Department of Primary Industry & Resources

Rum Jungle 2A - Air Noise & Vibration Baseline Monitoring Report

May 2019

Table of contents

1. Introduction 1

1.1 Rum Jungle rehabilitation 1

1.2 Purpose of this report 2

1.3 Limitations..2

1.4 Qualifications..3

2. Site location and surrounds 4

3. Baseline monitoring methodology..6

3.1 Scope of monitoring activities 6

3.2 Monitoring locations 6

3.3 Instrumentation 9

3.4 Monitoring periods..13

4. Meteorology 15

4.1 Data quality assessment..15

4.2 Wind pattern...15

4.3 Rainfall...17

5. Noise and vibration monitoring 18

5.1 Noise 18

5.2 Vibration...23

6. Air quality monitoring...27

6.1 Relevant criteria 27

6.2 Ambient gases results 28

6.3 Dust deposition results 30

6.4 Ambient particulate results 32

7. Surrounding air quality 34

7.1 Purpose 34

7.2 Station analysis..34

7.3 Palmerston AQMS..36

7.4 Temporal trend...36

7.5 Spatial distribution of pollutants 39

7.6 Correlations between datasets 40

7.7 Summary..41

8. Summary 42

9. References 43

Table index

Table 1 Summary of monitoring sites 7
Table 2 Unattended noise and vibration monitoring equipment details 10
Table 3 Attended noise measurement equipment details 11
Table 4 Air quality monitoring instrumentation utilised 12
Table 5 Overview of monitoring periods....14
Table 6 Summary of attended noise measurement results undertaken on 4 June 2018 18
Table 7 Summary of unattended noise monitoring results....19
Table 8 Minimum assumed intrusiveness noise levels (Table 3.4 of NT EPA Noise Management Framework Guideline 2018) 21
Table 9 Noise criteria recommended in accordance with NT EPA Noise Management Framework Guideline 2018....22
Table 10 Noise criteria recommended in accordance with NT EPA Noise Guidelines for Development Sites 2014....23
Table 11 Human comfort intermittent vibration limits (VDV), ms-1.75....24
Table 12 Guidance on effects of vibration levels for human comfort....24
Table 13 Guidance values for short-term vibration on structures....25
Table 14 Derived NEPM AAQ objectives for pollutants....27
Table 15 Period G1 ambient gas results....28
Table 16 Period G2 ambient gas results....28
Table 17 Summary of ambient particulate results 32
Table 18 Summary of nearby AQMS....34
Table 19 Summary of nearby AQMS....40

Figure index

Figure 1 Site Location 5
Figure 2 Monitoring locations 8
Figure 3 Wind rose for Rum Jungle AWS 01/07/2017-30/06/2018....16
Figure 4 Seasonal wind roses for Rum Jungle AWS (01/07/2017-30/06/2018)....16
Figure 5 Monthly rainfall totals at Batchelor 17
Figure 6 Site 1 - Ambient gas results....29
Figure 7 Site 3 - Ambient gas results....29
Figure 8 Rum Jungle - total insoluble material 31
Figure 9 Site 1 - Ambient PM_{10} and $PM_{2.5}$ results....33
Figure 10 Site 1 and Palmerston - Ambient $PM_{2.5}$ results....35

Figure 11 $PM_{2.5}$ concentration vs hour of day 38
Figure 12 Total mass of $PM_{2.5}$ moved 39
Figure 13 Rum Jungle Site 1 and Palmerston AQMS - 7 day average ambient $PM_{2.5}$ results 41

Appendices

Appendix A – Meteorological data comparison
Appendix B – Noise monitoring sites
Appendix C – Vibration monitoring results
Appendix D – Palmerston AQMS
Appendix E – Nearby AQMS

1. Introduction

GHD Pty Ltd (GHD) was engaged by the Department of Primary Industry & Resources (DPIR) to conduct baseline air quality, noise and vibration monitoring in relation to proposed rehabilitation of the former Rum Jungle Mine site (Rum Jungle), located near Batchelor in the Northern Territory, approximately 63 kilometres south-southeast of Darwin.

1.1 Rum Jungle rehabilitation

The Rum Jungle mine operated between 1953 and 1971 and produced approximately 3,530 tonnes of uranium oxide and 27,000 tonnes of copper concentrate. The mining and processing operations resulted in legacy soil contamination impacts, significant acid and metalliferous drainage (AMD) issues and subsequent adverse environmental impacts to the East Branch Finniss River (EBFR). The site has been the subject of numerous phases of investigation, remediation and rehabilitation since the late 1970s, with the most significant rehabilitation works to date implemented in the mid-1980s.

Since 2009, the Northern Territory Government's Department of Primary Industry and Resources (DPIR) and the Commonwealth have been working under a National Partnership Agreement (NPA) to deliver site maintenance and continuing environmental monitoring. These programs have been used to develop an improved rehabilitation strategy that is consistent with the views and interests of traditional Aboriginal owners and meets contemporary environmental and mined land rehabilitation standards.

1.1.1 Rehabilitation project objectives

Objectives for the Rum Jungle site are to create a rehabilitated landscape that:

- Is safe for people and wildlife
- Is chemically, radiologically and physically stable
- Has a significantly reduced contaminant load (associated with AMD) travelling beyond the boundaries of the site
- Supports sustainable land uses by Traditional Owners of the area
- Encourages beneficial alternative post-rehabilitation land uses

The current Rum Jungle Stage 2A project involves:

- Optimisation of existing 'Stage 2' rehabilitation works designs to a more advanced and detailed design standard
- Preparation of the supporting Environmental Impact Statement (EIS) and supporting technical reports, as required by the NT Environment Protection Authority (NT-EPA) Terms of Reference for the project (NT-EPA, 2017)

1.1.2 Preferred rehabilitation strategy

The (currently) preferred rehabilitation strategy for Rum Jungle incorporates an 8-10 year construction period of mostly dry season earthworks, which incorporates:

- Relocation and consolidation of waste rock and contaminated soil to the Main Pit and to a new purpose built Waste Storage Facility (WSF) in the north of the site.
- Construction of a cover system over the backfilled Main Pit that sheds surface water to a new low-flow channel north of the Main Pit, reinstating as closely as possible the original course of the EBFR.
- Retention of the Intermediate Pit as a water-filled void; to provide passive water management and treatment for the site, including treatment of WSF seepage.
- Placement of an earthen cover system over the backfilled Dysons Pit, following the removal of contaminated materials to design grades.
- Relocation of the Mt Burton Waste Rock Dump (WRD) and minor quantities of waste rock and contaminated soil to Rum Jungle.
- Relocation and consolidation of the Mt Fitch WRD into the Mt Fitch Pit and removal of minor quantities of waste rock and contaminated soil to Rum Jungle.

1.2 Purpose of this report

This Air Noise and Vibration Baseline Monitoring Report presents the baseline data collected for the purpose of characterising the existing air quality, noise and vibration environment at the project site and at surrounding sensitive land use areas. This data will inform the following EIS Chapters; and supporting technical reports to those Chapters:

- Air Quality and Greenhouse Gas
- Noise and Vibration

1.3 Limitations

This report has been prepared by GHD for Department of Primary Industry & Resources and may only be used and relied on by Department of Primary Industry & Resources for the purpose agreed between GHD and the Department of Primary Industry & Resources as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Department of Primary Industry & Resources arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1.4 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Department of Primary Industry & Resources and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are partially based on information obtained from, and testing undertaken at or in connection with, specific monitoring points installed on site by third parties and at regional monitoring stations operated by the NT-EPA. Conditions across other parts of the site may be different from the conditions found at the specific sample points.

The assessments in this report are based on onsite inspections and measurements obtained by GHD between June 2018 and October 2018. Due to the nature of environmental assessments, this report cannot assert that all variations in environmental conditions of the site have been assessed and uncertainty concerning the conditions of the ambient air quality environment cannot be completely eliminated. It is neither the intention of this assessment to cover every element of the air, noise and vibration environment, but rather to conduct the assessment with consideration to the prescribed scope of work. Professional judgement must be expected in the investigation and interpretation of observations.

1.4 Qualifications

- All data used from monitoring equipment provided accurate measurements unless otherwise stated.
- This report has been written based on the information on hand as of December 2018.
- The selected monitoring locations are reasonably representative of the existing background environment.
- It is assumed that meteorological data from the Rum Jungle Automatic Weather Station (AWS) and air quality data measured at Palmerston, Winnellie and Stokes Hill Air Quality Monitoring Stations (AQMS) were collected in accordance with the relevant Australian Standards.

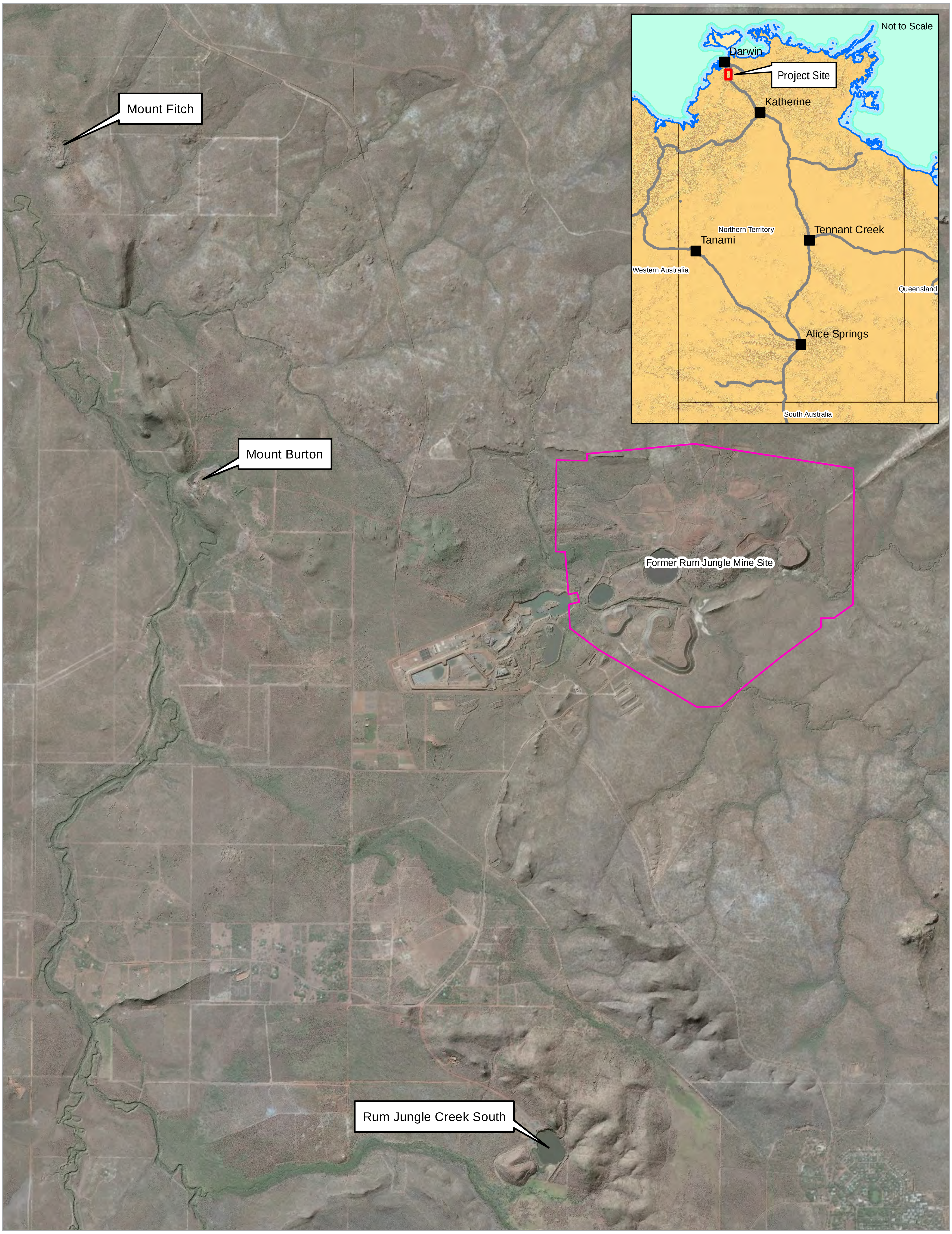
2. Site location and surrounds

The mine is located approximately 65 km south-southeast of Darwin, west of the Stuart Highway and lies north of the township of Batchelor. An aerial image of the site and surrounding areas is shown in Figure 1.

Potential influences to the baseline air, noise and vibration environment, include the following:

- Stuart Highway to the east of the investigation area – traffic and truck activity is expected with possible impacts to noise and air quality
- Freight rail corridor to the east of the investigation area is expected to pose possible impacts to noise, vibration and air quality
- Batchelor and Rum Jungle townships – possible impacts to noise

With regards to air quality, it is likely that the background environment will be driven primarily by pollutant sources which are not within the local surrounds but instead from the wider air shed. Wind erosion from large expanses of dry desert ground and smoke from fires in the dry season are likely to be the primary contributors to particulate concentrations at the mine and its surrounds.



Legend

Site Locations

Paper Size ISO A3

0 0.25 0.5 0.75 1

Kilometers

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52

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Baseline Monitoring Report

Site Location

Project No.	43-22822
Revision No.	A
Date	29/06/2018

FIGURE 1

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Print date: 29 Jun 2018 - 15:18

Data source: GA - Roads, Places (2018), GHD - Site Locations, DEM (2018). Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Created by: hrpimm

3. Baseline monitoring methodology

3.1 Scope of monitoring activities

3.1.1 Noise and vibration

Long-term (unattended) noise and vibration, and short-term (attended) noise measurements were conducted as a part of the baseline monitoring program.

The results of the baseline noise and vibration monitoring are to be used to develop operational noise goals for the Rum Jungle project.

3.1.2 Air quality

The objective of air quality monitoring was to collect site specific air quality data to determine background levels of pollutants at the Rum Jungle mine site and surrounding areas. Air quality monitoring was conducted for the following parameters:

- Ambient particulate concentrations, including:
  - PM_{10}
  - $PM_{2.5}$
- Ambient gas concentrations including:
  - Nitrogen Dioxide (NO_2)
  - Sulphur Dioxide (SO_2)
- Dust deposition rates, including:
  - Total insoluble matter
  - Total soluble matter
  - Heavy metals deposition rates

A longer period of site-specific ambient particulate monitoring data was collected than originally planned. This was undertaken to evaluate the degree of correlation between air quality records available from the Palmerston Air Quality Station (operated by the NT-EPA) and site-specific conditions. The use of surrogate regional air quality data (from the Palmerston station) will provide advantages in the evaluation of baseline air quality conditions, due to the length of records available from NT-EPA equipment and due to the measurement precision available from those instruments.

