Balla Balla Project

AIR QUALITY IMPACT ASSESSMENT

- Rev 0
- 25 January 2013

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Limitations Statement

The sole purpose of this report and the associated services performed by Sinclair Knight Merz ('SKM') is to provide air quality modelling for Forge Resources in connection with the Balla Balla Project. The services were provided in accordance with the scope of services set out in the contract between SKM and Forge Resources. That scope of services, as detailed in this report, was agreed with Forge Resources.

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Executive Summary

The proposed Forge Resources Ltd (Forge) Balla Balla Project involves mining and processing of magnetite ore at Balla Balla near Whim Creek in the Pilbara, slurry-pipeline transport to Port Hedland and storage and shipping from Utah Point at Hedland.

The Project was approved by the Minister for the Environment on 28 April 2009 (Implementation Statement No. 0794). Forge then acquired the Project from Atlas Iron Ltd in May 2012, though the acquisition did not include the export option via Utah Point in Port Hedland.

Forge has selected a barge export option with a loading facility approximately 15 km northwest of the approved mine site and is now seeking approval to develop associated infrastructure. The development will produce and export 6.0 Mtpa of magnetite concentrate. The magnetite concentrate will be loaded onto barges for transhipment to larger Ocean Going Vessels (OGV) with a typical shipment size of 165,000 tonnes.

Forge engaged Sinclair Knight Merz (SKM) to conduct air quality modelling for the proposed barge export option and assess if any significant change to the project air quality impact at identified receptor locations is likely as a result of the proposed export infrastructure development.

SKM developed an AUSPLUME model to simulate dust emissions from two scenarios:

1) the Balla Balla mine operating at its highest conceptual throughput (55.2 Mtpa of ore and waste rock), and
2) the Balla Balla mine as per scenario 1, including the proposed export option (6 Mtpa of processed ore)

The model simulated emissions of particulate matter less than 10 micrometers (µm) in equivalent aerodynamic diameter (PM_{10}), total suspended particulate (TSP), and the rate of dust deposition. Modelled ground-level concentrations were compared across the two scenarios to determine if expected air quality impact at identified receptor locations will change due to the introduction of the proposed export facility.

Modelled ground-level concentrations were also compared to ambient air quality criteria adopted for this assessment from the standards described in the National Environment Protection Measures (NEPM) for PM_{10}, the Kwinana Environmental Protection Policy (Kwinana EPP) for TSP, and NSW regulatory standards for dust deposition.

Modelled ground-level concentrations of PM_{10}, TSP concentrations, and the dust deposition rate at the Accommodation Village and West Moore Fishing Lodge are compared to assessment criteria levels in **Table E-1** for each scenario.

Table E-1 Expected maximum impacts at identified sensitive receptor locations

	Scenario 1 – Mine only			Scenario 2 – Mine and export option		
	PM_{10} (µg/m^3)	TSP (µg/m^3)	Deposition (g/m^2/month)	PM_{10} (µg/m^3)	TSP (µg/m^3)	Deposition (g/m^2/month)
Accomm. Village	10	11	0.11	10	12	0.11
Fishing Lodge	3	5	0.01	3	5	0.01
Criteria	50	90	2	50	90	2

There will be no change to the expected air quality impact at the Accommodation Village or West Moore Fishing Lodge as a result of the export option proposed.

The Accommodation Village and West Moore Fishing Lodge are also unlikely to be exposed to dust concentrations exceeding the adopted assessment criteria as a result of the operation of the Balla Balla mine and export facility.

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1. Introduction

The proposed Forge Resources Ltd (Forge) Balla Balla Project involves mining and processing of magnetite ore at Balla Balla near Whim Creek in the Pilbara, slurry-pipeline transport to Port Hedland and storage and shipping from Utah Point at Hedland. The Project was approved by the Minister for the Environment on 28 April 2009 (Implementation Statement No. 0794).

Forge acquired the Project from Atlas Iron Ltd. in May 2012, the previous owners had intended on transporting the concentrate via slurry pipeline to Port Hedland for export. Forge acquired the Project without obtaining the port access at Port Hedland and has been exploring options for an alternate export facility.

To that end, Forge has selected a barge export option with a loading facility approximately 15 km northwest of the approved mine site and is now seeking approval to develop associated infrastructure. The development will produce and export 6.0 Mtpa of magnetite concentrate. The magnetite concentrate will be loaded onto barges for transhipment to larger Ocean Going Vessels (OGV) with a typical shipment size of 165,000 tonnes.

