ENVIRONMENTAL TECHNOLOGIES & ANALYTICS

Warrawoona Gold Project - Calidus Resources Limited

Assessment of Dust Emissions

Final Report
Version 1

Prepared for Rapallo

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Signature		

Deanna Tuxford

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1 Introduction

1.1 Background

Environmental Technologies and Analytics Pty Ltd (ETA) was commissioned to provide technical advice (desktop assessment) on the potential air quality (dust) emissions from the Warrawoona Gold Project (the Project).

The Warrawoona Gold Project is located approximately 20 kilometres (km) southeast of Marble Bar, in the east Pilbara region of Western Australia. Elevated ambient dust levels are naturally occurring in the Pilbara, especially under dry and windy conditions. The region is also prone to bushfires during the dry season (generally July to January). Background dust levels during these periods are therefore often elevated. Published monitoring for the region is available from the Port Hedland Industries Council (PHIC) regional background monitor (Yule River) which is located approximately 40 km inland from Port Hedland. The annual average particulate concentrations (PM_{10}) at this station are approximately 22 µg/m^3, with maximum monitored 24-hour averages of 101 µg/m^3 (PHIC, 2017).

The expected Project life is six years, involving the mining of approximately 12 million tonnes per annum (Mtpa) of material (ore:waste strip ratio 4.91). Based on the presentation of the ore body, a combination of surface, open pit and underground mining will be pursued. It is expected that dust emissions will be generated during the construction and operational phases of the Project. Construction dust will principally be generated from clearing and earth moving activities, with operational dust arising from the mining and processing activities including material handling and movement.

Key sensitive receptors in the vicinity of the Project are:

- Prospector on tenements M45/004 and M45/646, located approximately 2.5 km to the south-west of the plant area, and
- Roost sites for the Pilbara Leaf-nosed Bat and Ghost Bat, the closest site located approximately 1.3 km north-west of the plant area, and 200 metres (m) from any related Project activity.

This assessment has been undertaken to support environmental regulatory approvals.

1.2 Description of project

For the purpose of this dust impact assessment, the Project comprises the ore processing facilities and associated infrastructure including road network, buildings and support facilities. The general site layout is shown in Figure 1-1.

The Warrawoona Gold Project is centred around two main deposits (Copenhagan and Klondyke). The Copenhagan deposit, which consists of 0.2 Million tonnes (Mt) at 6.1 grams per tonne (g/t) of gold (Au) is located approximately 10 km from the Klondyke deposit (20 Mt at 1.79 g/t Au). Processing and support facilities will be co-located at Klondyke, including conventional crushing and a CIL (carbon-in-leach) plant with an estimated throughput of 2 Mtpa, tailings storage facility (TSF), waste rock dumps, and camp.

Based on the nature and scale of the operation, and the separation distance of approximately 2.5 km to the Prospector on tenements M45/004 and M45/646, the risk of the operations creating an unacceptable dust impact is considered low. The closer proximity of the Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) and Ghost Bat (*Macroderma gigas*) roost sites to the operations increases the potential for ambient dust concentrations to be higher at these locations than the background levels. A literature review has not identified any specific criteria appropriate to represent the protection of this ecological value.

