7648.
- Ref 9. AERMOD View Users Guide. Lakes Environmental, 2015.
- Ref 10. Derby Export Facility Air Quality Assessment. Environ, 2012. AS110576.
- Ref 11. Environmental Referral – Thunderbird Project. Sheffield Resources Limited, 2015.
- Ref 12. Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. 2005.
- Ref 13. Google Earth, Various Satellite Imagery. Accessed June, July 2016.
- Ref 14. Thunderbird Mine Air Quality Assessment. AS-16-1108-RPT-02. Atmospheric Solutions. 2016.
- Ref 15. Northern Minerals Limited – Air Quality Assessment. Air Assessments, 2014.
- Ref 16. Derby Export Facility Air Quality Assessment. Rey Resources, 2014.