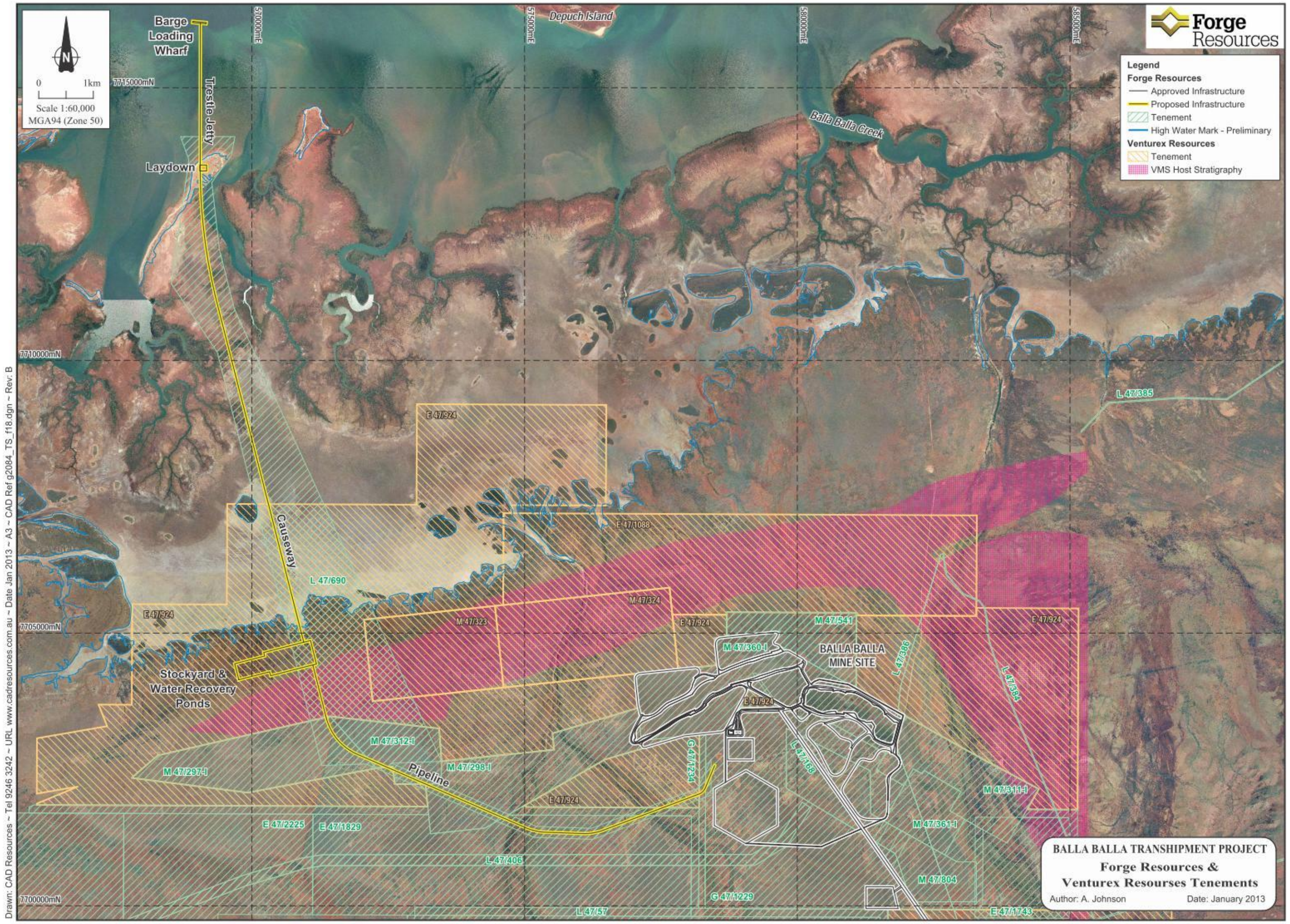
The location of the proposed trans-shipping facility and infrastructure route is shown in **Figure 1-1** below.

Forge has engaged Sinclair Knight Merz (SKM) to conduct air quality modelling for the proposed export infrastructure and assess if any significant change to the project air quality impact at local receptor locations is likely as a result of the proposed export infrastructure development.

This report describes the process of assessment by:

- identifying the key emissions to air from the proposed operations
- identifying sensitive receptors that may be impacted by emissions to air from the operations
- identifying and adopting relevant air quality assessment criteria
- determining emission source locations and emissions rates using mine activity information and published emission factors
- developing a representative meteorological dataset for use in modelling
- setting of model parameters to reflect the operations and regional conditions
- comparing model results to adopted air quality assessment criteria

This study has been undertaken with reference to the WA Department of Environment Air Quality Modelling Guidelines (DoE 2006).



■ **Figure 1-1 Proposed Balla Balla Transhipment Facility Location**

2. Air Quality Objectives

2.1. Overview

The key air emissions identified for the modelling include all substances that may be deemed to cause a human health effect or an environmental impact. The species addressed in this section are considered the most relevant to the assessment based on the nature of the works to be undertaken during the overall development and operation of the proposed mine.

For this assessment, airborne particulate matter (dust) is considered to be the only emission of concern for potential sensitive receptors in the area.

Mine operations may also result in the generation of nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and carbon monoxide (CO) from combustion sources (vehicles and portable generators). However, in the absence of an on-site power station, emissions of these substances from typical mining operations are not sufficiently high to present a significant risk to potential sensitive receptors, and are thus not included in this assessment.

2.2. Airborne Particulate Matter

Airborne or suspended particulate matter is typically defined by its size, chemical composition or source. Particles can also be defined by whether they are primary particles such as a suspension of the fine fraction of soil by wind erosion, sea salt from evaporating sea spray, pollens or soot particles from incomplete combustion, or secondary particles from the conversion of sulfate and nitrate particles from SO_2 and NO_X.

2.2.1. Human Health Impacts

The principal health effect of particulates is the exacerbation of pre-existing respiratory problems. The population groups that are most susceptible include the elderly, people with existing respiratory and/or cardiovascular problems and children. The majority of particles greater than 10 µm in aerodynamic diameter do not pass further than the upper respiratory tract (nose and throat). Most of the health impacts are observed from the fine particles (less that 10 µm in equivalent aerodynamic diameter) that penetrate deeper into the respiratory system.

2.2.2. Environmental Impacts

Particulate matter can also enhance some chemical reactions in the atmosphere and reduce visibility. The deposition of larger particles can have the following consequences:

- staining and soiling surfaces
- aesthetic or chemical contamination of water bodies or vegetation
- effects on personal comfort, amenity and health

2.3. Emissions Assessed

For this assessment, the relevant emissions assessed include:

- particulate matter less than 10 micrometres (μm) in equivalent aerodynamic diameter (PM_{10})
- total suspended particulate (TSP)
- dust deposition

Emitted substances are described further in the following sections.

2.3.1. PM_{10}

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

A common standard to assess PM_{10} impacts is the Ambient Air Quality NEPM (NEPC 2003).

2.3.2. Total Suspended Particulates

"Total suspended particulate" (TSP) is defined as particulate matter of approximately 50 micrometres or less in equivalent aerodynamic diameter. TSP is generally considered to be associated with aesthetic impacts (DEP 2001), as this range includes particles to be too large for inhalation which is unsuitable for developing criteria based on observed health impacts (WHO 2000).

In Western Australia, TSP impacts are commonly discussed with reference to standards defined by the Kwinana Environmental Protection Policy (EPP). The Kwinana EPP specifies three different zones; Area A, B and C. These areas represent industrial zoning (A), buffer zoning (B), and the zone outside Area A and B (C) (EPA 1999). Typically the criteria specified for Area C are used at sensitive receptor locations.