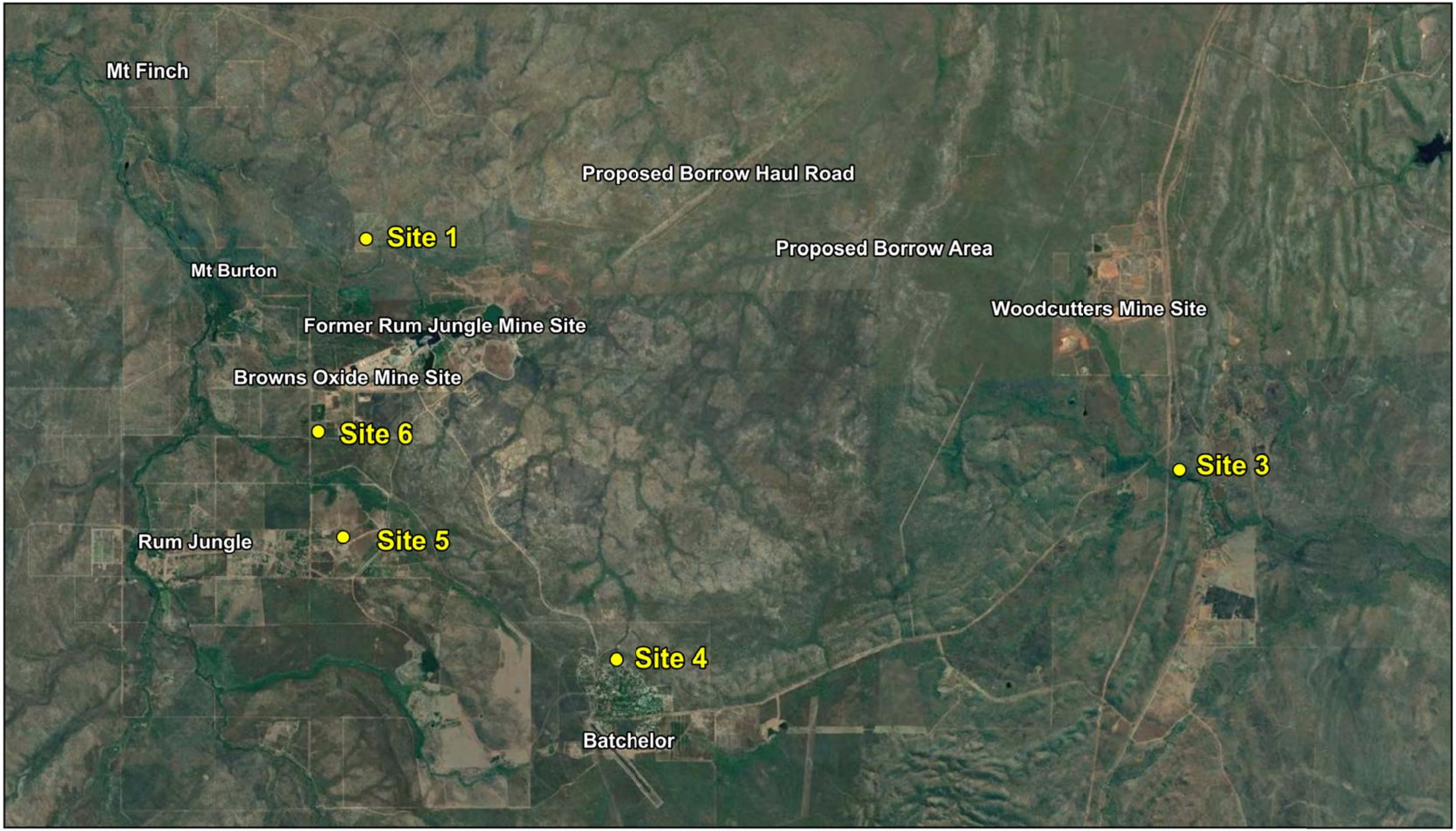
3.2 Monitoring locations

Air quality, noise and vibration monitoring were conducted at five locations surrounding the former mine. Prior to conducting monitoring, 6 locations were identified as potential monitoring sites (Site 1 – Site 6). Due to access constraints however, Site 2 (a proposed dust deposition monitoring location) was removed from the monitoring schedule.

The location of the monitoring sites are shown in Figure 2, with parameters measured at each site listed in Table 1. The rationale for selecting the location of each of the monitoring sites is also provided in Table 1.

Table 1 Summary of monitoring sites

Parameter measured	Rationale for monitoring site selection
Site 1	
Ambient particulates Ambient gases Dust deposition Noise levels (unattended and attended) Vibration levels	Site 1 was selected for the most comprehensive suite of monitoring. Site 1 is a residential property and was identified as being one of the closest sensitive (residential) receptors to the former Rum Jungle mine. Site 1 is located 2 km northwest of the former mine. This site is located in a downwind direction during the dry-season, when rehabilitation project activity levels are expected to annually peak. It is anticipated that Site 1 will be more sensitive to air quality, noise and vibration impacts; so it was considered important to understand baseline conditions at this location in detail.
Site 2	
Nil	Could not be safely accessed
Site 3	
Ambient gases Dust deposition Noise levels (unattended and attended) Vibration levels	Site 3 represents a mixed use premises, with both residential and temporary accommodation at the site. The site is also located east of the rail corridor and west of the Stuart Highway, in close proximity to the more significant contributors to baseline and background noise, vibration and exhaust emissions in the otherwise mainly rural area.
Site 4	
Dust deposition Noise levels (unattended and attended)	Site 4 was selected as being representative of ambient noise and air quality environments for the township of Batchelor. Traffic and residential activities were expected to be key contributors to baseline noise levels at this site.
Site 5	
Dust deposition Noise levels (unattended and attended)	Site 5 was selected as being representative of ambient noise and air quality environment at the rural blocks of land in the region of Rum Jungle itself.
Site 6	
Dust deposition Noise levels (unattended and attended)	Site 6 was selected as the closest receptor to the southwest of the site and due to its proximity to the existing Browns Oxide Mine Site.



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0 900 1800 2700

Metres (at A4)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid Of Australia, Zone 52

N

LEGEND

Monitoring location

CLIENTS | PEOPLE | PERFORMANCE

Department of Primary Industry and Resources
Rum Jungle 2A - Air Noise & Vibration
Baseline Monitoring Report

Job Number | 4322841
Revision | A
Date | 7/11/2018

Monitoring locations

Figure 2

N:\AU\Darwin\Projects\43\22841\GIS\Maps\Working

8/180 Lonsdale St Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au W www.ghd.com.au

Data Custodian: Google Earth Imagery 2018. Created by: SM

3.3 Instrumentation

3.3.1 Unattended noise and vibration monitoring

Unattended noise monitoring was conducted at five monitoring locations listed in Table 1, in general accordance with the Australian Standard AS 1055:2018 'Acoustics - *Description and measurement of environmental noise*' and, the NT EPA guideline 'Noise Management Framework Guideline' (NT EPA, 2018).

All noise monitoring instrumentation were in current National Association of Testing Authorities (NATA) calibration at the time of use. A calibration check was performed on site and the deviation between before/after measurement was found to less than 1 dB.

Sound level meters were calibrated using a Bruel & Kjaer IEC Class 1 acoustic calibrator model 4231. The calibration due date of this instrument is 3 May 2019. No discrepancies equal to or greater than 1 dB were noted throughout the measurement exercise, as required under Section 5.6 of AS 1055:2018.

Unattended noise monitoring was undertaken using five environmental noise loggers capable of measuring continuous sound pressure levels and logging L_{A90}, L_{Aeq} and L_{max} noise descriptors. Details of the unattended monitoring equipment are summarised in Table 2, with images of the sites provided in Appendix A.

Vibration monitoring was conducted at two locations (Site 1 and Site 3), co-located with noise loggers to enable data to be synchronised between the noise and vibration measurement results. As Northern Territory regulatory documents do not provide guidance on assessment of vibration impact from different sources, vibration monitoring and assessment was undertaken with reference to a number of documents, as follows:

- Australian Standard 2436:2010 – *Guide to noise and vibration control on construction, demolition and maintenance sites*
- British Standard BS 6472:2008 - *Guide to evaluation of human exposure to vibration in buildings - Part 1: Vibration sources other than blasting*
- British Standard BS 7385.2:1993 – *Evaluation and Measurement for Vibration in Buildings: Part 2 – Guide to damage levels from ground borne vibration*
- British Standard BS 5228.2:2009 – *Code of Practice for noise and vibration control on construction and open sites: Part 2 Vibration*
- German Standard DIN 4150.3:1999 – *Structural vibration – Part 3: Effects of vibration on structures*
- *Assessing vibration: A technical guidelines (*NSW EPA 2006)

Vibration monitoring was performed using Instantel Micromate® vibration logger, which reports tri-axial (Transverse, Vertical and Longitudinal) Peak Particle Velocity (PPV) vibration measurements. The details of the vibration monitoring equipment is provided in Table 2.

Table 2 Unattended noise and vibration monitoring equipment details

Monitoring locations (refer to Figure 2)	Site 1		Site 3		Site 4	Site 5	Site 6
	Noise	Vibration	Noise	Vibration	Noise	Noise	Noise
Model	SVAN 955	Micromate®	SVAN 955	Micromate®	SVAN 955	SVAN 955	SVAN 955
Equipment Serial No.	69215	UM10468	36821	UM10469	59668	59674	69212
Type	Type 1	*Not Relevant*	Type 1	*Not Relevant*	Type 1	Type 1	Type 1
Start Date (time)	4/06/2018 (16:00)	4/06/2018 (15:35)	4/06/2018 (11:45)	4/06/2018 (11:20)	4/06/2018 (12:45)	4/06/2018 (14:00)	4/06/2018 (15:00)
Finish Date (time)	16/06/2018 (4:00)	19/06/2018 (11:25)	19/06/2018 (8:30)	19/06/2018 (8:55)	19/06/2018 (9:15)	19/06/2018 (10:15)	19/06/2018 (10:30)
Measurement Time Interval	15-minute	15-minute	15-minute	15-minute	15-minute	15-minute	15-minute

3.3.2 Attended noise measurements

Attended noise measurements were conducted using a Type-1 Bruel & Kjaer 2270 sound level meter (SLM). The SLM was calibrated before and after each measurement. No discrepancies in excess of 1 dB were noted throughout the measurement exercise as is required under Section 5.6 of Australian Standard AS 1055.1:1997 *Acoustics – Description and Measurement of Environmental Noise Part 1: General Procedures.*

Table 3 provides details of the attended noise measurement equipment used for the assessment. In addition to the measurements undertaken at Site 1 - Site 6 (excluding Site 2), an attended noise measurement was also conducted at Mount Burton. The calibration due date for the equipment outlined in Table 3 is 3 May 2019.

Table 3 Attended noise measurement equipment details

Site	Measurement date & time	Equipment type	Equipment model	Serial number	Calibration 94 dB @ 1000 Hz	
					Pre Cal	Post Cal
1	4/6/2018 3:45 pm	Sound level meter	Bruel & Kjaer 2270	3009634	93.9 dB	93.8 dB
		Microphone	Bruel & Kjaer 4189	3086784		
		Acoustic calibrator	Bruel & Kjaer 4231	2560035		
3	4/6/2018 11:30 am	Sound level meter	Bruel & Kjaer 2270	3009634	93.9 dB	93.8 dB
		Microphone	Bruel & Kjaer 4189	3086784		
		Acoustic calibrator	Bruel & Kjaer 4231	2560035		
4	4/6/2018 12:30 pm	Sound level meter	Bruel & Kjaer 2270	3009634	93.9 dB	93.8 dB
		Microphone	Bruel & Kjaer 4189	3086784		
		Acoustic calibrator	Bruel & Kjaer 4231	2560035		
5	4/6/2018 1:30 pm	Sound level meter	Bruel & Kjaer 2270	3009634	93.9 dB	93.8 dB
		Microphone	Bruel & Kjaer 4189	3086784		
		Acoustic calibrator	Bruel & Kjaer 4231	2560035		
6	4/6/2018 2:30 pm	Sound level meter	Bruel & Kjaer 2270	3009634	93.9 dB	93.8 dB
		Microphone	Bruel & Kjaer 4189	3086784		
		Acoustic calibrator	Bruel & Kjaer 4231	2560035		
Mt Burton	4/6/2018 4:49 pm	Sound level meter	Bruel & Kjaer 2270	3009634	93.8 dB	93.9 dB
		Microphone	Bruel & Kjaer 4189	3086784		
		Acoustic calibrator	Bruel & Kjaer 4231	2560035		

3.3.3 Air quality

Ambient particulate monitoring was conducted at Site 1 using a TSI DustTrak DRX Aerosol Monitor 8533 (DustTrak). The instrument simultaneously measured ambient concentrations of PM_{10} and $PM_{2.5}$ in accordance with the requirements of AS/NZS 3580.12.1:2015: *Methods for sampling and analysis of ambient air - Determination of light scattering - Integrating nephelometer method.*

Dust deposition, including total insoluble matter, total soluble matter and heavy metals deposition rates was measured at five locations (Sites 1, 3, 4, 5 and 6) using a Dust Deposition Gauge (DDG). The deposited dust monitoring was undertaken in accordance with the requirements of AS/NZS 3580.10.1:2016: *Methods for sampling and analysis of ambient air - Determination of particulate matter - Deposited matter - Gravimetric method.*

Ambient gas concentration monitoring of Nitrogen Dioxide (NO_2) and Sulphur Dioxide (SO_2) was conducted at two locations (Sites 1 and 3) using passive diffusion matrices. The passive diffusion matrices were co-located at each of the two sites, therefore a total of four matrices were installed. The requirements of the following standards were considered, for each respective ambient gas:

- Australian Standard AS 3580.5.1 – 2011: *Methods of sampling and analysis of ambient air: Determination of oxides of nitrogen – direct-reading instrumental method* (Standards Australia, 2011)
- Australian Standard AS 3580.4.1 – 2008: *Methods of sampling and analysis of ambient air: Determination of sulphur dioxide – direct-reading instrumental method* (Standards Australia, 2008)

Where possible all sampling inlet positions complied with the following criteria, as per Australian Standard AS 3580.1.1 – 2016: *Methods of sampling and analysis of ambient air: Guide to siting air monitoring equipment* (Standards Australia, 2016):

- Clear sky angle 120º
- Unrestricted airflow of 270º around sample inlet or 180º if inlet is on side of building
- 10 m from any object with a height exceeding 2 m below the height of the sample inlet
- 10 m from any road
- No extraneous sources nearby

Details of the air quality monitoring instrumentation used is summarised Table 4.