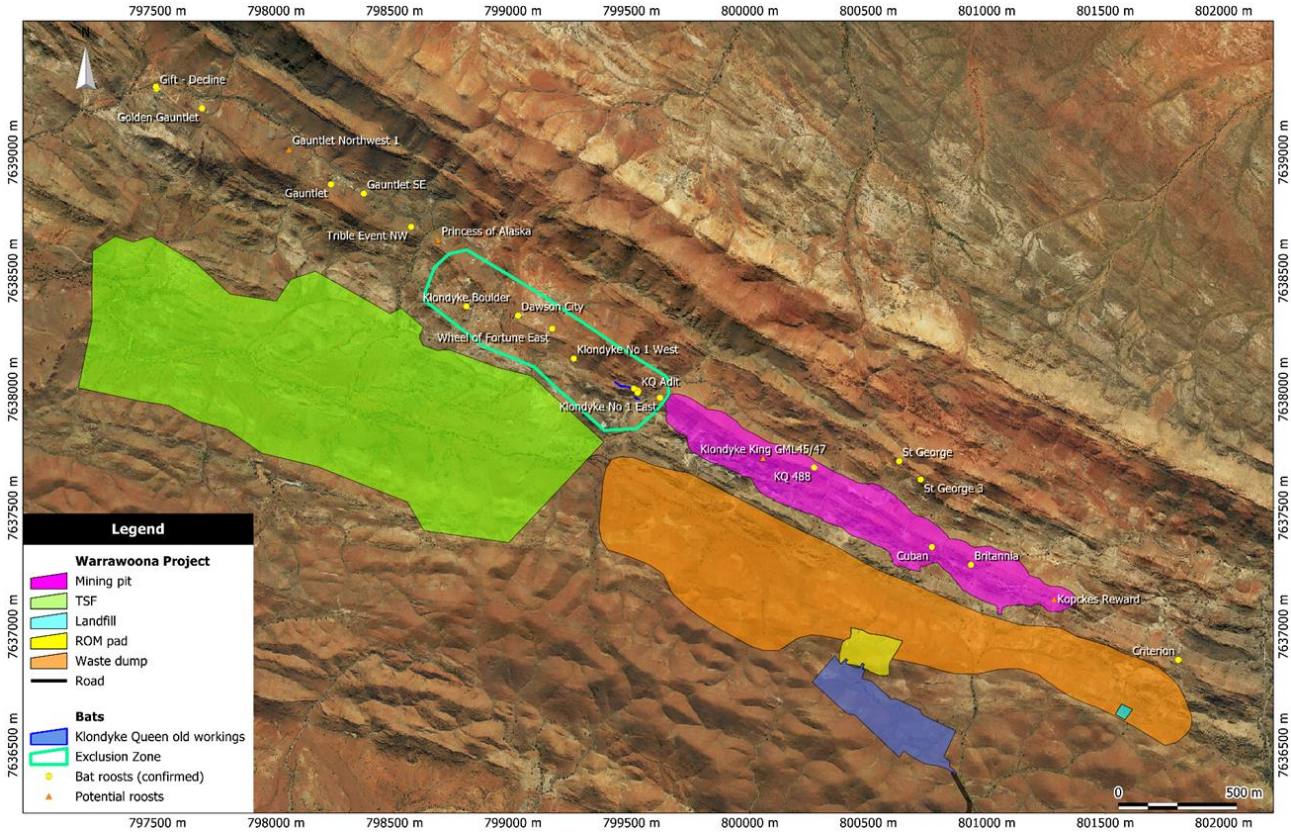

Figure 1-1: Waroona Project proposed layout and sensitive receptor locations (Calidus, 2019)

2 Climate and Meteorology

This section outlines the key climate and meteorological characteristics of the region important for the dispersion, transformation and removal (or deposition) of pollutants from the atmosphere, and therefore ambient air quality.

The Project area is located 20 km southeast of Marble Bar, in the inland Pilbara region of Western Australia. This region has a desert climate (arid), characterised by hot dry days and cold clear nights, with unreliable rainfall occurring during the year. The climate is classified according to the Köppen-Geiger climate classification system as BWh (Arid, Desert, Hot) (Kotteck et al, 2006). Two seasons are used to distinguish the general conditions:

- A hot summer period extending from October to April, and
- A mild winter from May to September.

A summary of the long term meteorological conditions for the Bureau of Meteorology (BoM) station at Marble Bar is shown in Figure 2-1 to Figure 2-8. It is expected that the project area itself will experience some localised conditions due to topography however site specific measurements are not available at this stage.

2.1.1 Temperature

Recorded temperature in the Pilbara region is variable, and notably also at Marble Bar. The temperature range is characterised by high maxima, and the diurnal difference can be extreme. At Marble Bar measured mean monthly maximum temperatures range from a high of 41.9 degrees Celsius (°C) in December to 27 °C in June. The mean monthly minimum temperatures range from 26.5 °C in January to 12.1 °C in July, as shown in Figure 2-1.