2.3.3. Deposition

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

In Western Australia there are no prescribed standards for assessing dust deposition impact, however an impact assessment standard does exist in New South Wales (NSW DEC 2005) for nuisance dust to humans. The standard states that the maximum allowable increase from background contributions in deposited dust is 2 g/m^2/month with a total allowable maximum of 4 g/m^2/month. The NSW criterion for allowable increases has been adopted for this assessment.

It is noted that this standard is specific to human amenity. The impact of dust deposition on vegetation is not fully understood within the Australian context. In absence of criteria specific to vegetation applicable to this assessment, the human amenity criterion has been applied in this assessment as a surrogate standard to screen for potential risks.

2.4. Air Quality Criteria Summary

The criteria adopted for this assessment are summarised in **Table 2-1** below.

- **Table 2-1 Criteria adopted for assessment**

Pollutant	Averaging Period	Maximum Concentration
PM_{10}	24-hour	50 $\mu g/m^3$
TSP	24-hour	90 $\mu g/m^3$
Dust deposition	Monthly	2 g/m^2/month (maximum increase)

3. Meteorology

3.1. Available Data

There are no site specific meteorological data available.

The Australian Bureau of Meteorology (BoM) maintains a number of meteorological stations in the Pilbara. The closest stations to the project area are Cossack (004054, 62.2 km west), Roebourne (004090, 65.8 km west and 004035, 67.3 km west) and Port Hedland (004032, 94 km east).

For this study data from the nearest BoM stations were not assessed as it is believed the distance of these sites to Balla Balla, as well as the coastal location of the project, would preclude measured data at these stations from being suitably representative.

In the absence of local meteorological measurements, SKM has used the TAPM meteorological model to develop meteorological data representative of the local area.

3.2. Meteorological Model File Development

The TAPM meteorological and air dispersion model, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), was used to create three site specific meteorological data files for the modelling assessment, one at the mine site, one at the stockyard facility, and one at the wharf area. These three files were used to model emissions specific to these locations.

TAPM is a three-dimensional, prognostic air dispersion model capable of predicting meteorological and pollution parameters on an hourly basis over the modelled period (Hurley 2008).

TAPM was configured with four nested 25 x 25 computational grids to optimise model resolution and run time. Default grid meshes of 30 km, 10 km, 3 km, and 1 km were used. The model domain was centred at the point -20° 43’S and 117° 43.5’E. This corresponds to 575059E 7708926N (Zone 50) on the Map Grid of Australia (MGA). To generate meteorological data, TAPM uses synoptic data input and progressively refines predictions made as it moves down grid mesh sizes.

4. Emission Estimates

This section details the emission identification and estimation techniques applied in this assessment. Emission estimates for the proposed mine are consistent with those that are publicly available, or have been estimated using techniques detailed further in this section.

4.1. Existing Environment

The only contributor to ambient dust concentrations in the area is from natural sources (wind-blown). There are no significant industrial operations nearby that would influence air quality in the Project area.

While no ambient dust monitoring data from the Project area was available for this assessment, it is known that the Pilbara region can be a dusty environment. Wind generated dust provides a noticeable contribution to overall dust concentrations in the region. The aggregated emission study conducted by SKM (SKM 2003) found the Pilbara emitted approximately 170,000 tonnes of airborne particulate in the 1998/1999 financial year from windblown sources.

4.2. Construction Emissions

The construction of the mine, processing plant, export infrastructure and administration buildings is likely to generate emissions to air from material handling, wheel generated dust, and wind erosion of exposed surfaces.

Dust generated by construction activities are expected to be short term (minutes to days), and orders of magnitude smaller compared to dust emissions expected from normal mining operations. With the application of standard construction dust management measures, dust emissions from construction are not considered to be an issue, and thus have not been included in modelling.

4.3. Operational Emissions

While some data have been provided by Forge regarding the proposed operation of the Balla Balla project, a number of operational assumptions have been made to allow emission estimations to be calculated. To compensate for uncertainty in estimates arising as a result of these assumptions a conservative approach to estimation was applied during calculations. A summary of key operational assumptions are presented in **Appendix A**.

Mine throughput used in the modelled year represents the year with the largest expected waste and ore tonnage handled. The model has simulated 45.3 Mt of waste rock being moved and 9.9 Mt of ore extracted and processed, producing 5.7 Mt of concentrate.

After drilling and blasting, ore and waste rock is loaded on haul trucks. Waste rock is transported to waste piles adjacent to the two pits and dumped, with the loose material then shaped by bulldozers. Ore is transported to the primary crusher where it can either be dumped directly into a crusher hopper, or stockpiled for later processing. For conservatism in model results, the modelled process assumes all ore is stockpiled, with a bulldozer then being used to push ore into the hopper.

All material handled between the mine and waste pile/primary crusher has been assumed to be completely dry. Haul roads in the mine are assumed to be unsealed with water carts running dust suppression.

A single primary crusher has been modelled operating at 1,413 tonnes per hour (tph), feeding into a single conveyor line. Primary crushing will introduce water to the product flow, reducing the dustiness of the ore throughout the rest of 'dry' processing.

Output from the primary crusher will feed a single buffer stockpile, which then gravity feeds onto a conveyor line feeding the secondary crushing/screening plant.

Once reaching the secondary crusher, sufficient water will have been added to exceed the dust extinction moisture of the ore. The processing plant also becomes more enclosed and shielded at this stage. At this stage the 'dry' process is considered to have ended and the 'wet' process begins. It has been assumed that processed ore will be sufficiently wet and controlled at this point to prevent any further significant emissions of dust due to processing.

Concentrate produced from processing will be sent from the mine site for export via a slurry pipeline to the stockyard facility located approximately 7 km west of the mine. From here, the slurry is dewatered and stockpiled in rows, ready for export. Stockpiled product is then reclaimed using a bucket wheel reclaimer and conveyed overland to the wharf shiploader 13 km to the north of the stockyard facility.

Back at the mine, the tailings from magnetite processing will be pumped to a tailings storage area. This is a large hexagonal storage facility to the south of the mine and processing area. As the tailings dries there is the potential for wind erosion emissions. For this assessment SKM has assumed that tailings will form a crust as it dries. The tailings storage will also be designed and managed to reduce dust as low as reasonably possible. Accordingly, tailings emissions are not expected to be significant compared to mining and processing emissions, and are thus not included in the model.