Table 4 Air quality monitoring instrumentation utilised

Equipment description	Parameters measured	Quantity
TSI DustTrak DRX Aerosol Monitor 8533	Ambient PM_{10}, $PM_{2.5}$,	1
Dust Deposition Gauge	Dust deposition, Metals deposition	5
Passive Diffusion Matrices	Ambient NO_2, SO_2	4 (2 at each location)

3.3.4 Meteorology

Weather data (including temperature, wind speed, wind direction, etc.) is also analysed in this report. Meteorological data was obtained from an Automatic Weather Station (AWS) located at the Rum Jungle site. GHD has not received information verifying the compliance of this AWS with respect to AS 3580.14 – 2014: *Methods of sampling and analysis of ambient air: Meteorological monitoring for ambient air quality monitoring applications.*

GHD has also included meteorological results from the nearby Bureau of Meteorology (BOM) operated station Batchelor Airport which is located approximately 15 km south of the former Rum Jungle Mine Site. The BOM Batchelor Airport site operates to the exposure and siting standard from the Bureau (and thus the requirements of the World Meteorological Organisation (WMO) and the Australian Standard AS/NZS 3580.14 – 2014). The BOM weather station data has been used to evaluate Rum Jungle AWS data validity.

3.4 Monitoring periods

Noise and vibration measurements were undertaken during the period between 4 June 2018 and 18 June 2018, whilst air quality measurements were taken in the period between 4 June 2018 and 5 October 2018.

The monitoring program was conducted in a number of periods in order to meet the requirements of the relevant Australian Standards. Details of the specific monitoring periods for each parameter are outlined below and summarised in Table 5:

- Noise measurements: Unattended noise logging (at 15 minute intervals) was performed for a total of 14 full days. A time period of 14 days was selected as this was deemed sufficient to gain a complete understanding of the range of background noise levels in the area. Attended noise measurements (15 minute duration) were taken upon installation of unattended noise loggers.
- Vibration measurements: Unattended vibration measurements were undertaken for a total of 14 full days, to coincide with the unattended noise monitoring.
- TSI DustTrak DRX Aerosol Monitor 8533: filter collection and replacement was carried out at 15 day intervals, with every second exchange being coincident with the 30-day DDG sampling period. Fifteen day intervals were used to allow a greater number of data adjustment factors to be calculated, increasing the accuracy of the results. A total of six periods were conducted.
- Dust deposition gauges: sample collection and bottle replacement was carried out on a 30 (±2) day basis in line with AS3580.10.1. A total of four periods were monitored.
  – GHD notes that Period D3 was a total of 33 days.
- Passive diffusion matrices: sampler change and replacement was carried out at 15 day intervals to coincide with the 30 day DDG sample period. A total of two periods were conducted.

Table 5 Overview of monitoring periods

Monitoring type	4th June	18th June	5th July	29th July	7th August	22nd August	6th September	21st September	5th October
Unattended noise and vibration	NV1								
Ambient particulates			P1	P2	P3	P4	P5	P6	
Dust deposition	D1		D2		D3		D4		
Ambient gases	G1		G2						

4. Meteorology

Local wind patterns and rainfall are the primary meteorological parameters relevant to this assessment and to the potential for the transport of air quality and noise pollutants between the rehabilitation project works and surrounding receiving environments or sensitive receptors.

4.1 Data quality assessment

Meteorological data was provided to GHD from the Rum Jungle AWS for the period from May 2013 to October 2018 and was analysed for prevailing wind speed, direction and temperature.

Initial review of the Rum Jungle data identified a number of periods of missing or invalid data. The most complete and highest quality data record was for the 12 months to 30 June 2018.

Analysis of data from the Batchelor Airport AWS operated by BOM and located approximately 15 km south of the Rum Jungle AWS was completed to evaluate the validity of the site-specific data. Considering the proximity of the sites, generally similar meteorological conditions would be expected, although some localised variation in climate is also likely.

Based on the comparison of wind speed and direction records of the Rum Jungle and Batchelor Airport AWS presented in Appendix A, GHD considers that data measured at the Rum Jungle AWS is appropriate for characterisation of the site-specific meteorological environment and for use in air quality assessments.

4.2 Wind pattern

The local meteorology will largely determine particulate, gas or noise dispersion patterns from the site. The characterisation of local wind patterns requires accurate site-representative hourly recordings of wind speed and direction over a period of at least 12 months.

The general wind climate of any particular location is most readily assessed by means of wind rose plots, which show the frequency of various wind directions and wind-speed ranges. The features of particular interest in this assessment are:

1. prevailing wind directions
2. relative incidence of more stable light wind conditions
3. ‘good’ dispersion conditions, involving wind speeds of over 5 m/s

A distinction can be made for fugitive deposited dust entrained into strong winds, as opposed to dust emissions from process sources where the emission rate is independent of local wind conditions. The ‘worst case’ in the former class is wind speed greater than 5 m/s, while ‘worst case’ in the latter is light, stable winds.

The wind rose for the 12-month data period to 30 June 2018 is shown in Figure 3 and reveals the following features:

- The measured average wind speed is 2.4 m/s at Rum Jungle AWS
- The general wind pattern is along the northwest-southeast axis, with a significant portion of winds observed from the southeast sector
- Very light winds are measured from all directions
- Strong winds primarily occur from the south-east sector

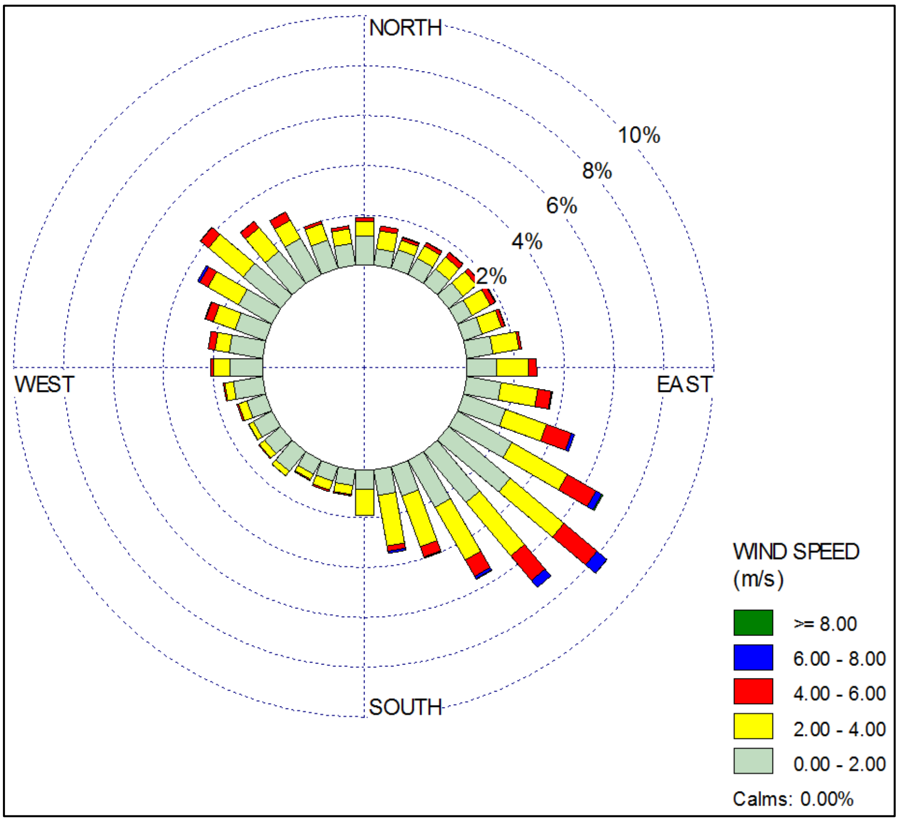

Figure 3 Wind rose for Rum Jungle AWS 01/07/2017-30/06/2018

Given the distinct seasonal conditions that occur in tropical latitudes of northern Australia, wind roses for the dry-season (April to October) and wet-season (November to March) are presented in Figure 4. The seasonal wind rose assessments show that:

- During the dry season, winds are dominated by south easterlies known as the trade winds. These winds range from very light to strong (6 m/s).
- Winds during the wet season remain primarily on a northwest-southeast axis, ranging from very light to strong.

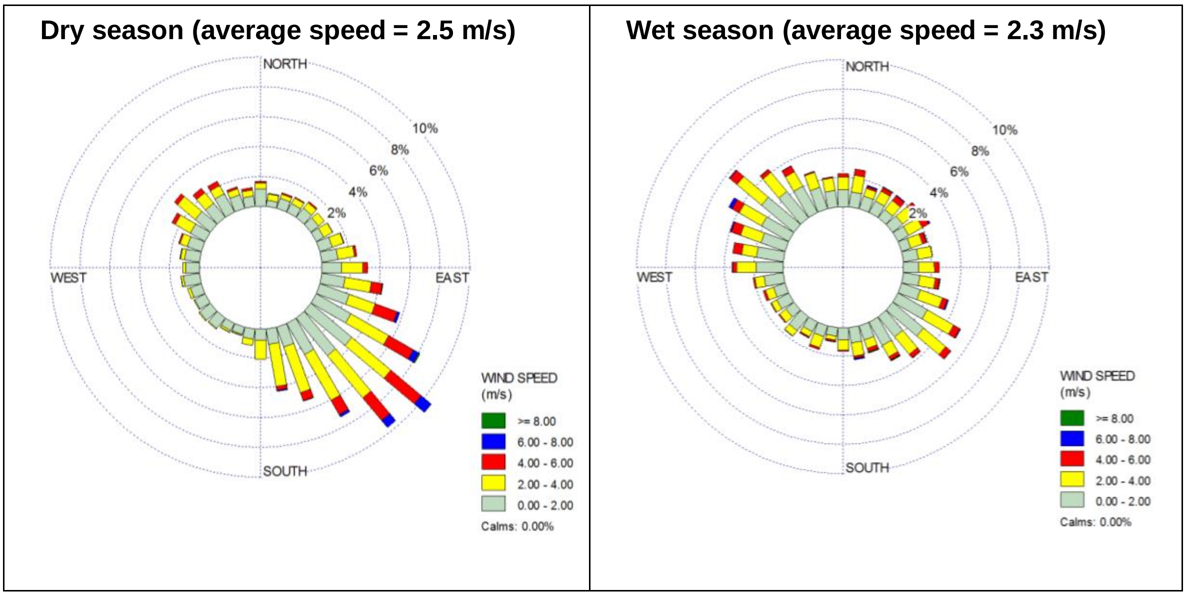

Figure 4 Seasonal wind roses for Rum Jungle AWS (01/07/2017-30/06/2018)

4.3 Rainfall

Rainfall data has been collected at Batchelor Airport BOM station since 1994. Figure 5 below presents total monthly rainfall for:

- Long term monthly average (1994 to present) at Batchelor Airport BOM
- July 2017-June 2018 (inclusive) at Batchelor Airport BOM

The distinction between the wet and dry seasons is clearly demonstrated in Figure 5 in both the long term average and the 2017-2018 period. The annual rainfall as a long term average and the 2017-2018 period were 1610 mm and 1503 mm respectively. January 2018 saw a monthly rainfall total of greater than twice the long term average, however this was countered by less than average totals for December, February and March.

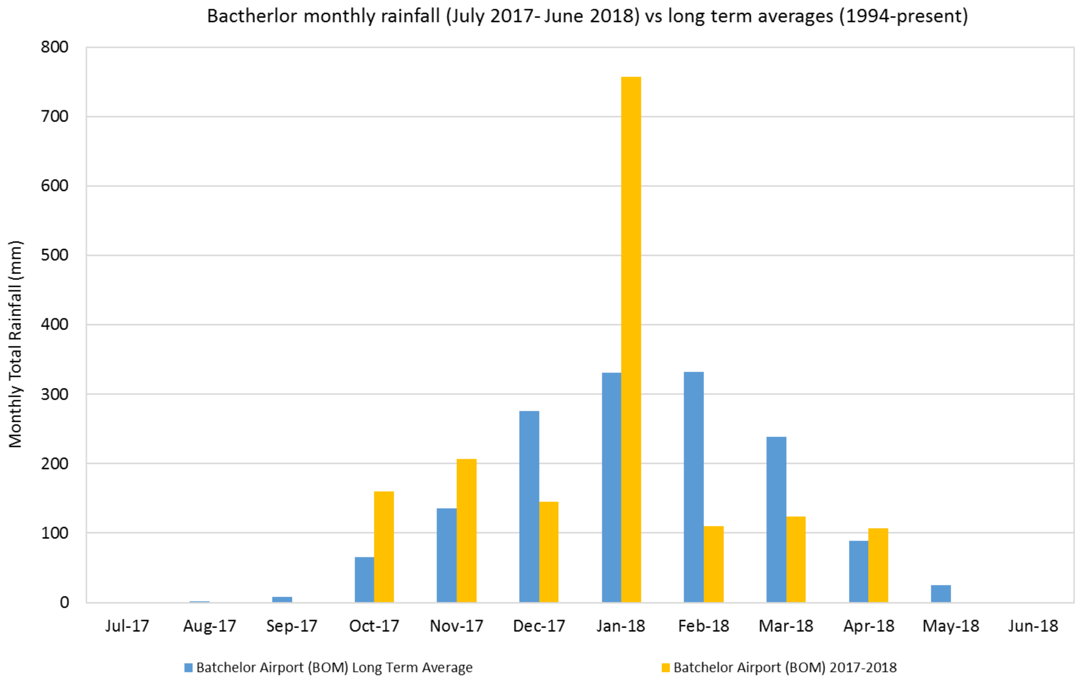

Figure 5 Monthly rainfall totals at Batchelor

5. Noise and vibration monitoring

5.1 Noise

5.1.1 Attended monitoring results

Attended noise measurements were undertaken at the five locations, with additional monitoring conducted at the nearby Mount Burton site. The attended noise monitoring at the five Rum Jungle monitoring sites provided baseline noise levels at the main proposed works area. The monitoring at the satellite Mount Burton works area was to determine whether any notable differences exist between the main Rum Jungle site and the Mount Burton site.