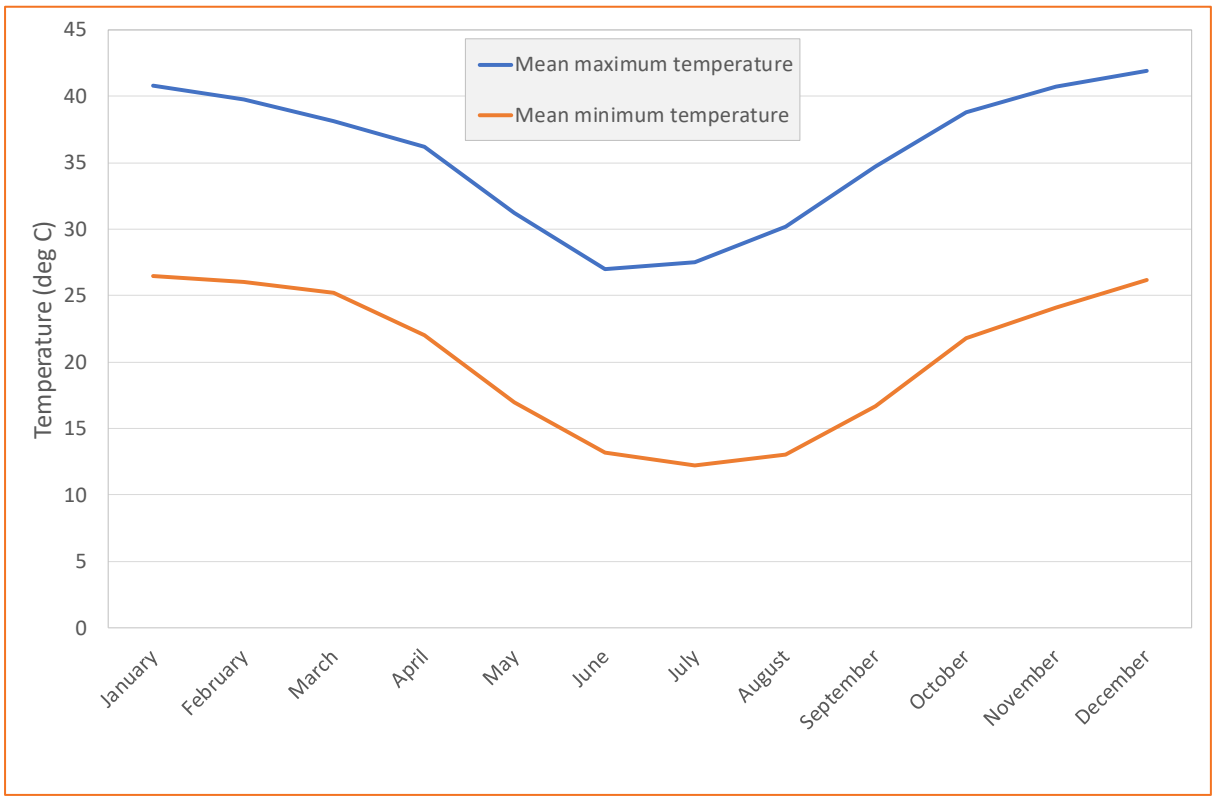

Figure 2-1: Mean Temperature 2000 to 2019 (BoM Marble Bar)

2.1.2 Humidity

Humidity in Marble Bar is also characterised by variability. Mean monthly humidity, recorded at 9am and 3pm, for Marble Bar is shown in Figure 2-2. The higher humidity levels are associated with the summer months, however the monthly averages tend to be relatively low all year round.

Figure 2-2: Relative Humidity 2000 to 2019 (BoM Marble Bar)

2.1.3 Rainfall

There are two dominant rainfall systems that influence the Pilbara region:

- The northern rainfall systems of tropical origin, and
- The southern winter rainfall system.

This results in a bi-modal rainfall distribution, with the majority of rainfall occurring between December and March as a result of tropical cyclones originating from the north. A smaller peak in rainfall occurs between April and June, and is a result of extensive cold fronts moving across the south of Western Australia in an easterly direction, which on occasion may extend in the Pilbara.

The long term rainfall data for Marble Bar is presented in Figure 2-3 and this data indicates that rainfall is unreliable, variable and occurring infrequently, with less than 30 days in the year receiving more than 1 millimetres (mm) of rain (long term average). This variability will influence the need or extent for dust management and mitigation.

The amount, and seasonality, of rainfall is important for understanding the periods in which natural dust suppression occurs from windblown sources associated with surface and open pit mining and material handling activities. It is also important to understand periods in which there is the potential for elevated windblown dust emissions to occur. This would primarily be periods with high evaporation and low rainfall. For the Pilbara region the period August to December is most conducive to high windblown dust emissions.