4.4. Emission Estimation

The material handling operations likely to occur at the proposed Balla Balla project include:

- drilling and blasting
- loading and unloading of bulk material (including front end loaders and bulldozers)
- vehicle (wheel) generated dust
- crushing and screening operations
- stockpile stacking, reclaiming and shiploading

- wind erosion from stockpiles, waste dumps and unsealed open areas
- fugitive emissions from conveyor transfers

Particulate emission rates for material handling activities were estimated based on the methodologies and values outlined in the National Pollutant Inventory (NPI) Emission Estimation Technique Manual (EETM) for Mining Version 3.1 (DSEWPC 2012). These factors account for TSP and PM_{10} emissions. Deposition model runs use TSP emission factors.

4.4.1. Drilling

Drilling emissions have been calculated using the default NPI drilling emission rates from Table 2 of the NPI EETM for Mining v3.1 (DSEWPC 2012). For PM_{10} this is specified as 0.31 kg/hole and for TSP as 0.59 kg/hole.

Drilling information was not provided for this assessment. For this assessment drilling emission events were assumed to occur at all hours except during blast events. By assuming an approximate number of holes per blast and using a calculated number of blast events for a year, the total number of drill holes required for the modelled year was calculated. The total emissions were then spread over all possible operating hours (6am to 6pm) at six evenly distributed locations within the pit areas during any given hour.

4.4.2. Blasting

Dust emissions from blasting are difficult to model due to the short time interval and variability of the physical factors that define a blast event. Blasting activities are episodic in nature and the impacts are generally short-term. The uncertainties associated with calculating dust impacts from blasting are generally greater than those associated with other longer term activities of the mining operations as a whole.

Dust emissions from blasting have been estimated using the NPI blasting emission equation 19 from the NPI EETM for Mining v3.1 (DSEWPC 2012), presented as **Equation 4-1** below.

- **Equation 4-1**

$$E = 0.00022 \times A^{1.5}\text{, kg/blast,}$$

Where: A = the blast area (m^2)

Specific blast information was not provided for this assessment. To calculate blasting emissions, the area per blast were assumed based on other similarly sized mine operations. Blast events across the site were simulated to occur at one of six locations in the pit area, and were scheduled to occur either at 0900, 1200, or 1500 hours.

4.4.3. Ore and Waste Loading and Dumping

After blasting, waste and ore is loaded on haul trucks and taken and deposited at either a waste dump, or the ore stockpile feeding the primary crusher. Emissions from this process occur as material is handled, dropped from height, or as it falls from the back of haul trucks. Equation 10 from the NPI EETM for Mining v3.1 (DSEWPC 2012) provides emission rates for loading and dumping of trucks. These are presented in **Equation 4-2**.

- **Equation 4-2**

$$E = k \times 0.0016 \times \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \text{, kg/t}$$

Where: k = 0.74 for TSP, 0.35 for PM_{10}
U = wind speed (m/s)
M = moisture content of material (%)

Loading of ore and waste rock was simulated at pit locations for all hours except during scheduled blasting hours. Unloading at the waste pile or the ore stockpile occurred during the same hour as loading. Waste rock was unloaded at one of nine waste dump locations depending on where it was loaded from. All ore was unloaded at ROM area feeding the primary crushers. The default NPI moisture content of 2% was applied for loading and dumping emissions.

4.4.4. Bulldozing

After being dumped at the waste pile, waste material is then bulldozed to clear the way for further dumping or to shape the pile. Bulldozing also occurs at the ROM area, pushing ore into primary crushers. Emissions were calculated by the equation provided in the NPI EETM for Mining v3.1 (DSEWPC 2012) for bulldozers operating on material other than coal. This equation is presented as **Equation 4-3**.

- **Equation 4-3**

$$E = A \times \frac{s^B}{M^C} \text{, kg/h}$$

Where: s = silt content (%)
M = moisture content (%)
A = 0.34 for PM_{10}, 2.6 for TSP
B = 1.5 for PM_{10}, 1.2 for TSP
C = 1.4 for PM_{10}, 1.3 for TSP

The silt and moisture content were set to the NPI default values of 10% and 2% respectively. Dozers were assigned to the four unloading locations on the waste pile and the two unloading locations on the ore stockpile feeding the primary crushers. All dozers (waste and ore) were simulated at the same operational capacity of the primary crusher (1,413 tph). Dozers were simulated as able to operate at any given hour, with hours spread over a year using a random number function. It was assumed each dumping location only needs one dozer to move the required tonnages.

4.4.5. Ore Crushing

The first stage of the processing circuit is primary crushing. Secondary crushing also occurs further along the process circuit.

The emission estimation factors for crushing are defined in Table 3 of the NPI EETM for Mining v3.1 (DSEWPC 2012) are simple default emission factors and are presented in **Table 4-1** below.

- **Table 4-1 Default emission factors for crushing**

Activity	Size fraction	High Moisture Ore Emission rate (kg/t)	Low Moisture Ore Emission rate (kg/t)
Primary crushing	PM_{10}	0.004	0.02
	TSP	0.01	0.2
Secondary crushing	PM_{10}	0.012	NA
	TSP	0.03	0.6

For crushing and screening, the emission factor depends on of the moisture content of the material. There are two categories, one is ‘low moisture’ for materials with a moisture content less than or equal to 4%, the other is ‘high moisture’ for materials with a moisture content higher than 4% (DSEWPC 2012). The ore moisture (as mined) is expected to be below 4% (thus considered ‘low’), the addition of water during crusher operations is expected to raise the moisture content of ore being processed to ‘high’.

4.4.6. Transfers, Stacking and Reclaiming

Transfer points are present in processing operations linked with crushing operations. Transfer emissions were simulated before and after the buffer stockpile. At the stockyard facility, transfers have been simulated feeding the stacker as well as between the overland conveyor and reclaimer.

Emissions from stacking occur when the buffer stockpile is built from primary crushing throughput. Stacking emissions also occur at the stockyard facility. Shiploading at the wharf has been simulated as a stacking operation.