A summary of short term attended noise level results are presented in Table 6, which shows that background (L_{A90}) and ambient (L_{Aeq}) noise levels were generally consistent across all locations except for Mount Burton.

Background noise levels of between 35 to 38 dB(A) and ambient noise levels of 40 to 46 dB(A) were measured at Rum Jungle sites 1 to 5. Although the maximum measured level at Mount Burton was similar to the five Rum Jungle sites, the L_{90} and L_{eq} (i.e. background and average) noise levels were lower. This is likely due to the slightly more remote location of Mount Burton.

Table 6 Summary of attended noise measurement results undertaken on 4 June 2018

Site	Time	Measured noise		Observations/comments
		Descriptor	Level, dB(A)	
1	15:45 – 16:00	L_{90}	35	• Ambient noise dominated by noise from insects, birds whistling and wind • Occasional plane noise
		L_{eq}	40	
		L_{max}	69	
3	11:30 – 11:45	L_{90}	38	• Dominant background noise source from bird noise, insect noise and occasional road traffic activity involving cars • Train pass by noise
		L_{eq}	46	
		L_{max}	61	
4	12:30 – 12:45	L_{90}	38	• Dominant background noise source from mechanical noise – potentially dozers • Bird noise, insect noise and wind noise consistent throughout observation period • Occasional road traffic activity involving cars
		L_{eq}	43	
		L_{max}	62	
5	13:30 – 13:45	L_{90}	38	• Ambient noise dominated by noise from insects • Occasional noise from birds and winds
		L_{eq}	45	
		L_{max}	70	
6	14:30 – 14:45	L_{90}	37	• Dominant noise source was a sprinkler located approximately 20 m away • Plane pass by also consistently occurred during the monitoring period • Occasional road traffic activity involving cars
		L_{eq}	41	
		L_{max}	58	
Mt Burton	16:49 – 17:04	L_{90}	24	• Dominant background noise source from insects and wind passing through trees • Frequent noise from birds • Occasional plane pass by
		L_{eq}	33	
		L_{max}	61	

5.1.2 Unattended monitoring results

Results of unattended noise monitoring are shown in Table 7. The results have been filtered to exclude adverse weather conditions (as discussed below). Raw instrument data below 25 dB have also been excluded to reflect the minimum instrument measurement range.

Table 7 shows average $L_{A10,18hrs}$, background (L_{A90}) and ambient (L_{Aeq}) noise levels measured during day, evening and night-time periods, which in this report and in all applicable guidelines are defined as:

- Day: 7 am to 6 pm
- Evening: 6 pm to 10 pm
- Night: 10 pm to 7 am

The results show that background noise levels at the five monitoring sites are generally very low, with the exception of ambient day-time noise of 65 LA_{eq} dB(A) measured at Site 5. This is likely due to the proximity of a private helicopter landing site at this property. The noise levels outlined in Table 7 have been used to derive noise level criteria for the rehabilitation of the Rum Jungle site, detailed in Section 5.1.3.

Table 7 Summary of unattended noise monitoring results

Site	$L_{A10,18hrs}$ dB(A)	Background $L_{A90,\ 15min}$ dB(A)			Ambient L_{Aeq} dB(A)		
		Day	Evening	Night	Day	Evening	Night
1	40	28	34	27	43	45	37
3	45	31	30	25	48	44	41
4	43	31	28	26	43	44	45
5	42	31	30	29	65	44	40
6	42	33	34	26	45	38	40

Correction for meteorological conditions

Adverse meteorological conditions such as high winds and rainfall can contaminate noise monitoring results. The *NSW Noise Policy for Industry* (NSW NPI, 2017) stipulates:

> "*noise monitoring should not be conducted (or data should be excluded) when average wind speed (over 15-minute periods or shorter) at microphone height are greater than 5 m/s, or when rainfall occurs*" (NSW NPI, 2017, p.50).

Australian Standard *AS 1055.1:1997: Acoustics – Description and Measurement of Environmental Noise* specifies:

> *"Where the maximum wind speed exceeds 5 m/s at the measurement position and noise measurement are (sic) required caution should be applied and special windscreens should be utilised"* (AS1055.1:1997, p. 11).

Rainfall and wind speed during the period of noise measurements were checked based on the nearest automatic weather station (AWS) situated at Rum Jungle.

The Rum Jungle weather data is recorded from an assumed standard measurement height of 10 m (mast height), and therefore requires correction for the noise microphone height of 1.5 m. The correction is undertaken using the wind shear extrapolation technique defined by the US EPA, the standard logarithmic profile of wind speed with height in a neutral atmosphere (US EPA, 2000).

Where the BoM AWS wind speed was greater than 7 m/s or whenever rainfall occurred, noise data was excluded from the assessment.

5.1.3 Establishment of project specific noise criteria

Project-specific noise criteria for the Rum Jungle rehabilitation project have been established from the baseline noise monitoring results and as per the requirements of noise policy and regulation in the NT, as outlined in the following guidelines:

- *Noise Management Framework Guideline* (NT EPA, 2018)
- *Noise Guidelines for Development Sites* (NT EPA, 2014)
- *Road Traffic Noise on NT Government Controlled Roads* (NT Department of Transport, 2014)

The application of each of these guidelines in the development of noise criteria for the former Rum Jungle mine site rehabilitation project is discussed in sequence below.

Application of the NT EPA Noise Management Framework Guideline 2018

Noise criteria for the project have been derived in accordance with the *NT EPA Noise Management Framework Guideline 2018*, which addresses noise pollution and abatement requirements for the following activities and sources:

- Neighbourhood noise i.e. people's activities in and around the home
- Business activities, including the industrial and commercial sectors and government
- Construction noise
- Entertainment venue noise
- Vibration and blasting

The project specific assigned noise level is a recommended mandatory limit, which if exceeded will require noise management or mitigation actions to be implemented by proponents of commercial or industrial premises.

A modified table has also been added (Table 3.5 in the NT EPA guidance) for use in determining Component A of the project specific assigned noise level. This modified table includes recommended maximum assigned amenity noise levels, which are mandatory limits in the NT.

Two groups of noise criteria are used to develop the project specific assigned noise level:

- Intrusiveness noise level (Component A): Established based on background noise measurements (rating background level + 5 dB). Minimum intrusiveness noise levels are specified in Table 8 (below), for any case where "rating background level + 5 dB(A)" is less than the minimum values specified.
- Amenity noise level (Component B): The Guideline states that the ambient noise level within an area from all industrial noise sources combined should remain below the recommended maximum assigned amenity noise levels specified in Table 3.5 of the Guideline, where feasible and reasonable.
  - For residential receivers Table 3.5 defers to Table 3.6, which considers specific residential receiver categories, based on property zoning.
  - In the case of this assessment, residential receivers are located on unzoned land (with the exception of receivers near Site 4). For unzoned land, the Guideline requires the purpose the premises at the time the noise assessment to be considered. GHD has adopted the 'rural residential' category as being most relevant to all sites, except for Site 4.

- Receivers located near Site 4 are zoned Single Dwelling Residential (SD) which is categorised as ‘suburban residential’ within the Guideline. Moreover, the recorded existing background levels (outlined in Table 7) are in line with those outlined in Table 3.6 of the Guideline.
- Minus 5 dB(A), plus 3 dB(A) has been applied to these values, in line with the *NT EPA Noise Management Framework Guideline 2018*.

The project specific assigned noise level is then determined as the least of:

- The adopted intrusiveness noise level
- A-weighted equivalent amenity noise levels (measured over 12-minute intervals)

The project specific assigned noise level for residential receivers located in zones adjacent to the Rum Jungle monitoring sites are summarised in Table 9. Since the background derived criteria are low, the policy stipulates minimum acceptable project assigned noise levels should be the same for all monitoring sites.

Table 8 Minimum assumed intrusiveness noise levels (Table 3.4 of NT EPA Noise Management Framework Guideline 2018)

Site	Background L_{A90} dB(A)		
	Day	Evening	Night
1	40	35	35
3	40	35	35
4	40	35	35
5	40	35	35
6	40	35	35

Table 9 Noise criteria recommended in accordance with NT EPA Noise Management Framework Guideline 2018

Site	Time period	Measured Rating Background Level L_{A90} dB(A)	Intrusiveness noise level L_{A90} + 5 dB(A)	Adopted intrusive noise level dB(A)	Project amenity noise level dB(A)	Project Specific Assigned Noise Level dB(A)
1	Day	28	33	40	48	Day: 40 Evening: 35 Night: 35
	Evening	34	39	35	43	
	Night	27	32	35	38	
3	Day	31	36	40	48	
	Evening	30	35	35	43	
	Night	25	30	35	38	
4	Day	31	36	40	53	
	Evening	28	33	35	43	
	Night	26	31	35	38	
5	Day	31	36	40	48	
	Evening	30	35	35	43	
	Night	29	34	35	38	
6	Day	33	38	40	48	
	Evening	34	39	35	43	
	Night	26	31	35	38	

NT EPA Noise Guidelines for Development Sites 2014 (Construction Noise)

The *Noise Guidelines for Development Sites* are intended for construction sites and are considered less relevant to the assessment of Rum Jungle rehabilitation.

The *Noise Guidelines for Development Sites* again suggest number of criteria depending on the zoning of receivers. If the proposed Rum Jungle rehabilitation activities are considered to be similar to those of construction sites, then these guidelines may become applicable for defining noise criteria.

For the purposes of applying these guidelines, it has been assumed that for the nearest noise sensitive receivers, the limits for residential use areas are applicable. Therefore the criteria for the monitoring sites have been defined using the “ambient noise plus 5 dB(A)” rule as summarised in Table 10. It should be noted that this Guideline adopts construction times of between 7:00 am to 7:00 pm (Monday to Saturday) and between 9:00 am and 6:00 pm on Sundays and public holidays. It also outlines penalties that may be applied to audible noise if it contains tonality, modulation or impulsiveness.

Table 10 Noise criteria recommended in accordance with NT EPA Noise Guidelines for Development Sites 2014

Site	Measured Rating Background Level L_{A90} dB(A)	Noise Limit dB(A) Daytime Background L_{A90} + 5 dB(A)
1	28	33
3	31	36
4	31	36
5	31	36
6	33	38

Road Traffic Noise on NT Government Controlled Roads 2014 (NT DOT 2014)

The NT Road Traffic Noise Guideline is applicable for new roads only. The document outlines a target level of 63 dB(A) for existing residential receivers and 58 dB(A) for other noise sensitive receivers. The guideline states that the relevant acoustic descriptor used for assessing road noise is $L_{A10,18hrs}$. The results of the baseline monitoring show low $L_{A10,18hrs}$ levels and indicate that traffic volumes through the area are likely low and therefore the roads do not influence local ambient environment.

As there are no sensitive receivers in close proximity to the proposed haul road, road noise is not expected to be a substantial contributor and the above noise criteria are likely to be met.

5.2 Vibration

5.2.1 Relevant regulatory documents and standards

As NT regulatory documents do not provide guidance on the assessment of vibration impact from different sources, a number of documents may be taken into account for the purpose of establishing project specific vibration criteria:

- *Assessing Vibration: A Technical Guideline* (NSW EPA, February 2006)
- Australian Standard 2436:2010 – Guide to noise and vibration control on construction, demolition and maintenance sites
- British Standard BS 6472:2008 - Guide to evaluation of human exposure to vibration in buildings - Part 1: Vibration sources other than blasting
- British Standard BS 7385.2:1993 – Evaluation and Measurement for Vibration in Buildings: Part 2 – Guide to damage levels from ground borne vibration
- British Standard BS 5228.2:2009 – Code of Practice for noise and vibration control on construction and open sites: Part 2 Vibration
- German Standard DIN 4150.3:1999 – Structural vibration – Part 3: Effects of vibration on structures

Human comfort

Vibration has been assessed on the basis of criteria provided in *Assessing Vibration: A Technical Guideline* (NSW EPA 2006).

Typically, construction activities generate ground vibration of an intermittent nature. Intermittent vibration is assessed using the Vibration Dose Value (VDV). Acceptable values of vibration dose are presented in Table 11 for sensitive receptors.

Whilst the assessment of response to vibration in *Assessing Vibration: A Technical Guideline* (NSW EPA 2006) is based on VDV and weighted acceleration, for construction related vibration, it is considered more appropriate to provide guidance in terms of a peak value, since this parameter is likely to be more routinely measured to monitor potential building damage.

Table 11 Human comfort intermittent vibration limits (VDV), ms-1.75

Location	Day[1]		Night[1]	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas[2]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Source: BS 6472-1992

Note 1: Day is 7.00 am to 10.00 pm and night is 10.00 pm to 7.00 am.

Note 2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be need to assess intermittent values against the continuous or impulsive criteria for critical areas. These locations for the proposal are provided in Table 3.2 and 3.3.

Humans are capable of detecting vibration at levels well below those causing risk of damage to a building. The degrees of perception for humans are suggested by the vibration level categories given in BS 5228.2 – 2009, Code of Practice for noise and vibration on construction and open sites – Part 2: Vibration, as shown below in Table 12.

Based on the categories of vibration perception suggested n BS 5228.2 – 2009, the risk of adverse comment or complaint in response to vibration could be summarised as:

- A vibration level in the range between 0.14 mm/s to 0.3 mm/s would generate low probability of adverse comment or complaints
- A vibration level in the range between 0.3 mm/s to 1 mm/s would generate the possibility of adverse comment or complaints
- A vibration level greater than 1 mm/s would likely cause adverse comment or complaints

The vibration limits in Table 12 have been adopted for this assessment.