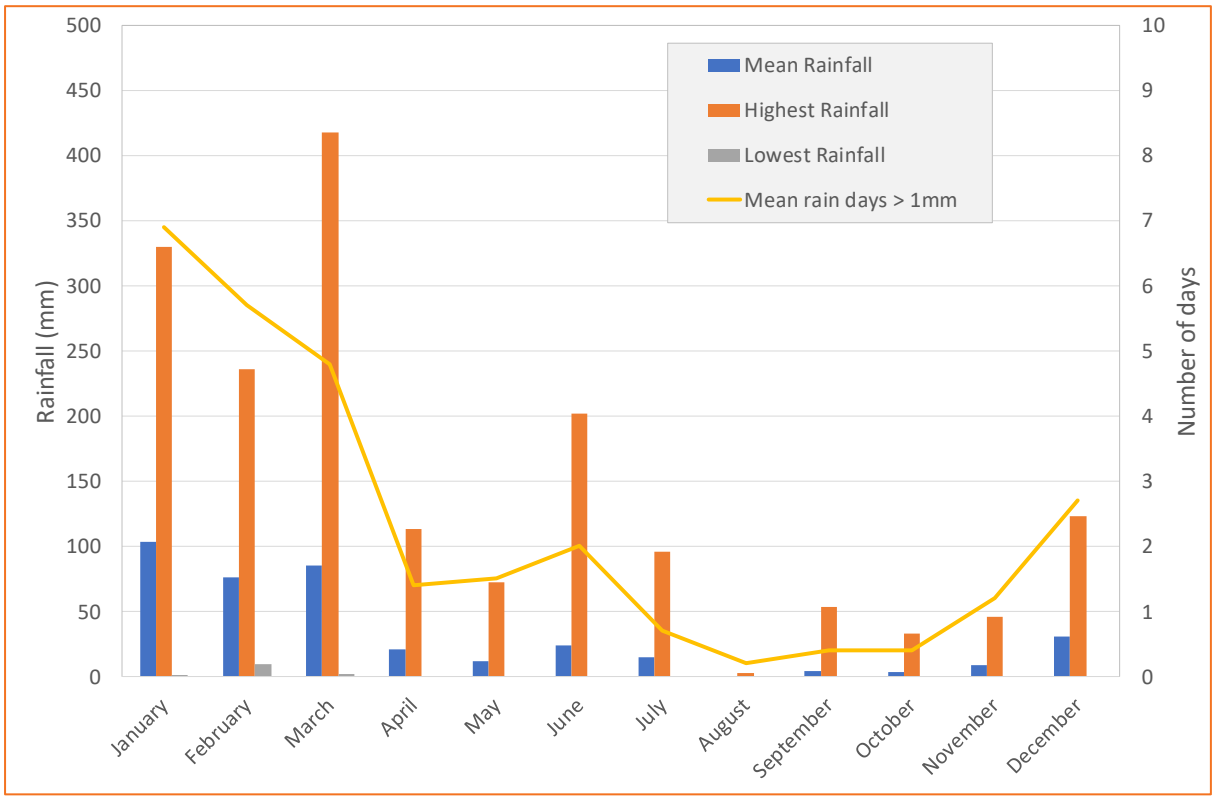

Figure 2-3: Mean Rainfall 2000 to 2019 (BoM Marble Bar)

2.1.4 Winds

For this assessment meteorological data from the BoM station at Marble Bar from 2011 to 2018 was obtained. Analysis of this data indicated that the average wind speed for the 8 years was 2.9 m/s. The annual wind rose for 2011 to 2018 is presented in Figure 2-4 and from this figure it is apparent that the prevailing wind direction is south east.

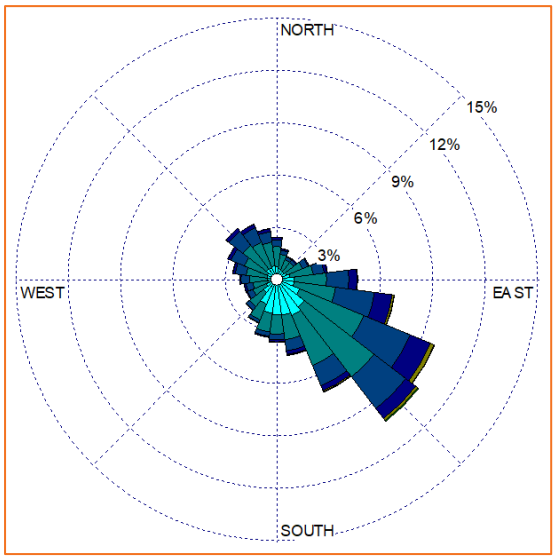

Figure 2-4: Annual wind rose for Marble Bar (2011 – 2018)

The seasonal wind roses are presented from Figure 2-5 to Figure 2-8 and from these figures the following can be inferred:

- During the summer period (December – February) the prevailing wind direction is from the northwest though there are a percentage of winds from the southeast.
- The autumn months (March – May) the main prevailing wind direction is from the southeast
- The winter period (June – August) is dominated by southeasterly winds
- The spring period is a transitional period.

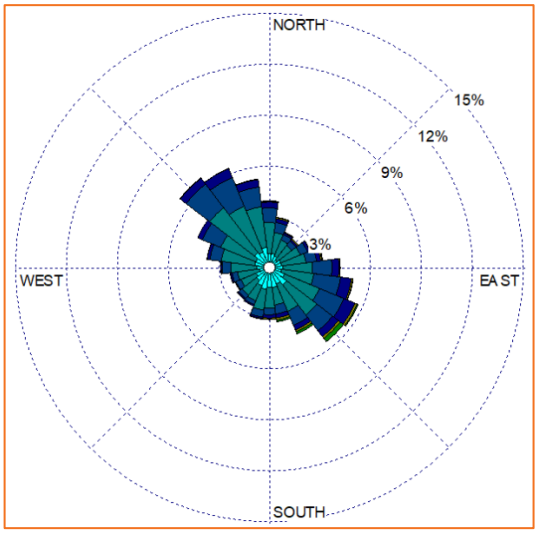

Figure 2-5: December – February wind rose (2011 – 2018)

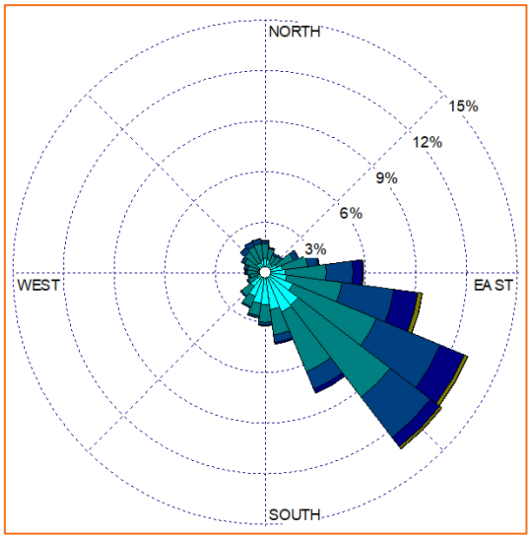

Figure 2-6: March – May wind rose (2011 – 2018)