Reclaiming emissions only occur at the stockyard facility when material is reclaimed and fed to the overland conveyor for export.

The emission estimation factors for transfers and stacking of ore defined in Table 2 and 3 of the NPI EETM for Mining v3.1 (DSEWPC 2012) are simple default emission factors and are presented in **Table 4-2** below.

- **Table 4-2 Default emission factors for transfers, stacking and reclaiming**

Activity	Size fraction	High Moisture Ore Emission rate (kg/t)	Low Moisture Ore Emission rate (kg/t)
Handling, transferring and conveying, including reclaiming (Table 3)	PM_{10}	0.002	0.03
	TSP	0.005	0.06
Loading stockpiles (Table 2)	PM_{10}	0.0017	
	TSP	0.004	

The definition of high and low moisture ore is described in **Section 4.4.5** above. Due to the addition of water in the primary crusher, and ore moisture treatment when de-watering at the stockyard facility, it is reasonable to assume high moisture emission rates apply for all transfer, stacking and reclaiming emissions.

4.4.7. Wheel Generated Road Dust

For this assessment the dominant traffic activity is considered to be haul trucks moving between the pit and ore/waste stockpiles, and road trains transporting concentrate off-site. The emissions of particulate matter due to vehicular activity at the mine were determined using the equation from the NPI EETM for Mining v3.1 (DSEWPC 2012) presented in **Equation 4-4**.

- **Equation 4-4**

$$EF = \left(\frac{0.4536}{1.6093}\right) \times k \times \left(\frac{s}{12}\right)^{A} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45} \text{, kg/VKT}$$

Where: EF = emission factor in kilograms per vehicle kilometre travelled (kg/VKT)
k = 4.9 for particles less than 50 micrometres aerodynamic diameter
k = 1.5 for particles less than 10 micrometres aerodynamic diameter
s = surface material silt content, %
W = vehicle gross mass, tonnes
A = 0.7 for TSP and 0.9 for PM_{10}

In the absence of site specific data the silt content was assumed at 1% (well maintained gravel packed roads). Vehicle weight for mining haul trucks was assumed as 250 tonnes for a loaded haul truck, and 23 tonnes for an empty haul truck. The calculated emission rates using these values in **Equation 4-4** are presented in **Table 4-3**.

- **Table 4-3 Wheel generated road dust – emissions factors**

Description of Road Type	PM_{10} Emission Factor (kg/VKT)	TSP Emission Factor (kg/VKT)
Haul Trucks (Full)	0.33	1.78
Haul Trucks (Empty)	0.12	0.62

Vehicle kilometres travelled were estimated based upon the distance between loading and unloading source locations, the length of the haul road in the model domain area, and the number of loads required to move 55.2 Mt of ore and waste rock in the modelled year. Haul trucks were assumed to operate at all hours except scheduled blast hours.

4.4.8. Wind Erosion

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

- **Equation 4-5**

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

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

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

The constant k used was 2.5 x 10^{-6} with a wind speed threshold of 6 m/s. The constant k and wind speed threshold value is consistent with other dust studies in the Pilbara, including the study for the original option of exporting Balla Balla mine output through Utah Point (SKM 2007, 2008, 2010 and 2011). Solving **Equation 4-5** using model generated meteorology (**Section 3.2**) results in an average PM_{10} emission rate of 0.18 kg/ha/hr which is comparable to the default PM_{10} emission factor of 0.2 kg/ha/hr provided in the NPI EETM for Mining v3.1 (DSEWPC 2012). A TSP emission factor was determined using the particle size fractions described later in **Section 5.3.3**.

For this assessment wind erosion was taken to occur from the pit, waste dumps, and active open areas around crushing and stockyard facilities.

4.4.9. Dust Control Measures

While most emission sources are quantified using these emission factors, the various dust controls mitigate emissions differently at each source. The extent to which control factors reduce dust emissions in this assessment is defined in the NPI EET for Mining v3.1 (DSEWPC 2012). The only factor not from the NPI EET for Mining was the control for the haul road off site. This value is assumed from the main haul road surface being gravel packed and well maintained given the high volume of traffic expected during operations.

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

- **Table 4-4 Controls for various port operations.**

Operation	Type of Control	% Reduction in Emissions
All pit operations	Pit retention	50% for TSP 5% for PM_{10}
Primary crushing	Water sprays	50
Secondary crushing	Water sprays Enclosure and extraction	50 83
Transfer stations	Water sprays	50
Stacking and reclaiming	Water sprays	50
Wheel generated dust	Water trucks Surface management (haul road)	50 90

5. Model Setup

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

5.1. Overview

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

5.2. Modelling Methodology

Potential air quality impacts from the Balla Balla mine and proposed export option have been assessed using the Victorian EPA's AUSPLUME (Version 6.0) computer dispersion model. This model is one of the primary air dispersion models used for assessing air quality impacts from industrial sites within Australia. The model is designed to calculate ground-level concentrations or dry deposition of pollutants emitted from one or more sources, such as stacks, area sources, volume sources, or any combination of these. AUSPLUME is essentially a statistical Gaussian plume model that requires a time series of both meteorological and source emission data.

AUSPLUME was selected for this assessment due to:

- Ground-level emissions – no stack releases
- No significant terrain features in the model domain
- Predominately short range transportation of emission (some longer distance emissions)
- Lack of detailed environmental data in the area required for advanced dispersion models – advanced models would likely require more assumptions, potentially reducing confidence in model output
- Computationally simple

5.3. AUSPLUME Modelling

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

- 500 m grid spacing (**Section 5.3.1**)
- terrain not included in model (**Section 5.3.2**)
- dry plume depletion (**Section 5.3.3**)
- Pasquill Gifford dispersion curves (**Section 5.3.4**)

- roughness length of 0.1 m. (**Section 5.3.5**)
- meteorological data generated from TAPM model (**Section 5.3.6**)
- hourly variable emissions data (**Section 5.4.1**)

5.3.1. Grid System

AUSPLUME can calculate concentrations both on a set grid (typically Cartesian) or at specified locations. The model was configured to calculate ground-level concentrations on a square grid (10 km by 10 km) of spacing established at 500 m intervals, centred on the Accommodation Village for the mine. This grid approach was chosen to optimise the duration of model runs while still maintaining a reasonable spatial resolution of model output. A grid was not plotted for the West Moore Fishing Lodge; the ground-level concentration was calculated at its specific location.