Table 12 Guidance on effects of vibration levels for human comfort

Vibration level	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction.
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration at this level in residential environments would cause complaints, but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure.

Source: BS 5228.2 – 2009

Structural damage

Currently, there is no Australian Standard that sets criteria for the assessment of building or other structural damage caused by vibration. Australian Standard 2436:2010 (R2016) – *Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites;* does refer to the control of vibration in Section 4.8.1. The information in AS 2436 is general in nature and refers to other standards and guidelines if a more detailed assessment is required, i.e. quantification of vibration exposure. British Standard BS 7385.2:1993 – *Evaluation and Measurement for Vibration in Buildings: Part 2 – Guide to Damage Levels from Ground Borne Vibration* and British Standard BS 5228.2:2009 – *Code of Practice for Noise and Vibration Control on Construction and Open Sites: Part 2 Vibration*; are referenced in AS 2436 as being able to supply detailed vibration quantification.

Additional to the detailed British Standards, the German Standard *DIN 4150-3: 1999 Structural Vibration – Part 3: Effects of Vibration on Structures* (German Standards, 1999) provides more stringent vibration criteria as opposed to BS 7385.2:1993 for above ground structures, but less stringent criteria for below ground structures when compared to BS 5228.2:2009. Therefore, a combination of the German and British Standards is recommended, in the absence of specific criteria being supplied by the asset owner, as shown in Table 13.

Table 1 of Section 5 of DIN 4150.3:1999 presents guideline values for the maximum absolute value of the velocity "*at the foundation and in the plane of the highest floor of various types of building. Experience has shown that if these values are compiled with, damage that reduces the serviceability of the building will not occur. If damage nevertheless occurs, it is to be assumed that other causes are responsible.*"

Measured values exceeding those listed in Table 13 "*… does not necessarily lead to damage; should they be significantly exceeded, however further investigations are necessary.*"

Table 13 Guidance values for short-term vibration on structures

Line	Type of structure	Guideline values for velocity v(t)[a] (mm/s)		
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[b]
At grade structures (DIN 4150.3:1999)				
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design.	20	20 to 40	40 to 50
2	Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	3	3 to 8	8 to 10
Underground structures (BS 5228.2:2009)				
Competent structure such as steel or concrete pipeline		30		
Dilapidated brickwork		15		

[a] The term vi refers to vibration levels in any of the x, y or z axis..

[b] Where frequencies are above 100 Hz the values given in this column may be used as minimum values.

The vibration criteria related to structural damage exceeds the human comfort criteria. Therefore, for facilities that people occupy the human comfort criteria should override the structure damage criteria for the assessment of any vibration.

5.2.2 Monitoring results

Ground vibration monitoring was acquired at Site 1 and Site 3. A trigger level for transient vibration events was chosen to address the potential for any complaints and was set at 1 mm/s Peak Particle Velocity (PPV)

Histograms of the recorded events (over 1 mm/s PPV) are presented in Appendix C. From Appendix C it can be seen that the vibrational levels are typically low. The histogram for Site 1 shows some events with relatively high vibration levels measured at the beginning and end of the monitoring period. These events are likely associated with the installation and withdrawal of the monitoring equipment. These values have therefore been excluded from the baseline assessment.

The results of the vibration monitoring show an absence of events with high vibration magnitudes. This indicates that there are currently no significant vibration generating activities in the area. As the nearest sensitive receiver is located approximately 800 m away from the mine, vibration impact is expected to be very low.

Operational vibration monitoring is not expected to be required unless operations that may cause excessive vibration impact are planned. Vibration impact prediction is desirable for any blast operations that may be executed. Vibration and acoustic overpressure monitoring also may be recommended in this case.

6. Air quality monitoring

6.1 Relevant criteria

6.1.1 Ambient particulates and gases

Air quality in the NT is managed using the *National Environment Protection Measure (Ambient Air Quality)* (NEPM AAQ), which was developed under the *National Environment Protection Council Act 1994.* The NEPM AAQ outlines specific air quality objectives for NO_2, SO_2, PM_{10} and $PM_{2.5}$ which are reproduced in Table 14 below.

Table 14 Derived NEPM AAQ objectives for pollutants

Pollutant	Averaging Period	Maximum (ambient) concentration standard	Maximum allowable exceedances
NO_2	1 hour	0.12 ppm	1 day a year
	1 year	0.03 ppm	None
SO_2	1 hour	0.20 ppm	1 day a year
	1 day	0.08 ppm	1 day a year
	1 year	0.02 ppm	None
Particles as PM_{10}	1 day	50 µg/m^3	None
	1 year	25 µg/m^3	None
Particles as $PM_{2.5}$	1 day	25 µg/m^3	None
	1 year	8 µg/m^3	None

6.1.2 Dust deposition

As the NT does not have specific dust deposition legislation, and as the results presented in this report are in relation to baseline conditions (i.e. prior to construction), an assessment of the deposited dust results against specific criteria is not required. Dust deposition objectives from other states are presented in order to interpret the baseline monitoring results. Proposed dust deposition objectives are discussed below with reference to the following guidance:

- Department of Environment and Conservation, Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (Approved Methods), (Department of Environment and Conservation, 2005)
- EPA Victoria, Protocol for Environmental Management: Mining and Extractive Industries (Mining PEM), (EPA Victoria, 2007)

NSW Approved Methods state that the maximum increase in deposited dust levels should not exceed 2 g/m^2/month, whilst maximum total deposited dust levels should not exceed 4 g/m^2/month. The Victorian Mining PEM states that deposited dust levels should not exceed 4 g/m^2/month (no more than 2 g/m^2/month above background).

Nuisance dust can be more appropriately described as insoluble solids, as defined in the NSW Approved Methods, as per AS 3580.10.1 – 1991 (now superseded by AS 3580.10.1 – 2016) and stated in the New Zealand *Good practice guide for assessing and managing the environmental effects of dust emissions* (Ministry for the Environment, 2001). As such, the rate of deposition of total insoluble matter has been presented in this report.

6.2 Ambient gases results

The results of ambient gas measurements for periods G1 and G2 (see Table 5) are presented in Table 15 and Table 16, respectively. All measured concentrations are significantly below the NEPM AAQ objectives for all pollutants.

The as-measured values in the passive diffusion matrices for Site 1 and Site 3 are also presented in Figure 6 and Figure 7, respectively. From these Figures it can be seen that the largest concentrations of nitrate and sulphate were observed at Site 3 during Period G1, but significantly decreased in Period G2. The reverse was the case at Site 1, where larger concentrations were observed in Period G2.

Table 15 Period G1 ambient gas results

Pollutant	Units	Site 1 Results		Site 3 Results			NEPM Objective (ppm /hr)
		Sample 1	Sample 2	Sample 1	Laboratory duplicate	Sample 2	
Nitrate as NO_2	µg/tube	9.4	12	25	25	24	-
	ppm per hour	< 0.01 (1.1×10^{-9})	< 0.01 (1.4×10^{-9})	< 0.01 (2.8×10^{-9})	< 0.01 (2.8×10^{-9})	< 0.01 (2.7×10^{-9})	0.12
Nitrate as NO_3	µg/tube	1	1.7	4.7	4.7	3.3	-
	ppm per hour	< 0.01 (8.4×10^{-11})	< 0.01 (1.4×10^{-10})	< 0.01 (4×10^{-10})	< 0.01 (4×10^{-10})	< 0.01 (2.8×10^{-10})	0.12
Sulphate as SO_4	µg/tube	1.1	1.3	15	14	14	-
	ppm per hour	< 0.01 (2.8×10^{-11})	< 0.01 (3.3×10^{-11})	< 0.01 (3.8×10^{-10})	< 0.01 (3.6×10^{-9})	< 0.01 (3.6×10^{-9})	0.2

Table 16 Period G2 ambient gas results

Pollutant	Units	Site 1 Result		Site 3 Result			NEPM Objective (ppm / hr)
		Sample 1	Sample 2	Sample 1	Laboratory duplicate	Sample 2	
Nitrate as NO_2	µg/tube	8.8	7.6	3.1	3.3	8.7	-
	ppm per hour	< 0.01 (8.8×10^{-10})	< 0.01 (7.6×10^{-10})	< 0.01 (3.1×10^{-10})	< 0.01 (3.3×10^{-10})	< 0.01 (8.7×10^{-10})	0.12
Nitrate as NO_3	µg/tube	17	5.6	0.8	2.9	4	-
	ppm per hour	< 0.01 (1.3×10^{-9})	< 0.01 (4.2×10^{-10})	< 0.01 (5.9×10^{-11})	< 0.01 (2.2×10^{-10})	< 0.01 (3×10^{-10})	0.12
Sulphate as SO_4	µg/tube	13	2.9	1.3	1.4	4.7	-
	ppm per hour	< 0.01 (2.9×10^{-10})	< 0.01 (6.5×10^{-11})	< 0.01 (2.9×10^{-11})	< 0.01 (3.1×10^{-11})	< 0.01 (1.1×10^{-10})	0.2

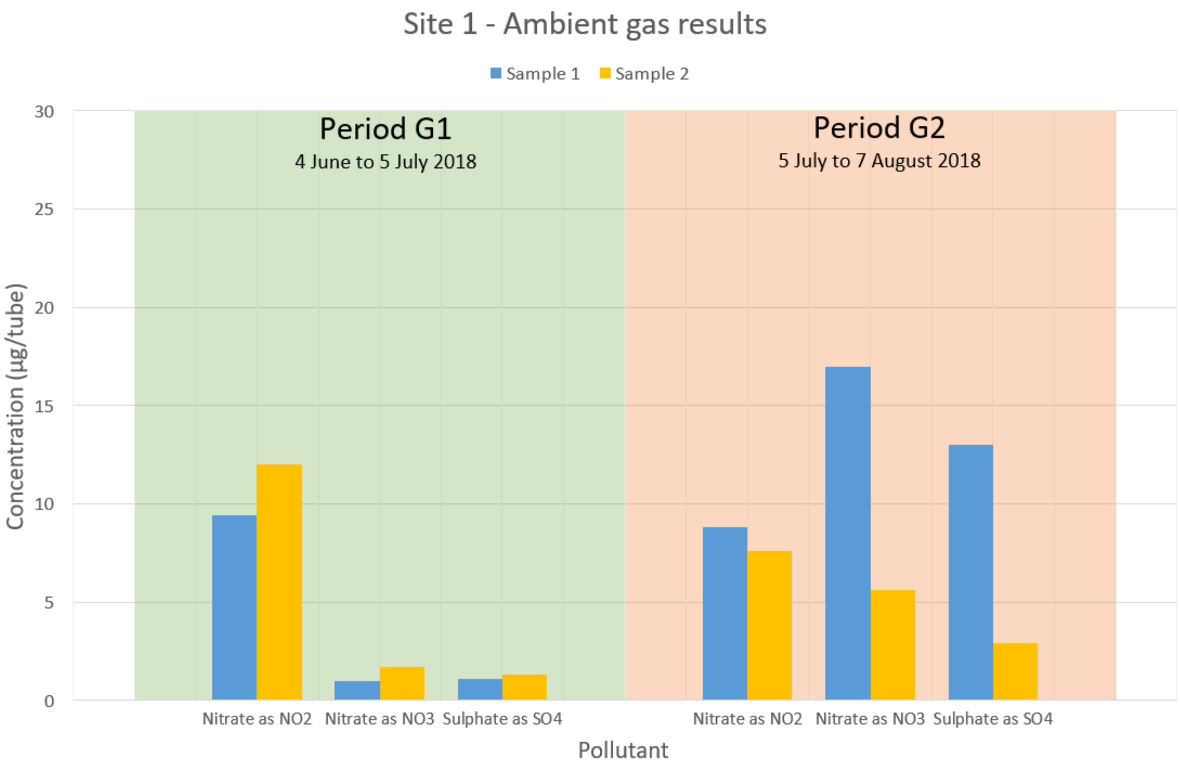

Figure 6 Site 1 - Ambient gas results

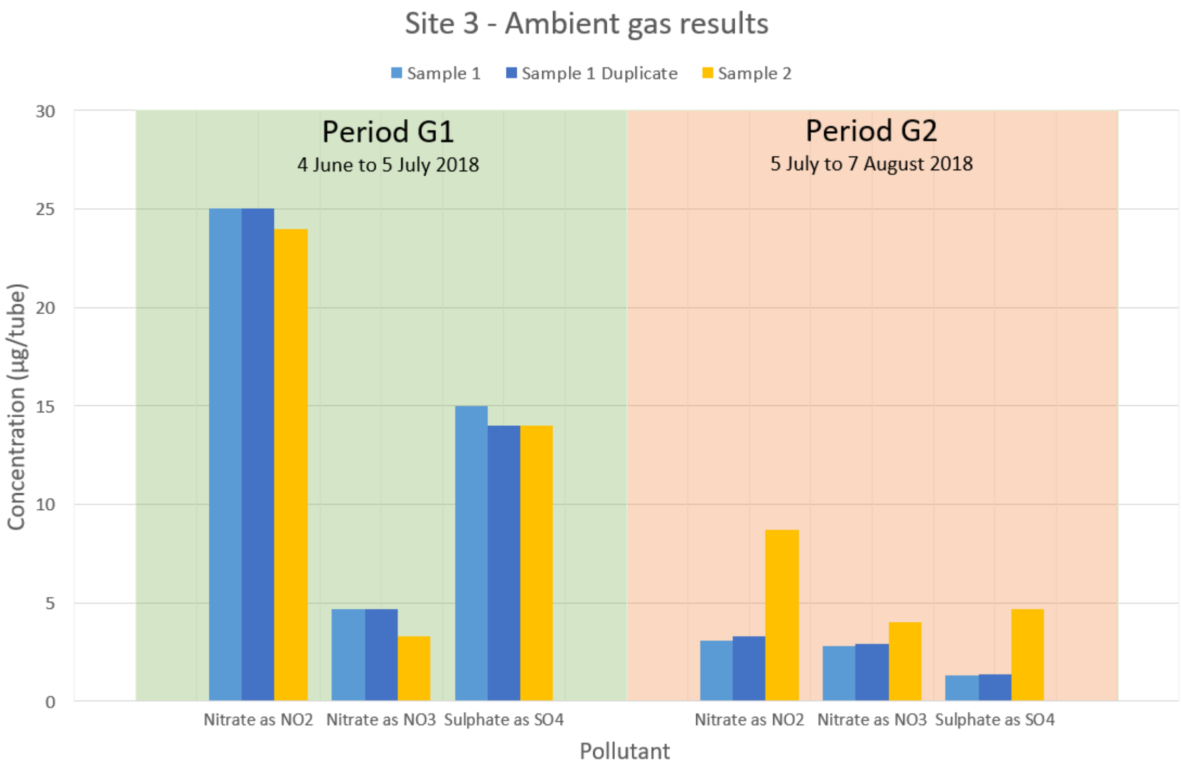

Figure 7 Site 3 - Ambient gas results

6.3 Dust deposition results

The results of the dust deposition measurements for each monitoring period (Periods D1 – D4) (see Table 5) are presented in Figure 8. The overall deposited dust levels remain relatively constant across the monitoring periods, with an increase seen at all sites at the conclusion of Period D4 (October 2018). The highest measured value (1.5 g/m^2/month) can be seen at Site 4 and Site 5 during this period. When dust deposition levels are compared against the criteria outlined in Section 6.1.2, all values are below 2 g/m^2/month.