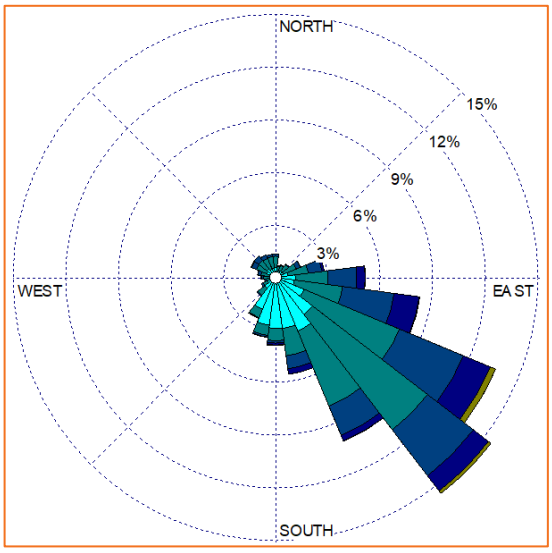

Figure 2-7: June – August wind rose (2011 – 2018)

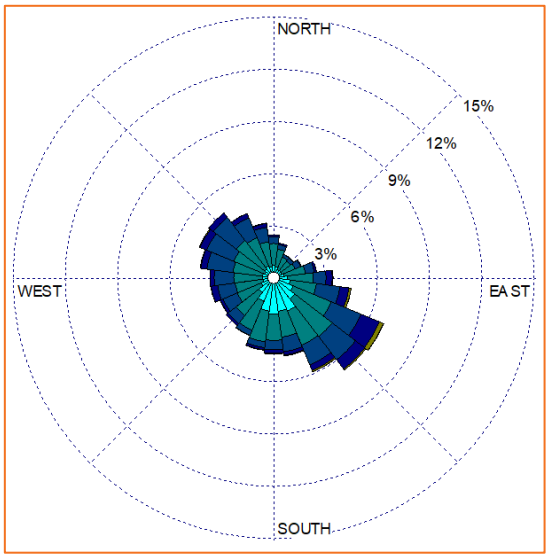

Figure 2-8: September - November wind rose (2011 – 2018)

3 Pollutants of Potential Concern

The section outlines the key pollutants of potential concern from the processing of ore, and the corresponding ambient air quality assessment criteria for evaluating the potential impact on sensitive receptors.

3.1 Pollutants of Potential Concern

Open pit mining, including blasting activities, is a source of dust (particulate) emissions, comprised of TSP (total suspended particulates), PM_{10} (particulate matter with an aerodynamic diameter of less than 10 microns) and $PM_{2.5}$ (particulate matter with an aerodynamic diameter of less than 2.5 microns). There is also the potential for fugitive wind-blown dust emissions to be generated from open stockpiles, processing and handling (including crushing and screening), conveyors and the Tailings storage facility (TSF).

There is strong scientific evidence linking potential adverse human health risk with PM_{10} and $PM_{2.5}$ particulate size fractions in ambient air. TSP tends to be considered in terms of potential for adverse impacts upon amenity (dust nuisance) due to dust deposition onto surfaces. In addition the Pilbara leaf-nosed Bat is known to be susceptible to dust impacts, largely associated with blasting activities.

3.2 Ambient Air Quality Assessment Criteria

Ambient air quality assessment criteria have been adopted based on the protection of human health and amenity impacts, consistent with the guideline for air quality published by the Environmental Protection Authority (EPA, 2016).

While it is acknowledged that bat species present at the site are susceptible to dust, there is no known or recognised assessment criteria against which to evaluate acceptability.

3.2.1 Human Health Assessment Criteria

Health impacts can arise from acute (short-term) and chronic (longer-term) exposures to the pollutants of potential concern (particulates) present in ambient air.

The National Environmental Protection Measure (NEPM) for Ambient Air Quality (NEPC, 2015) specifies ambient standards for various common air pollutants that are based on the protection of human health. The pollutants covered by the NEPM include (but is not limited to) PM_{10} and $PM_{2.5}$. The maximum number of allowable exceedances specified forms part of the NEPM standards. The NEPM standards for PM_{10} and $PM_{2.5}$ (24-hour average) do not allow for any exceedances, except in the case of an 'exceptional event' that is directly related to bushfire, jurisdiction authorised hazard reduction burning, or continental scale windblown dust. The intent of the NEPM is for the $PM_{2.5}$ 24-hour average standard to move to 20 $\mu g/m^3$ in 2025, and for the annual average for $PM_{2.5}$ to become 7 $\mu g/m^3$.

The assessment criteria adopted for the protection of human health are summarised in Table 3-1.