5.3.2. Model Terrain

The model was run without incorporating terrain effects due to the size of the model grid spacing relative to any significant terrain features that may exist. The influence of terrain effects simulated in AUSPLUME would not be significant compared to uncertainties in source emission estimates.

5.3.3. Dry Depletion Method

Particles settling under gravity are subject to dry deposition. For this option, particle size distribution data and the particle density for each size fraction is required. AUSPLUME then calculates a settling velocity and a deposition velocity for each of these size categories. The settling velocity causes an elevated plume to “tilt” towards the surface as it travels downwind, while the deposition velocity is used to calculate the flux of matter deposited at the surface. Plume depletion allows material to be removed from the plume as it is deposited on the surface.

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

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

AUSPLUME also has the ability to simulate the removal of airborne dust through rainfall events (wet deposition). This feature has not been used, so as to increase the conservatism of model output.

The particle size distribution for particles from the proposed development was obtained from the USEPA AP-42 (USEPA 2006) and is presented in **Table 5-1**. Particle density was set to 2.3 g/cm^3.

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

Mid Range Particle Size (µm)	Mass Fraction	
	PM_{10}	TSP
2.5	0.15	0.07
5	0.42	0.20
10	0.43	0.20
15	-	0.18
30	-	0.35

5.3.4. Dispersion Curves

Horizontal dispersion of plumes can be determined within AUSPLUME using Pasquill Gifford curves or through the standard deviation in wind direction known as sigma theta (σ_θ). The latter is preferred where observations are available, as sigma theta is a direct measure of horizontal dispersion and the resultant lateral dispersion coefficient will be a continuous function, not discrete curves. As sigma theta observations were not available (only simulated values from TAPM) the Pasquill Gifford option was selected for horizontal dispersion.

5.3.5. Roughness Length

Terrain features such as vegetation, buildings and roads influence the vertical dispersion of dust within an air flow. As a general rule, dense vegetation and tall buildings cause turbulent air flow. Low lying vegetation and flat terrain has less of an influence on the dispersion of airborne dust. AUSPLUME uses an average surface roughness for the modelled area. Taking into consideration the flat coastal terrain, a roughness length of 0.1 metres was simulated for this assessment.

5.3.6. Time Series Meteorological Data

A time series meteorological data file is required for AUSPLUME modelling, including hourly averaged values of:

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

These data were derived from TAPM generated meteorology for the Project area, described in **Section 3.2**.

5.4. Model Inputs

A model of the Balla Balla mine and proposed export option was established to calculate 24-hour ground-level concentrations of PM_{10} and TSP, and dust deposition rates at relevant receptor locations to the site. Inputs to the model include:

- meteorological files containing hourly data for 2009, detailed in **Section 3.2**
- operational data and emissions release estimates, detailed in **Section 4.4**

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

5.4.1. Emission Sources

The sources modelled in this assessment were specific to mining and bulk material handling operations described in **Section 4**.

5.4.2. Receptor Locations

Two human receptor locations were identified and included in this assessment.

- **Table 5-2 Receptor locations**

Receptor	Easting (m)	Northing (m)
Accommodation Village	581534	7700140
West Moore Fishing Lodge	570691	7718075

6. Model Results

This section presents the results of atmospheric dispersion modelling undertaken for this assessment. The modelling results are tabulated for the different assessment criteria. The maximum modelled ground-level concentrations across the defined air quality assessment area (model domain) have also been plotted.

This assessment addresses two scenarios:

1) the Balla Balla mine operating at its highest conceptual throughput (55.2 Mtpa of ore and waste rock), and
2) the Balla Balla mine as per scenario 1, including the proposed export option

As discussed in **Section 1**, the scenarios selected for this assessment will be used to assess whether the proposed export option will significantly change the air quality impacts of the currently approved mine operations.

Model results do not include background concentrations as no local monitoring data was available for assessment. However, this information is not required for the purpose of this study.

6.1. Model Results

Maximum modelled ground-level concentrations of $PM_{10,}$ TSP, and the dust deposition rate at the Accommodation Village and West Moore Fishing Lodge are presented in **Table 6-1** and **Table 6-2**.

Expected ground-level concentrations and deposition rates are highest at the Accommodation Village. At this location PM_{10} is no more than 20% of the adopted assessment criteria. For TSP the maximum modelled ground-level concentration is no more than 13% of the adopted assessment criteria, and for dust deposition, no more than 5% of the adopted assessment criteria.

The modelled ground-level concentrations show little or no difference between scenarios.

Contour plots providing a visual representation of model output with respect to the Accommodation Village are presented in **Appendix C**. Criteria limits for the modelled pollutant are presented as red contour lines.

Table 6-1 Modelled ground-level concentrations at Accommodation Village

Pollutant		Scenario	Maximum	Percentiles				Annual Average
				99th	95th	90th	70th	
24-hour PM_{10}	µg/m^3	1	10	7	4	3	1	1
		2	10	7	4	3	2	1
24-hour TSP	µg/m^3	1	11	9	5	4	2	2
		2	12	9	5	4	2	2
Monthly Deposition	g/m^2/month	1	0.11	-	-	-	-	-
		2	0.11	-	-	-	-	-

Table 6-2 Modelled ground-level impacts at West Moore Fishing Lodge

Pollutant		Scenario	Maximum	Percentiles				Annual Average
				99th	95th	90th	70th	
24-hour PM_{10}	µg/m^3	1	3	2	2	1	< 1	< 1
		2	3	3	2	1	1	< 1
24-hour TSP	µg/m^3	1	5	4	2	1	1	1
		2	5	4	2	2	1	1
Monthly Deposition	g/m^2/month	1	0.01	-	-	-	-	-
		2	0.01	-	-	-	-	-

7. Conclusion

This study has focused on assessing the change to air quality impacts, if any, that may result from developing a local export option for the Balla Balla mine in the Pilbara

Modelling of dust emissions was undertaken using the AUSPLUME Gaussian plume dispersion model. A review of the model results raises the following observations:

- There will be no discernible change to the expected air quality impact at the Accommodation Village or West Moore Fishing Lodge as a result of the export option proposed.
- The Accommodation Village and West Moore Fishing Lodge are unlikely to be exposed to dust concentrations exceeding the assessment criteria detailed in **Section 2** as a result of the operation of the Balla Balla mine and export facility.
  - The only other source of particulate matter in the modelled area is ambient dust generated by natural processes. As noted in **Section 4.1**, the Pilbara is a naturally dusty environment, so there is some possibility that during days of high background concentrations Balla Balla emissions may contribute to an exceedence of the adopted assessment criteria for PM_{10} and TSP at the Accommodation Village or West Moore Fishing Lodge. However, model results show that any such contribution would be insignificant.
- Deposition criteria are expressed in terms of the increase above existing levels. The model results show that the maximum expected increase in deposition is very much less than the assessment criteria.