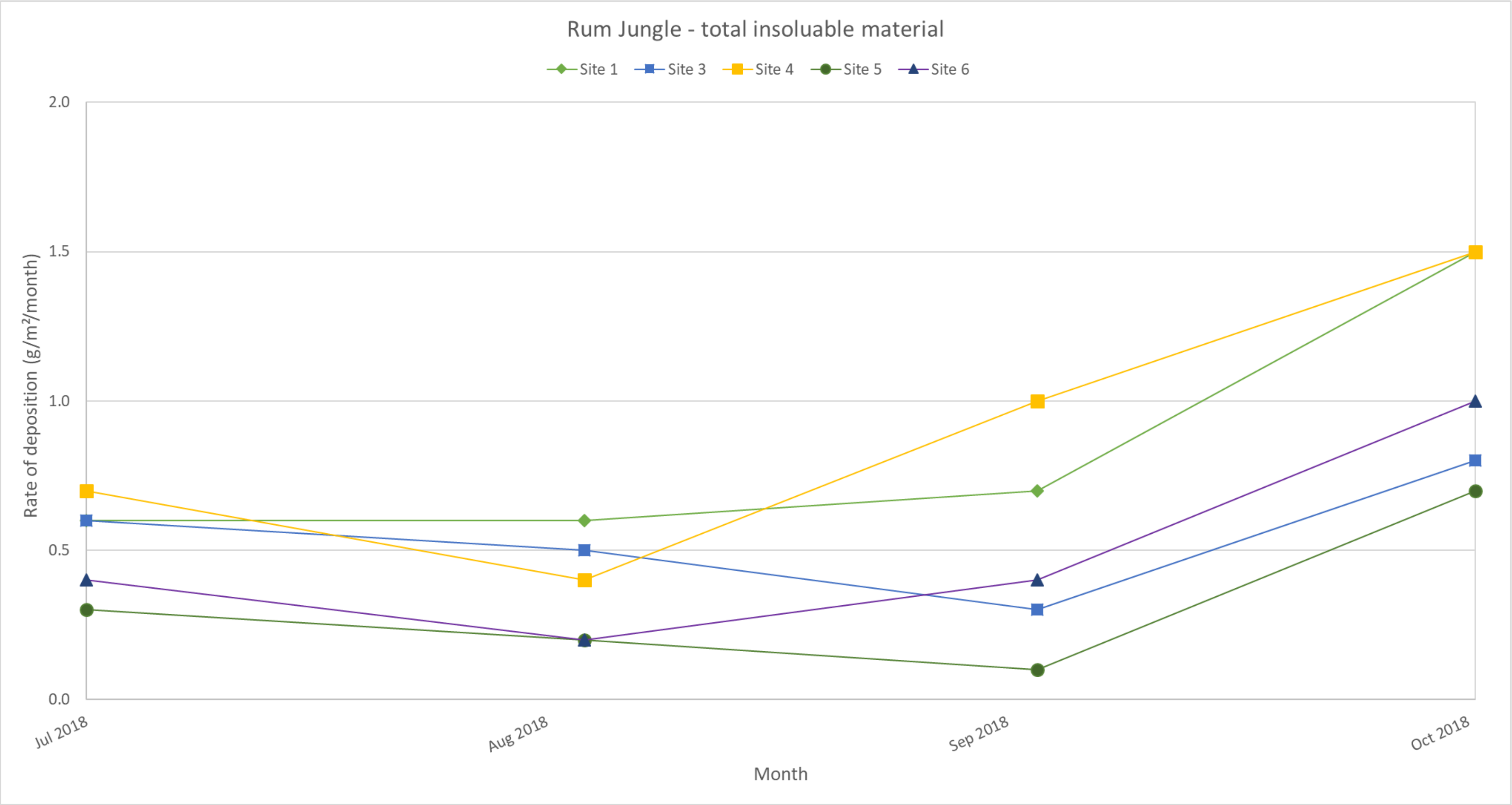

Figure 8 Rum Jungle - total insoluble material

6.4 Ambient particulate results

The results of ambient PM_{10} and $PM_{2.5}$ measurements taken between Period P1 and P6 (see Table 5) at Site 1 are presented in Figure 9, as daily averages. An overview and summary of the results is also provided in Table 17.

GHD notes that a k-factor for each period was calculated based on all data available between each filter change (i.e. not limited to the hours outlined in each period). The application of the k-factor to the data reduces the impact relative humidity may have on the data, as 'false' data associated with relative humidity does translate to actual particulates deposited on the filter. Measured data on days of filter changes was excluded to enable accurate and complete 24 hour averages to be calculated.

Average particulate concentrations for each period and for the entire monitoring period are presented in Table 17. The average $PM_{2.5}$ and PM_{10} concentrations for the period were measured as 12.7 µg/m^3 and 13.7 µg/m^3 respectively, relating to a $PM_{2.5}$ to PM_{10} particle size ratio of approximately 93%. This ratio is significantly elevated in comparison to what is measured at the Palmerston AQMS (56%) and what is generally expected (~50%) in rural environments. GHD attributes the elevated $PM_{2.5}$ to PM_{10} ratio to the low inlet flow velocities of the DustTrak not effectively collecting particles greater than $PM_{2.5}$.

Figure 9 provides a comparison of the DustTrak results to the 24 hour average PM_{10} and $PM_{2.5}$ NEPM AAQ criteria. Based on the above discussion of lower than expected PM_{10} concentrations, GHD has not provided any commentary comparing the PM_{10} concentrations to the NEPM AAQ objectives. The overall trend of the measured $PM_{2.5}$ concentrations are below the 25 µg/m^3 objective, however three peaks above the objective were recorded.

The three peaks occurred in Period P2 (one peak) and Period P3 (two peaks). The cause of these peaks is likely associated with local fire events resulting in smoke impacts. It is also noted that the matter deposited on filter in P6 is lower than the other periods.

Table 17 Summary of ambient particulate results

Period	Matter deposited on filter (µg/filter)	k – factor	Average PM_{10} concentration (µg/m^3)	Average $PM_{2.5}$ concentration (µg/m^3)	Data availability (%)
P1	589	2.18	12.3	11.5	99.6
P2	1020	2.38	21.8	20.7	100
P3	684	1.93	15.5	14.2	96.6
P4	590	1.88	13.2	12.1	98.5
P5	583	1.92	13.5	12.6	99.9
P6	235	4.69	5.8	5.3	99.2
Average	**617**	**2.5**	**13.7**	**12.7**	**99**

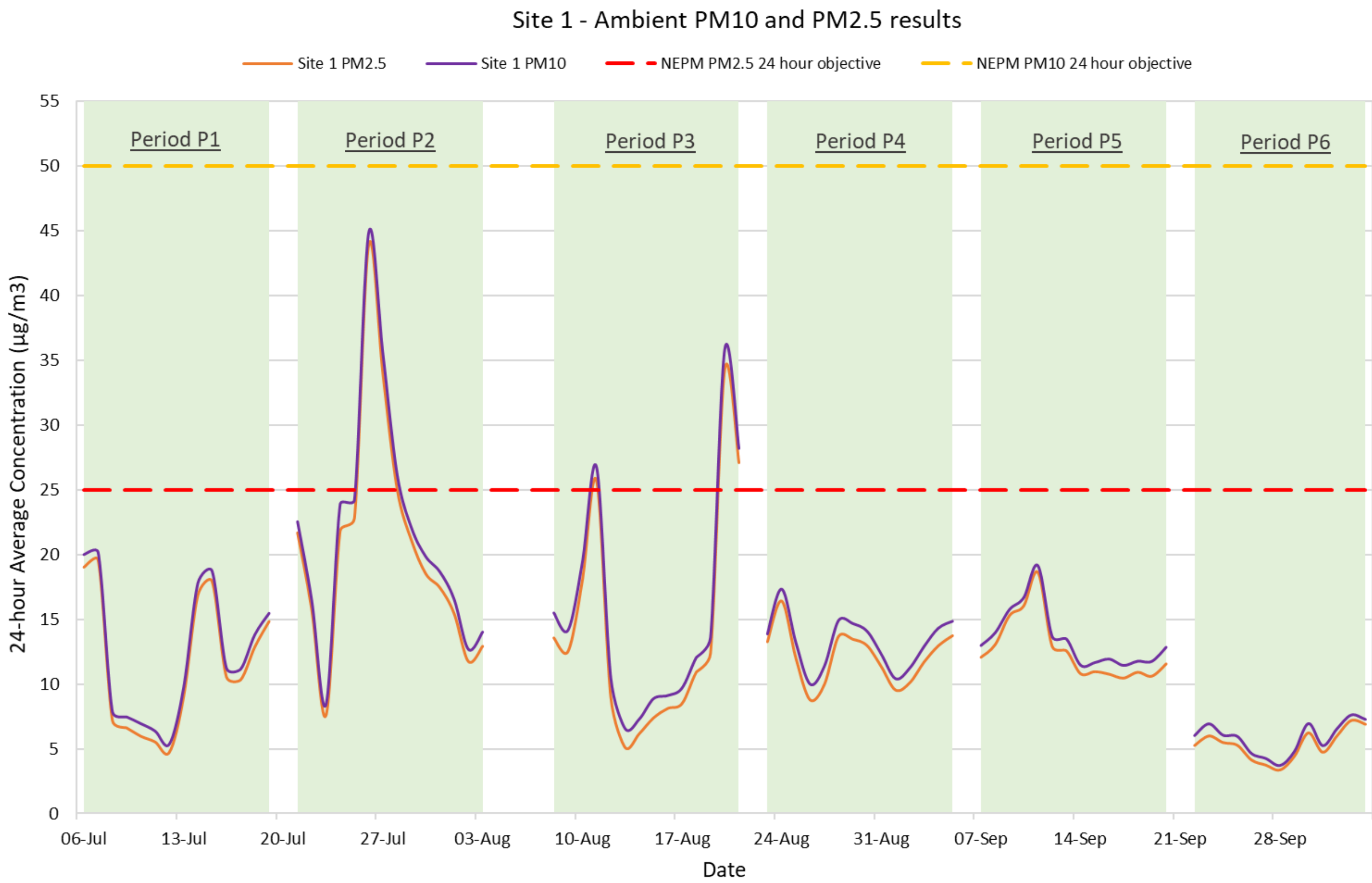

Figure 9 Site 1 - Ambient PM_{10} and $PM_{2.5}$ results

7. Surrounding air quality

7.1 Purpose

A further objective of the baseline air quality study was to compare site specific air-quality data to nearby Air Quality Monitoring Stations (AQMS) operated by the NT EPA, in order to assess whether any of the stations can provide appropriate surrogate data for use in the Environmental Impact Statement (EIS) and during implementation of the proposed Rum Jungle rehabilitation project. A description of the surrounding air quality monitoring stations and their location in relation to the former Rum, Jungle mine is provided in Table 18 below.

Table 18 Summary of nearby AQMS

Air Quality Monitoring Station	Description	Distance from the former Rum Jungle Mine Site
Palmerston	The Palmerston AQMS is located approximately 5 km WSW from Palmerston City, near Darwin Harbour. The station is situated near a forest. The air quality at the station is likely influenced by local traffic and forests as well as dry-season fires.	54 km
Winnellie	The Winnellie AQMS is in a central location, with Darwin International Airport to the east and Winnellie to the south of the station. The air quality at the station is likely influenced by local residences and traffic.	64 km
Stokes Hill	The Stokes Hill AQMS is located at Stokes Hill Wharf, and is close to the most densely populated part of the Northern Territory (Darwin CBD). The air quality at the station is likely influenced by the CBD, local industries, boats and the sea breezes.	60 km

7.2 Station analysis

GHD has compared the ambient $PM_{2.5}$ concentrations from each NT EPA operated AQMS against the results from the DustTrak located at Site 1. Comparisons of respective PM_{10} concentrations have not been provided due to the reasons outlined in Section 6.4. Comparisons are provided in Figure 10 (against the Palmerston AQMS) and Appendix E (for Stokes Hill and Winnellie AQMS') and are summarised below:

- The Stokes Hill values are significantly higher than those measured at Site 1 .
- Winnellie shows localised peaks that were not reflected in the measured data at Rum Jungle.
- The Palmerston results are generally similar to the values measured at Site 1, with similar short-term peaks (daily) and long-term (weekly) trends observed in both datasets (Figure 10).

Based on the above, GHD has provided further analysis of the correlation between the Palmerston AQMS data and the results from Rum Jungle Site 1 (Section 7.3).