Table 3-1: Summary of human health assessment criteria

Pollutant	Averaging Period	Concentration ($\mu g/m^3$)[1]	Allowable Exceedances	Reference
PM_{10}	24-hour	50	None	NEPC, 2015
	annual	25		
$PM_{2.5}$	24-hour	25	None	
	annual	8		

Notes:
1. Referenced to a temperature of 0°C and an absolute pressure of 101.325 kPa.

3.2.2 Amenity Assessment Criteria

Dust nuisance and amenity impacts can arise from dust deposition. There are no regulatory standards prescribed in Western Australia for dust deposition, however the criteria adopted in New South Wales (NSW) are widely referenced to evaluate the potential for dust nuisance and amenity impacts upon residences (NSW EPA, 2017). These criteria are based on studies that were undertaken on coal dust in the Hunter Valley region of NSW by the National Energy Research Development and Demonstration Council (NERDDC) (1988).

The dust deposition criteria allow an increase in deposited dust levels by up to 2 g/m^2/month, and the total deposited dust level (including background sources) must not exceed 4 g/m^2/month.

The assessment criteria adopted for amenity are summarised in Table 3-2.

Table 3-2: Summary of amenity assessment criteria

Pollutant	Air quality assessment criteria		Type	Reference
Deposited Dust [1]	2 g/m^2/month	Annual average	Maximum Increase [2]	NSW EPA, 2017
	4 g/m^2/month		Maximum Total [3]	

Notes:

1. Dust is assessed as insoluble solids as defined by AS 3580.10.1-1991.
2. Maximum increase in deposited dust level.
3. Maximum total deposited dust level.

3.2.3 Ecological Impact Assessment Criteria

To date there is limited published research available as to the ecological impact of dust on the Pilbara Leaf-nose Bat and the Ghost Bat, and the dust (particulate) concentrations at which the bats may experience a noticeable or negative impact.

The *Conservation Advice* (May 2016) of the Threatened Species Scientific Committee for the Ghost Bat references the impact of mining on the Ghost Bat but does not reference any specific impact associated with bat exposure to dust (TSSC, 2016). Wildcare Australia Inc (2014), report that microbats exposed to smoke and / or dust inhalation will exhibit shallow or difficulty in breathing, and will have wings outstretched. Again the guidance does not extend to advise on the concentrations or exposure levels that may be of concern.

Other studies in the region have been reviewed. Reference to the presence of dust within bat roost (cave) locations was made by Biologic (2018) in the comparison of the 2015 and 2017 monitoring results for the West Angelas Iron Ore mine, stating that "*…dust was prominent at all caves visited, as well as generally across the mining area*." Mining activity was occurring at distances between 70 m and 535 m from the monitored caves. The report stated that "*…cave monitoring results do not appear to show any obvious impact of mining at the current time*." The size and scale of the proposed Warrawoona Gold Mine is relatively small in comparison to the extent of the West Angelas Iron Ore mine, and the nature of the mining activity at Warrawoona will involve a significant smaller tonnage of ore being handled. An operational setback distance of 500 m to roost sites has been adopted by a number of projects in the region, (50 m for drilling activities) to account for bat sensitivity to blasting noise and vibration impacts.

Ecological studies undertaken for the Warrawoona Gold Project have not identified concentrations or exposure levels that may be of concern for the local bat population. The Pilbara leaf-nosed Bat is known to be susceptible to noise, vibration and dust impacts. As these impacts are largely associated with blasting activities, which will be restricted to daytime operations, habitat most likely to be at risk are those underground workings that support diurnal roosting, including the non-permanent breeding roost within the Klondyke Queen (old workings) Adit.

The Warrawoona project has adopted a mining setback distance of 500 m. The buffer eastern edge at the pit crest is 200 m from the Klondyke Queen Adit entrance. The exclusion zone over the Klondyke Queen workings (incorporating the buffer to the Klondyke Pit) is considered an adequate protection (R. Bullen *pers comm* May 2019) because of the topography between the Klondyke workings and the Klondyke pit crest. The proposed pit is located on a separate hill on the opposite side of a gully. The natural topography of the area and positioning of the mining pit is therefore expected to provide a natural shield to exposure.

4 Dust (Particulate) Emissions and Management

The assessment considers emissions only from the operational phase of the Project. Emissions associated with the construction phase of the Project are not considered as they are short term and transient in nature. It is noted that the construction phase activities are expected to contribute dust emissions that are only intermittent in occurrence and duration, and will not be present for the duration of the Project.

4.1 Emission Sources and Controls

Dust (particulate) emissions to air from the Project will be generated from open pit mining, processing and material handling. These potential emission sources are associated with the following activities:

- Open pit mining
  - Drilling and Blasting
  - Material handling from mining activities involving both ore and overburden
    - truck loading
    - trucks dumping
    - bulldozing
  - Wheel generated dust from haul roads
  - Wind erosion from stockpiles and open areas.