8. References

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Appendix A Key Operational Assumptions

Emission estimates for mine and export operations were made with the following assumptions:

Drilling:

- Blast hole spaced by 5 meters i.e. one hole every 25 m^2
- Can occur at all hours between 6am and 6pm except during blast events

Blasting:

- Area per blast assumed at 7,000 m^2
- Drill hole depth assumed at 5 m – thus blast volume is 35,000 m^3 (ignores loosened rock below drill depth)
- Density of blasted rock assumed at 5 t/m^3 – thus 175,000 tonnes of rock per blast
- To get 55.2 Mt at 0.175 Mt per blast need approximately 316 blast events
- Blast events can only occur at 0900, 1200 and 1500 hours

Loading/Unloading

- Can occur at all hours except during blast events
- Moisture content set to 2% (NPI default value)

Bulldozing:

- Silt content of waste rock and ore assumed at 10%
- Moisture content of waste rock and ore assumed at 2% (dry)
- All ore is stockpiled and pushed into primary crusher with bulldozers – no direct dumping simulated
- Can occur at all hours
- One dozer per unloading location assumed able to move required tonnages
- Dozers operating on the waste piles and ROM area are assumed able to process 1,413 tonnes per hour (tph) – matches primary crusher nominal processing rate

Crushing and Screening:

- Primary crusher can process 1,413 tph (dozers operate accordingly)
- The secondary crusher can process 1,238 tph
- 'High' moisture content emission factors used for crushing/screening operations

Transfers, Stacking and Reclaiming

- The primary crusher, secondary crusher, stockyard stacker and reclaimer trigger transfer station emissions when operational.

Vehicles

- Silt content of all road surfaces assumed at 1% (well maintained gravel packed roads)
- Haul truck specification assumed as CAT 793F haul truck (227 t capacity, 23 t empty) – data sheet available from the CAT website http://www.cat.com/cda/layout?m=413186&x=7
- Sufficient haul trucks will operate to move the required tonnages

Wind Erosion

- Pit area susceptible to wind erosion assumed at 212 ha, divided over 17 locations
- Waste pile area susceptible to wind erosion assumed at 394 ha, divided over 31 locations
- ROM pad and processing area assumed susceptible to wind erosion, each with an estimated area of 3 ha
- Stockpile area assumed susceptible to wind erosion assumed at 1 ha, divided over 2 locations

Appendix B Example AUSPLUME Output File

```
1         ______________________________________________________________

            WV04656 Balla Balla Mine 2009 (16/01/2013) SMB PM10 Contour

          ______________________________________________________________

 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                0.100 m
 Use the convective PDF algorithm?                     No

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

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

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

    Wind Speed                Stability Class
     Category       A      B      C      D      E      F
   ________________________________________________________
        1         0.000  0.000  0.000  0.000  0.020  0.035
        2         0.000  0.000  0.000  0.000  0.020  0.035
        3         0.000  0.000  0.000  0.000  0.020  0.035
        4         0.000  0.000  0.000  0.000  0.020  0.035
        5         0.000  0.000  0.000  0.000  0.020  0.035
        6         0.000  0.000  0.000  0.000  0.020  0.035

 WIND SPEED CATEGORIES
```

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

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

 AVERAGING TIMES
 24 hours

 _____________________________________________________________________________

1        ______________________________________________________________

           WV04656 Balla Ball Mine 2009 (16/01/2013) SMB PM10 Contour

                             SOURCE CHARACTERISTICS

         ______________________________________________________________


                    VOLUME SOURCE: PIT1

    X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
  576986  7703258            0m             5m        100m            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)
                   _____________________________
                      0.1500      2.5      2.30
                      0.4200      5.0      2.30
                      0.4300     10.0      2.30


                    VOLUME SOURCE: PIT2

    X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
  578087  7703856            0m             5m        100m            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)
                   _____________________________
                      0.1500      2.5      2.30
                      0.4200      5.0      2.30
                      0.4300     10.0      2.30


                    VOLUME SOURCE: PIT3

    X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
  579423  7704518            0m             5m        100m            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)
                ______________________________
                   0.1500      2.5      2.30
                   0.4200      5.0      2.30
                   0.4300     10.0      2.30


                 VOLUME SOURCE: PIT4

   X(m)      Y(m)      Ground Elevation     Height   Hor. spread   Vert. spread
 581000  7703943               0m              5m        100m              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)
                ______________________________
                   0.1500      2.5      2.30
                   0.4200      5.0      2.30
                   0.4300     10.0      2.30


                 VOLUME SOURCE: PIT5

   X(m)      Y(m)      Ground Elevation     Height   Hor. spread   Vert. spread
 581966  7703322               0m              5m        100m              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)
                ______________________________
                   0.1500      2.5      2.30
                   0.4200      5.0      2.30
                   0.4300     10.0      2.30


                 VOLUME SOURCE: PIT6

   X(m)      Y(m)      Ground Elevation     Height   Hor. spread   Vert. spread
 582778  7702355               0m              5m        100m              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)
0.1500	2.5	2.30
0.4200	5.0	2.30
0.4300	10.0	2.30

VOLUME SOURCE: WASTE1

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
576729	7703799	0m	5m	100m	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)
0.1500	2.5	2.30
0.4200	5.0	2.30
0.4300	10.0	2.30