- Processing of ore
  - Crushing
  - Material handling at the processing plant involving
    - front end loaders (FEL) on stockpiles
    - conveying
    - transfer points
  - Light vehicle movements on unsealed roads
  - Wind erosion from the TSF.

On this basis conventional dust suppression and management practices have been adopted into the design of the Warrawoona Gold Mine operations, as well as the adoption of an exclusion and setback distance to sensitive bat roost locations. The exclusion zone over the Klondyke Queen workings (incorporating the buffer to the Klondyke Pit) is considered an adequate protection (R. Bullen *pers comm* May 2019) talking into account the topography between the Klondyke workings and the Klondyke pit crest. The proposed pit is located on a separate hill on the opposite side of a gully which acts as a natural shield.

The following dust control measures and activities are planned to be implemented at the Project with the direct intent to minimise dust generation:

- Open pit mining
  - Maintain a mining set-back (separation distance of 500 m) between the nearest bat roost and the Klondyke Pit, and a mining exclusion zone
  - Blasting protocols will be implemented
  - Areas subject to topsoil stripping will be minimised reducing the surface area that may be prone to dust lift off
  - Water will be applied, by water truck, to disturbed surfaces
  - Water will be applied to unsealed road surfaces, by water truck
  - Road surfaces being maintained regularly to retain surface integrity
  - vehicle speeds will be limited on unsealed roads to minimise wheel generated dust

- Processing of ore
  - Dust suppression water sprays will be installed and operated at key areas within the plant, in particular on the primary crusher, conveyor to the surge bin, surge bin to the emergency conveyor, emergency conveyor to the stockpile, surge bin to the apron feeder, reclaim hopper to conveyor, and conveyor to the SAG Mill.
  - With the exception of the primary crusher, the above area will also be within an enclosed area minimising the potential for fugitive dust.

Operationally, all dust suppression equipment will be maintained in an efficient working condition. This will be reviewed through regular internal audits and checks.

4.2 Emission Estimation

Emission estimates for the Project have been derived in accordance with the NPI EET for Mining (EA, 2012), and are presented in Table 4-1 with dust controls applied. Information on the processing plant rates provided for this assessment that were used as the basis for the emission estimation is provided in Appendix A.

The Project emission estimates are subject to a notable degree of uncertainty as they are only generic in nature, and subject to many assumptions and uncertainties because of the complex nature of mining related fugitive dust generation.

Table 4-1 Annual emission estimates (processing)

Activity	Control Measure in Place	Total TSP	PM10
		kg per annum	
Primary crusher	Water Sprays	1511	604
Conveyor to surge bins	Water Sprays, Enclosed System	756	302
Surge bin to emergency conveyor	Water Sprays, Enclosed System	756	302
Emergency conveyor to stockpile	Water Sprays, Enclosed System	328	139
Surge bin to apron feeder	Water Sprays, Enclosed System	752	301
Apron feeder to conveyor	Water Sprays, Enclosed System	752	301
Reclaim hopper to conveyor	Water Sprays, Enclosed System	19	8
Conveyor to SAG Mill	Water Sprays, Enclosed System	752	301
Total		**4115**	**1654**

4.3 Predicted outcome

The Warrawoona Gold Project is located 20 km southeast of Marble Bar, in a region classified as having a climate description of arid, desert, hot. Naturally occurring background dust levels occurring in the region are relatively high, especially under dry and windy conditions. The development and operation of the Warrawoona Gold Project will create dust emissions due to construction, blasting, haulage, ore processing and handling, and from general traffic or light vehicle activities. The generation of dust may not be confined to the immediate activity area.

The Warrawoona Gold Project is located in a relatively remote location with the nearest sensitive receptor, a prospector, approximately 2.5 km from the Project's processing area. Potentially sensitive ecological sites (bat roost locations) are closer (approximately 1.3 km), with Project activities occurring no closer than 200 m.

Conventional dust suppression and management practices have been adopted into the design of the Warrawoona Gold Mine operations, with the intent of minimise dust generation, and will support the adopted exclusion zone and setback to sensitive roost locations. Therefore with the implementation of the conventional dust management measures it is expected that any generated airborne dust will be maintained within acceptable levels.

5 Summary

An air emissions desktop assessment has been completed for the proposed Warrawoona Gold Project, located in the inland Pilbara region of Western Australia. The scope of the assessment involved characterising the local climate and meteorology and potential atmospheric emissions for the Project, in support of the environmental regulatory approval.

The key findings of the air emissions desktop assessment completed for the Project are outlined below.

- The key climate and meteorological characteristics of the region have been described using long-term records obtained from the BoM weather station located at Marble Bar, considered to be generally representative of the Project site, noting that the geology of the project area will lead to localised influences.
- The Project comprises open pit mining, and gold processing, with local power generation. The key pollutants of potential concern include:
    - dust emission, (ie particulates as TSP, PM_{10} and $PM_{2.5}$) from processing activities associated with the gold mine.
- Ambient air quality assessment criteria have been adopted based on the protection of human health (Table 3-1) and amenity impacts (Table 3-2), taken from the NEPM for Ambient Air Quality (NEPC, 2015), and from other environmental regulatory authorities in Australia as required. No known assessment criteria are available for ecological protection representative of potential impacts on bats.
- Conventional dust management measures have been incorporated into the design of the Project. These measures, in conjunction with the adopted exclusion zone and setback to sensitive roost locations, airborne dust emissions are expected to be maintained within acceptable levels at sensitive receptor locations, are expected to be maintained within acceptable levels at sensitive receptor locations.

6 References

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7 Glossary

Acronym	Meaning
Au	Gold
BoM	Bureau of Meteorology
C	Degrees Celsius (temperature)
CIL	Carbon In Leach
DWER	Department of Water and Environmental Regulation
EET	Emissions Estimation Technique
EFi	Emission factor
ETA	Environmental Technologies& Analytics Pty Ltd
FEL	Front end loader
GLC	Ground Level Concentration
$g/m^2/month$	Grams per square metre per month
g/s	grams per second
h/yr	Hours per year
kg	kilogram
kg/t	kilogram per tonne
kg/yr	kilograms per year
kPa	kiloPascals
km	kilometre
m	metre
m/s	metres per second
mm	millimetre
MS	Ministerial Statement
Mt	Million tonnes

Acronym	Meaning
Mtpa	Million tonnes per annum
MW	Mega watt
NERDDC	National Energy Research Development and Demonstration Council
NEPC	National Environment Protection Council
NEPM	National Environmental Protection Measure
NPI	National Pollutant Inventory
NSW	New South Wales
PHIC	Port Hedland Industries Council
PM	Particulate matter, small particles and liquid droplets that can remain suspended in air.
PM_{10}	Particulate matter with an aerodynamic diameter of 10 µm or less.
tpa	tonnes per annum
TSF	Tailings Storage Facility
TSSC	Threatened Species Scientific Committee
t/h	tonnes per hour
$µg/m^2/min$	micro grams per square metre per minute
$µg/m^3$	micro grams (one millionth of a gram) per cubic metre
µm	micrometre

8 Appendices

Appendix A – Basis for emission estimation

Appendix Table 1: Annual emission estimate from source

Estimate of TSP and PM10 emissions	Primary Crusher	Conveyor to Surge Bin	Surge bin to Emergency Conveyor	Emergency Conveyor to Stockpile	Surge Bin to Apron Feeder	Apron Feeder to Conveyor	Reclaim Hopper to Conveyor	Conveyor to SAG Mill
A, Activity rate, t/h	230	230	230	230	188	188	188	188
OpHrs, operating hours, h/yr	6570	6570	6570	712	8000	8000	200	8000
PM10 Efi, uncontrolled emission factor of pollutant I, kg/t	0.004	0.002	0.002	0.0017	0.002	0.002	0.002	0.002
TSP Efi, uncontrolled emission factor of pollutant I, kg/t	0.01	0.005	0.005	0.004	0.005	0.005	0.005	0.005
PM10 CEi (Control measures from Table 3)	90	90	90	50	90	90	90	90
TSP CEi (Control measures from Table 3)	90	90	90	50	90	90	90	90
PM10 Emission Rate formula Ekpy,I = A * OpHrs * Efi * (1-(CEi/100)) = kg/yr	604	302	302	139	301	301	8	301
TSP Emission Rate formula Ekpy,I = A * OpHrs * Efi * (1-((CEi/100)) = kg/yr	1,511	756	756	328	752	752	19	752
Control measures in Place	Water Sprays	Water Sprays Enclosed System	Water Sprays Enclosed System	Water Sprays Enclosed System	Water Sprays Enclosed System	Water Sprays Enclosed System	Water Sprays Enclosed System	Water Sprays Enclosed System

Appendix B – Dust Management Plan

Appendix Table 2: Dust management plan

	Operational Dust Management Plan
Aim	Ensure dust emissions do not adversely affect the key environmental values, or the health, welfare and amenity of people and land uses
Key management practice	Blasting protocols will be implemented Areas subject to topsoil stripping will be minimised reducing the surface area exposed Water trucks will be used to apply water to disturbed surfaces and unsealed road surfaces Unsealed road surfaces will be maintained regularly to retain surface integrity Vehicle speeds will be limited on unsealed roads to minimise wheel generated dust Dust suppression water sprays will be installed and operated at the processing plant - primary crusher, conveyor to surge bin, surge bin to emergency conveyor, emergency conveyor to stockpile, surge bin to apron feeder, reclaim hopper to conveyor, and conveyor to SAG Mill.
Relevant company procedures | documents	Company Blasting Protocol Company Dust Management Procedure Bat Survey Procedure
Key performance indicators	To be determined
Monitoring	Bat Survey
Reporting	Monitoring data to be recorded in the company database Annual environmental report
Corrective actions	Appropriate actions will be issued and managed via the company's environmental management system