VOLUME SOURCE: WASTE2

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
576714	7702137	0m	5m	100m	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)
0.1500	2.5	2.30
0.4200	5.0	2.30
0.4300	10.0	2.30

VOLUME SOURCE: WASTE3

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
577784	7704397	0m	5m	100m	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)
0.1500	2.5	2.30
0.4200	5.0	2.30
0.4300	10.0	2.30

VOLUME SOURCE: WASTE4

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
578034	7702962	0m	5m	100m	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)
0.1500	2.5	2.30
0.4200	5.0	2.30
0.4300	10.0	2.30

VOLUME SOURCE: WASTE5

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
579599	7705191	0m	5m	100m	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)
0.1500	2.5	2.30
0.4200	5.0	2.30
0.4300	10.0	2.30

VOLUME SOURCE: WASTE6

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
579494	7703866	0m	5m	100m	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)

0.1500	2.5	2.30
0.4200	5.0	2.30
0.4300	10.0	2.30

VOLUME SOURCE: WASTE7

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
580541	7702758	0m	5m	100m	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)
0.1500	2.5	2.30
0.4200	5.0	2.30
0.4300	10.0	2.30

VOLUME SOURCE: WASTE8

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
581271	7702303	0m	5m	100m	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)
0.1500	2.5	2.30
0.4200	5.0	2.30
0.4300	10.0	2.30

VOLUME SOURCE: WASTE9

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
582185	7701417	0m	5m	100m	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)
0.1500	2.5	2.30
0.4200	5.0	2.30

```
                  0.4300     10.0      2.30


                VOLUME SOURCE: ROM

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
578869  7703293            0m             2m        25m            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)
               _____________________________
                  0.1500      2.5      2.30
                  0.4200      5.0      2.30
                  0.4300     10.0      2.30


                VOLUME SOURCE: PCRSH

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
579000  7703212            0m             5m        10m            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)
               _____________________________
                  0.1500      2.5      2.30
                  0.4200      5.0      2.30
                  0.4300     10.0      2.30


                VOLUME SOURCE: TS1

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
579000  7703145            0m             2m         1m            1m

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

      Hourly multiplicative factors will be used with
      this emission factor.

                Particle  Particle  Particle
                  Mass      Size    Density
                fraction  (micron)  (g/cm3)
               _____________________________
                  0.1500      2.5      2.30
                  0.4200      5.0      2.30
                  0.4300     10.0      2.30
```

```
                    VOLUME SOURCE: STK1

  X(m)     Y(m)     Ground Elevation     Height   Hor. spread    Vert. spread
579000  7703000             0m             15m        20m             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)
                   _____________________________
                      0.1500       2.5      2.30
                      0.4200       5.0      2.30
                      0.4300      10.0      2.30


                    VOLUME SOURCE: TS2

  X(m)     Y(m)     Ground Elevation     Height   Hor. spread    Vert. spread
578918  7703000             0m              2m         1m             1m

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

         Hourly multiplicative factors will be used with
         this emission factor.

                    Particle  Particle  Particle
                      Mass      Size    Density
                    fraction  (micron)  (g/cm3)
                   _____________________________
                      0.1500       2.5      2.30
                      0.4200       5.0      2.30
                      0.4300      10.0      2.30


                    VOLUME SOURCE: SCRSH

  X(m)     Y(m)     Ground Elevation     Height   Hor. spread    Vert. spread
578918  7702857             0m              5m        10m             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)
                   _____________________________
                      0.1500       2.5      2.30
                      0.4200       5.0      2.30
                      0.4300      10.0      2.30
```

```
          WV04656 Balla Ball Mine 2009 (16/01/2013) SMB PM10 Contour

                              RECEPTOR LOCATIONS

        _______________________________________________________________

 The Cartesian receptor grid has the following x-values (or eastings):
 576000.m  576500.m  577000.m  577500.m  578000.m  578500.m  579000.m
 579500.m  580000.m  580500.m  581000.m  581500.m  582000.m  582500.m
 583000.m  583500.m  584000.m  584500.m  585000.m  585500.m  586000.m
 586500.m  587000.m  587500.m  588000.m

 and these y-values (or northings):
7694000.m 7694500.m 7695000.m 7695500.m 7696000.m 7696500.m 7697000.m
7697500.m 7698000.m 7698500.m 7699000.m 7699500.m 7700000.m 7700500.m
7701000.m 7701500.m 7702000.m 7702500.m 7703000.m 7703500.m 7704000.m
7704500.m 7705000.m 7705500.m 7706000.m

 _____________________________________________________________________________

                  METEOROLOGICAL DATA :  AUSPLUME METFILE

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

 The input emission rates specfied above will be multiplied by hourly varying
 factors entered via the input file:
 D:\Ausplume\WV04656\Modelling\Base\PM10\WV04656 Balla Balla Mine PM10.src
 For each stack source, hourly values within this file will be added to each
 declared exit velocity (m/sec) and temperature (K).

 Title of input hourly emission factor file is:
 Balla Balla Mine PM10 Emissions smb 11/01/2013

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

 Prefix PIT1   allocated: PIT1
 Prefix PIT2   allocated: PIT2
 Prefix PIT3   allocated: PIT3
 Prefix PIT4   allocated: PIT4
 Prefix PIT5   allocated: PIT5
 Prefix PIT6   allocated: PIT6
 Prefix WASTE1 allocated: WASTE1
 Prefix WASTE2 allocated: WASTE2
 Prefix WASTE3 allocated: WASTE3
 Prefix WASTE4 allocated: WASTE4
 Prefix WASTE5 allocated: WASTE5
 Prefix WASTE6 allocated: WASTE6
 Prefix WASTE7 allocated: WASTE7
 Prefix WASTE8 allocated: WASTE8
 Prefix WASTE9 allocated: WASTE9
 Prefix ROM    allocated: ROM
 Prefix PCRSH  allocated: PCRSH
 Prefix TS1    allocated: TS1
 Prefix STK1   allocated: STK1
 Prefix TS2    allocated: TS2
 Prefix SCRSH  allocated: SCRSH
```

Appendix C Contour Plots of Modelled Impacts