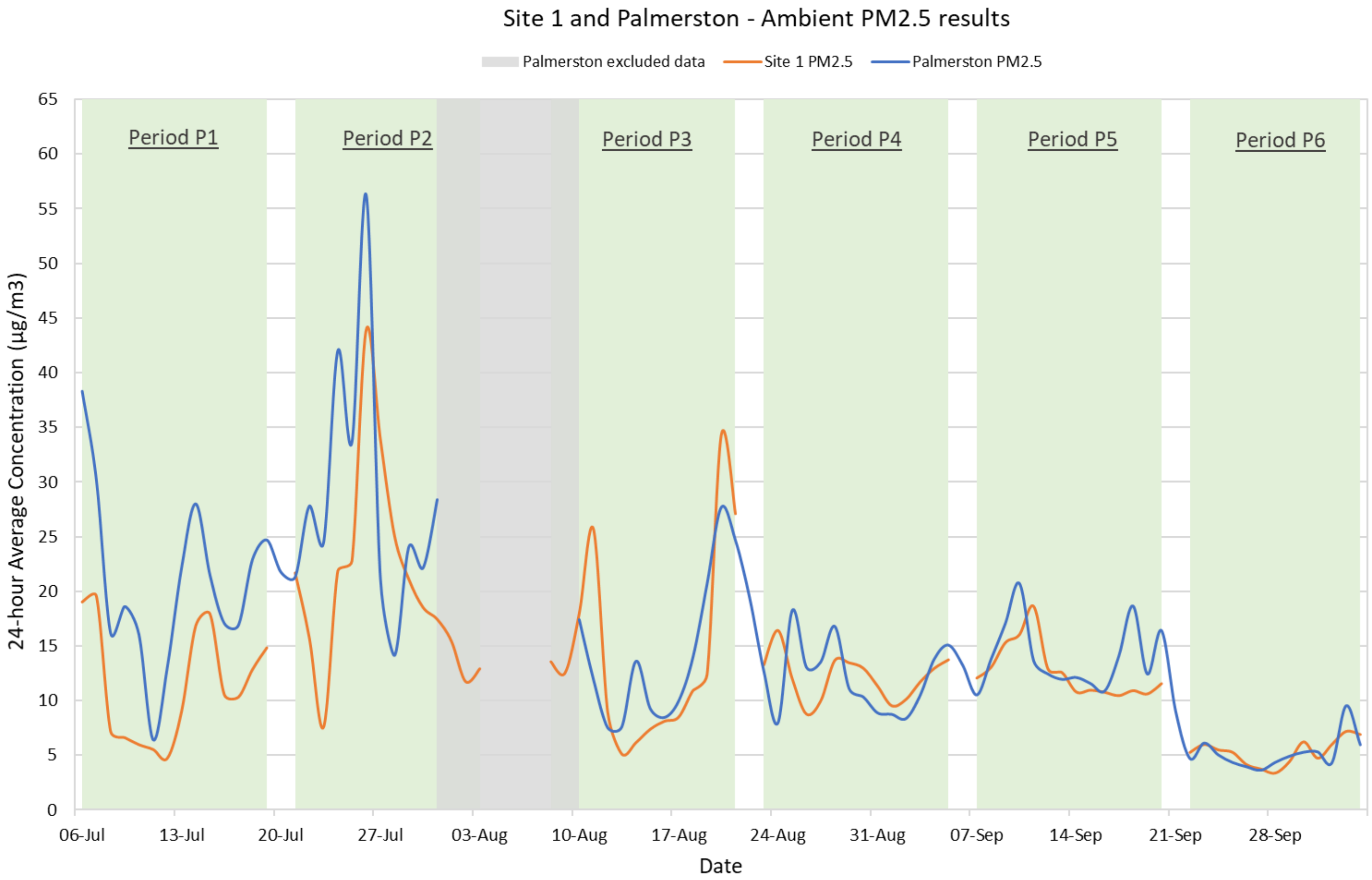

Figure 10 Site 1 and Palmerston - Ambient $PM_{2.5}$ results

7.3 Palmerston AQMS

GHD is of the opinion that the Palmerston AQMS provides a relatively accurate representation of air-shed conditions experienced at the Rum Jungle site due to the following reasons:

- The ambient $PM_{2.5}$ concentrations from the DustTrak located at Site 1 and at Palmerston recorded similar values and follow similar temporal trends (see Figure 10).
- The Palmerston station is exposed to nearby areas of vegetation, with limited exposure to residential/industrial emissions, which presents a similar environment to that of the Rum Jungle site. The air quality at both locations are likely to be influenced by smoke from regional fires.

Further analysis and comparison of the values and trends between the two sites is provided below to assess its suitability for use in the EIS and during the Rum Jungle rehabilitation project, in lieu of establishing additional site specific data.

7.4 Temporal trend

7.4.1 Periods

From Figure 10 the following trends can be seen for period P1 to P6 (as defined in Table 5):

Period P1

In Period P1 the values of Palmerston are overall greater than those recorded at Rum Jungle, with the average measured value being 21.4 µg/m^3 and 11.5 µg/m^3, respectively. Similar peaks are recorded in both datasets, however higher peak values were measured at Palmerston.

Period P2

Period P2 also saw overall higher values at Palmerston than compared to Rum Jungle Site 1, with an average of 28.7 µg/m^3 and 20.7 µg/m^3, respectively. The largest peak in the 24-hour averaged data (see Figure 10) was measured in Period P2 with Palmerston recording a value of 56.2 µg/m^3, compared to 43.9 µg/m^3 at Rum Jungle Site 1.

Period P3

The overall values recorded during Period P3 were very similar at the two sites, with only 0.2 µg/m^3 difference between the period averages. Figure 10 shows two major peaks occurred within Period P3, with both peaks recorded in both datasets. During these two peaks, Rum Jungle measured slightly higher values than Palmerston. A minor peak was also observed at the Palmerston site, which was not picked up in the Rum Jungle $PM_{2.5}$ values.

Period P4

In Period P4 very similar values were recorded at the two sites, with only 0.1 µg/m^3 difference between the period averages. Minor localised peaks were recorded in both datasets

Period P5

Three distinct peaks occurred during Period P5 at Palmerston with only one of these peaks being recorded at Rum Jungle Site 1. The difference in period average values was slightly larger in Period P5 (1.4 µg/m^3) than compared to the previous two periods, likely due to the additional localised peaks recorded at Palmerston.

Period P6

The similarities between the values measured and the similarity of overall trends are the greatest during Period P6 and can be seen visually in Figure 10.

Summary

A summary of the temporal trends observed is provided below:

- Overall the two datasets follow similar long term (weekly) trends with similar $PM_{2.5}$ concentrations measured at both sites.
- Similar short-term peaks (daily) are recorded at both sites. Generally, if a peak was recorded at Rum Jungle Site 1, it was also recorded at Palmerston. Additional peaks observed at Palmerston were not always recorded at Rum Jungle Site 1.
- The average values measured during periods P3, P4 and P6 were almost identical at the two sites with less than 0.3 µg/m^3 difference.
- Where there are significant differences in the average concentration between the two datasets, the higher concentration is generally measured at Palmerston. Consequently, if the Palmerston data are utilised as surrogate data for the assessment of $PM_{2.5}$ concentrations, this would provide conservatism to the assessment associated with the project.

7.4.2 Hour of day

A plot of average $PM_{2.5}$ concentrations vs time of day is shown in Figure 11 for both Rum Jungle Site 1 and Palmerston.

Variance between the two sites between approximately 2:00 am and 2:00 pm is minimal, however between 3:00 pm and 9:00 pm, measured concentrations at Palmerston increase significantly, a trend which is not observed in the data from Rum Jungle Site 1.

It is likely that a significant driver of diurnal particulate matter concentrations at Palmerston relates to the combustion of fuels, likely from traffic. This relationship cannot be assessed for Rum Jungle Site 1 due to the absence of a collocated gas monitor, but due to the more remote/rural nature of Rum Jungle Site 1, it is likely that this relationship would not be as prominent.

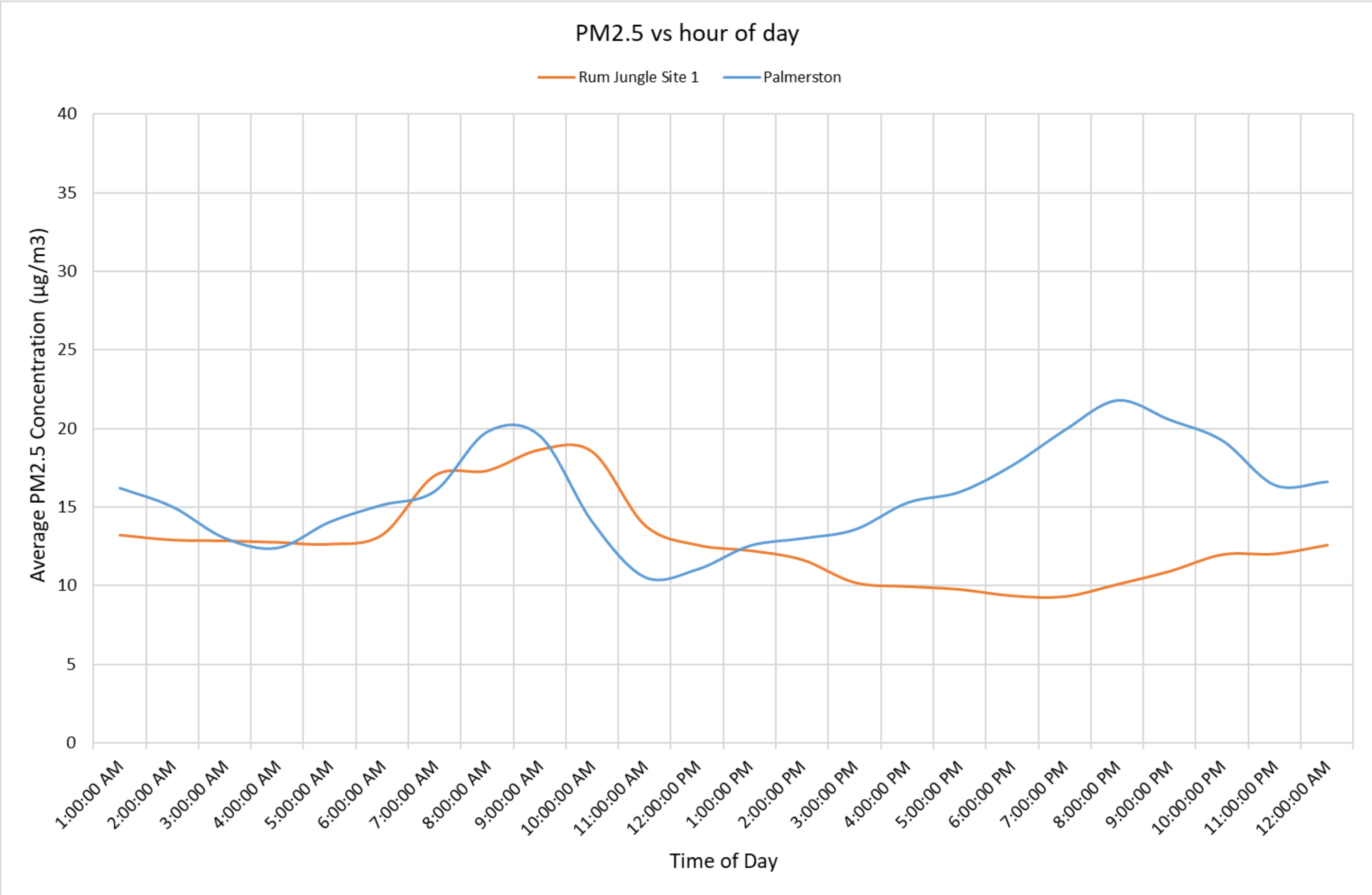

Figure 11 $PM_{2.5}$ concentration vs hour of day

7.5 Spatial distribution of pollutants

An analysis of the spatial distribution of $PM_{2.5}$ was also undertaken for the Palmerston and Rum Jungle Site 1. The spatial distribution was analysed to compare the offsite pollutant distribution between the two sites. The $PM_{2.5}$ spatial distribution was analysed by means of pollution webs at the two sites. A pollution web shows the directions (from), and total quantity of $PM_{2.5}$ transported during the monitoring period. A pollution web for Palmerston and Rum Jungle Site 1 is shown in Figure 12. From Figure 12 the following observations are made:

- There is a large overlap in the web of the two sites and this indicates that both the wind environment and the total quantity of particulates transported at each of the sites is similar.
- The Rum Jungle site sees a higher frequency of winds (and consequently pollutants) from the south-southeast in comparison to a higher frequency of winds from east-southeast at Palmerston.
- The general pattern of pollution appears similar for both sites.

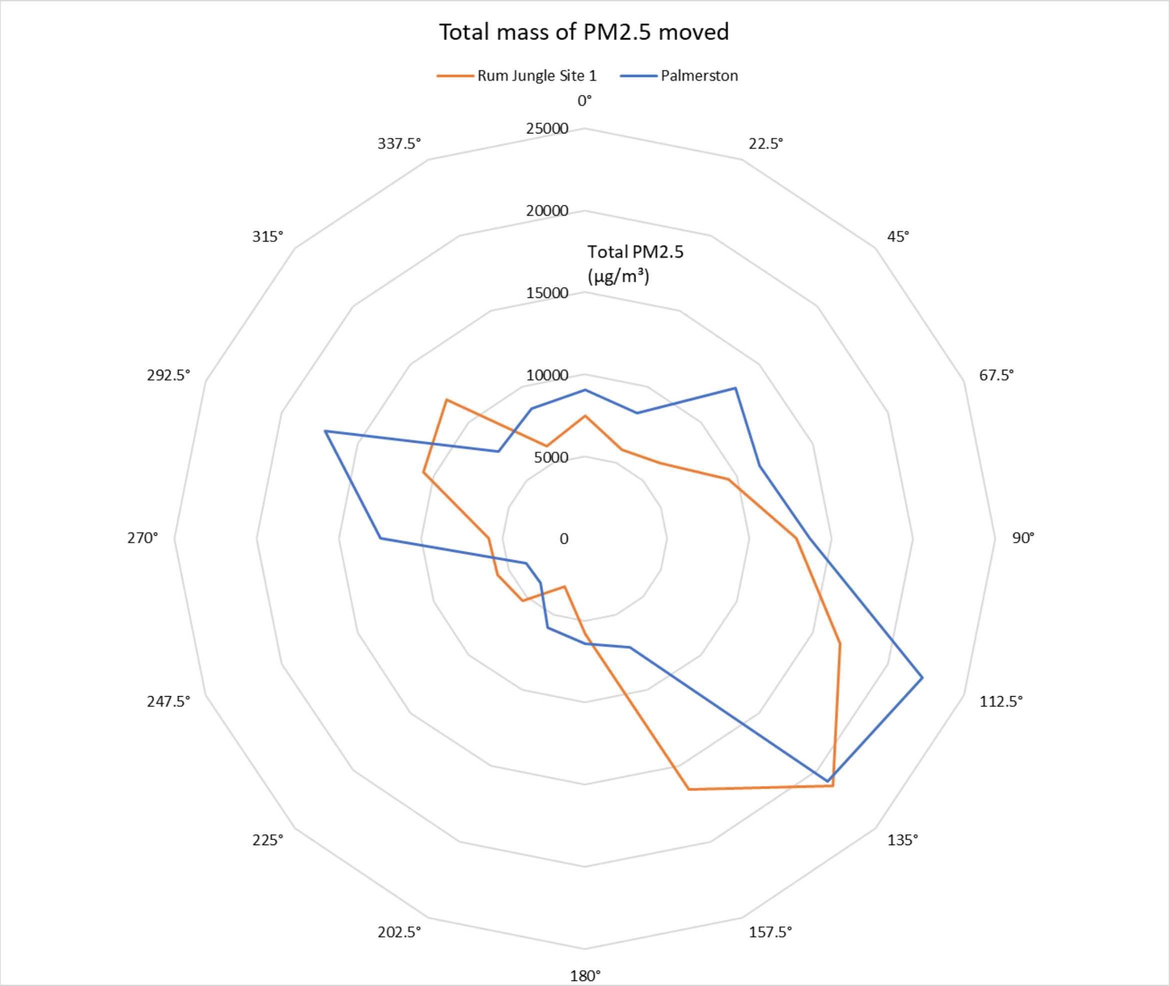

Figure 12 Total mass of $PM_{2.5}$ moved

7.6 Correlations between datasets

Based on the above analysis, it is noted that Rum Jungle Site 1 and Palmerston datasets have short term differences (localised peaks) however have similar long term trends. In order to use particulate data from Palmerston station to inform background concentrations for the Rum Jungle air quality assessment, the influence of localised peaks will need to be removed. In order to reduce the influence of local peaks whilst retaining data resolution, GHD has analysed the correlation between the two datasets for the following intervals:

- 24 hour average
- 7 day average (i.e. half a period)
- Fortnightly average (i.e. one period)
- Monthly (four week) average (i.e two periods)

A summary of correlation coefficients between the two datasets for each specified averaging period is provided in Table 19. Based on these values, GHD has determined the seven-day averaged data is the most appropriate for use in the air quality assessment to inform background concentrations for the Rum Jungle site. A seven-day average basis was selected to remove the influence of localised peaks, whilst still maintaining longer term trends, which would be removed in longer averaging periods.

The seven-day averaged results measured over the monitoring period are shown in Figure 13. From Figure 13, the overall, longer term trends observed in the 24-hour averaged data (Figure 10) can still be seen, however the localised peaks are no longer included. In Figure 13 it can be seen that although a similar trend is observed, elevated $PM_{2.5}$ levels were recorded at the Palmerston site in comparison to Rum Jungle Site 1 at the beginning of the monitoring period. Although the difference in these values do not appear to be representative of the remainder of the monitoring period, the inclusion the higher concentrations of particulates recorded at Palmerston as background values in the Rum Jungle air quality assessment will provide conservatism to the assessment.

Table 19 Summary of nearby AQMS

Averaging period	Correlation coefficient
24 hour	0.74
7 day	0.83
Fortnight	0.87
Month (4 weeks)	0.92

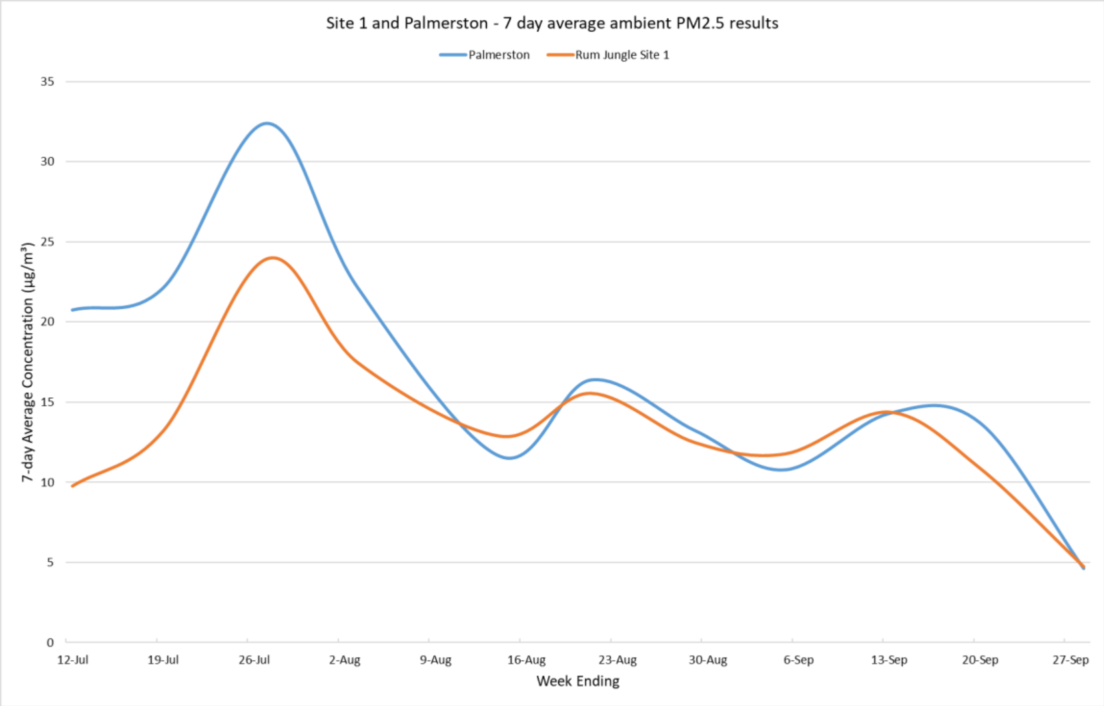

Figure 13 Rum Jungle Site 1 and Palmerston AQMS - 7 day average ambient $PM_{2.5}$ results

7.7 Summary

Conclusions regarding data

- The ambient $PM_{2.5}$ concentration trend between Site 1 and Palmerston has short term differences (localised peaks) but generally are highly correlated. The data recorded at Stokes Hill and Winnellie stations do not show the same degree of correlation.
- The hour of day distribution between Palmerston and Site 1 is similar during morning and afternoon hours, however Palmerston recorded higher values in the evening hours. This difference is likely a result of the more suburban location of the Palmerston AQMS resulting in an increase in combustion of fuels, likely from traffic. However, once rehabilitation activities begin, the generator sets, moxy trucks and earthmoving equipment will cause diesel combustion at the Rum Jungle site.
- The spatial distribution of the Palmerston and Rum Jungle Site 1 pollutants are mainly from the same sector (southeast). Moreover, similar quantities of pollutant moves were observed. This indicates that pollutants from similar sources are influencing both sites.
- On average, whilst data are comparable, Palmerston records higher concentrations of particulates than the more remote Rum Jungle site.

Methodology for application of background particulate data in air quality assessment

- Based on the above conclusions, GHD recommends that particulate data from the Palmerston AQMS be applied to the Rum Jungle air quality assessment as background concentrations.
- To remove the influence of localised peaks, background particulate data should be applied on a seven-day average basis.
- Both $PM_{2.5}$ and PM_{10} data recorded at Palmerston should be utilised in the air quality assessment.
- Considering that concentrations recorded at Palmerton are elevated in comparison to those recorded at Rum Jungle, this will add conservatism to the air quality assessment, by reducing allowable emissions from the Rum Jungle site.

8. Summary

GHD undertook noise, vibration and air quality monitoring at five locations within the vicinity of the former Rum Jungle mine site, as part of the Rehabilitation of the Rum Jungle Project. Noise and vibration measurements were undertaken in the period between 4 June 2018 and 18 June 2018, whilst air quality measurements were undertaken in the period between 4 June 2018 and 5 October 2018.

The noise and vibration results recorded very low background noise and vibration levels. The noise measurements allowed for the derivation of noise criteria for the project in accordance with the NT EPA Noise Management Framework Guideline 2018. It was determined that operational vibration monitoring is not expected to be required unless operations that may cause excessive vibration impact are proposed, such as drill-and-blast operations.

The air quality results indicated:

- Ambient gases: concentration levels of NO_2, and SO_2, were below the NEPM air quality objectives.
- Dust deposition: measured deposited dust rates remained relatively constant across the monitoring periods with an increase seen at all sites at the conclusion of Period D4. All values measured were below 2 g/m^2/month, which is suggested background dust deposition limit sourced from NSW and Victorian guidance.
- Ambient particulates: the overall trend of the measured $PM_{2.5}$ concentrations was below the 25 µg/m^3 objective, however three peaks above the objective were measured. The three peaks occurred in Period P2 (one peak) and Period P3 (two peaks). The cause of these peaks is likely associated with local fire events.

An assessment of the three nearby AQMS was conducted to assess whether these instruments operated by the NT EPA might be used to provide surrogate data for use in the EIS and during the Rehabilitation of the former Rum Jungle mine site, in lieu of site specific data.

It was determined that data generated from the Palmerston AQMS was relatively accurately representative of conditions measured at the Rum Jungle site for $PM_{2.5}$ concentrations. A strong correlation exists between data generated from the two sites, based on both temporal and spatial trend analyses. Whilst data are comparable on average, Palmerston records higher concentrations of particulates than Rum Jungle, which will provide conservatism to air quality assessments during the works. It was determined that in order to remove the influence of localised peaks, background particulate data will be applied on a seven-day average basis.

9. References

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Australian Standard 2436:2010 Guide to noise and vibration control on construction, demolition and maintenance sites

Australian Standard 3580.1.1:2016: Methods of sampling and analysis of ambient air: Guide to siting air monitoring equipment

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Australian Standard/New Zealand Standard 3580.12.1:2015: Methods for sampling and analysis of ambient air - Determination of light scattering - Integrating nephelometer method.

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British Standard 6472:2008 - Guide to evaluation of human exposure to vibration in buildings - Part 1: Vibration sources other than blasting

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National Environment Protection Council 1998, National Environment Protection (Ambient Air Quality) Measure

New Zealand Ministry for the Environment 2001, Good practice guide for assessing and managing the environmental effects of dust emissions

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NT EPA 2018. Noise Management Framework Guideline'

NT Department of Transport 2014, Road Traffic Noise on NT Government Controlled Roads

NSW Department of Environment and Conservation 2005, Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales

NSW EPA 2006. Assessing vibration: A technical guideline

NSW EPA 2017. Noise Policy for Industry

US EPA 2000, Meteorological Monitoring Guidance for Regulatory Modelling Applications

Appendices

Appendix A – Meteorological data comparison

The following analysis is dependent on the following assumption:

- The Rum Jungle AWS is sited and operated in compliance with Australian Standard AS/NZS 3580.14 – 2014

From a review of the Rum Jungle and Batchelor wind roses below, the following are observed:

- Average wind speed of 2.4 m/s at Rum Jungle
- Average wind speed of 2.1 m/s at Batchelor
- General wind pattern is similar for both sites, with a significant portion of winds observed from the south-east sector
- Very light winds are measured from all directions
- Strong winds primarily from the south-east sector

Considering the above, meteorological data measured at the Rum Jungle AWS, is appropriate for characterisation of the local meteorological environment at the subject site and for use in the air quality assessment.

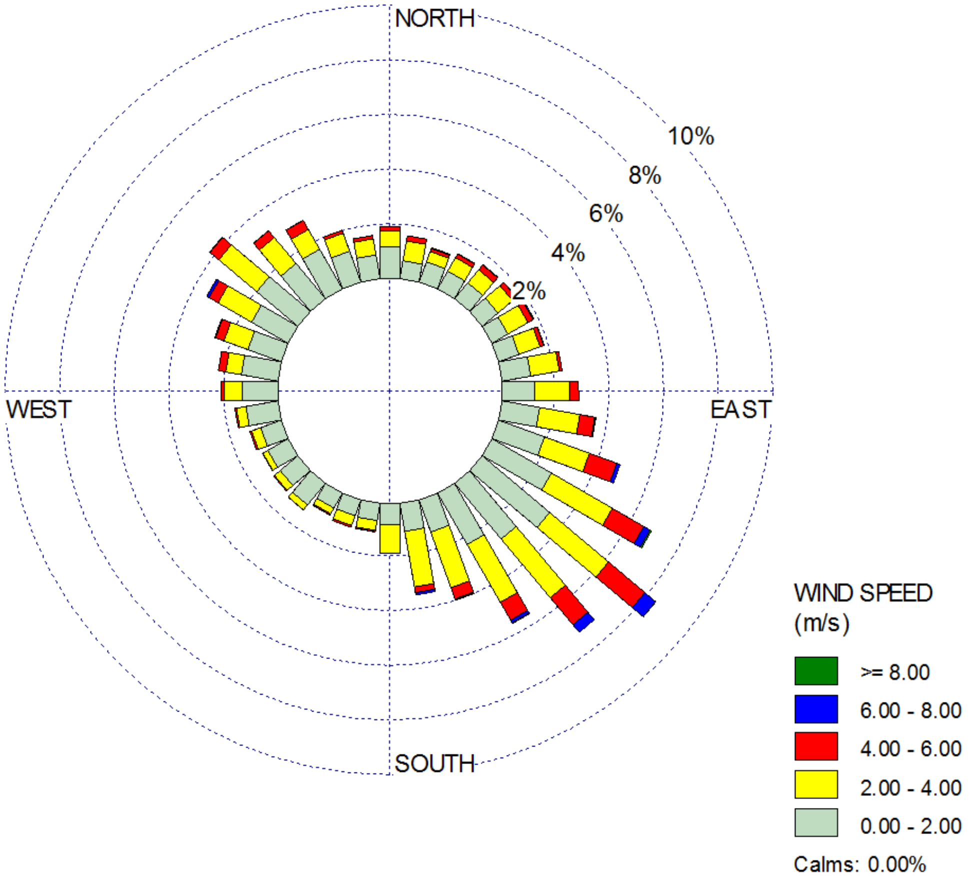


Figure A1 Wind rose for Rum Jungle AWS 01/07/2017-30/06/2018

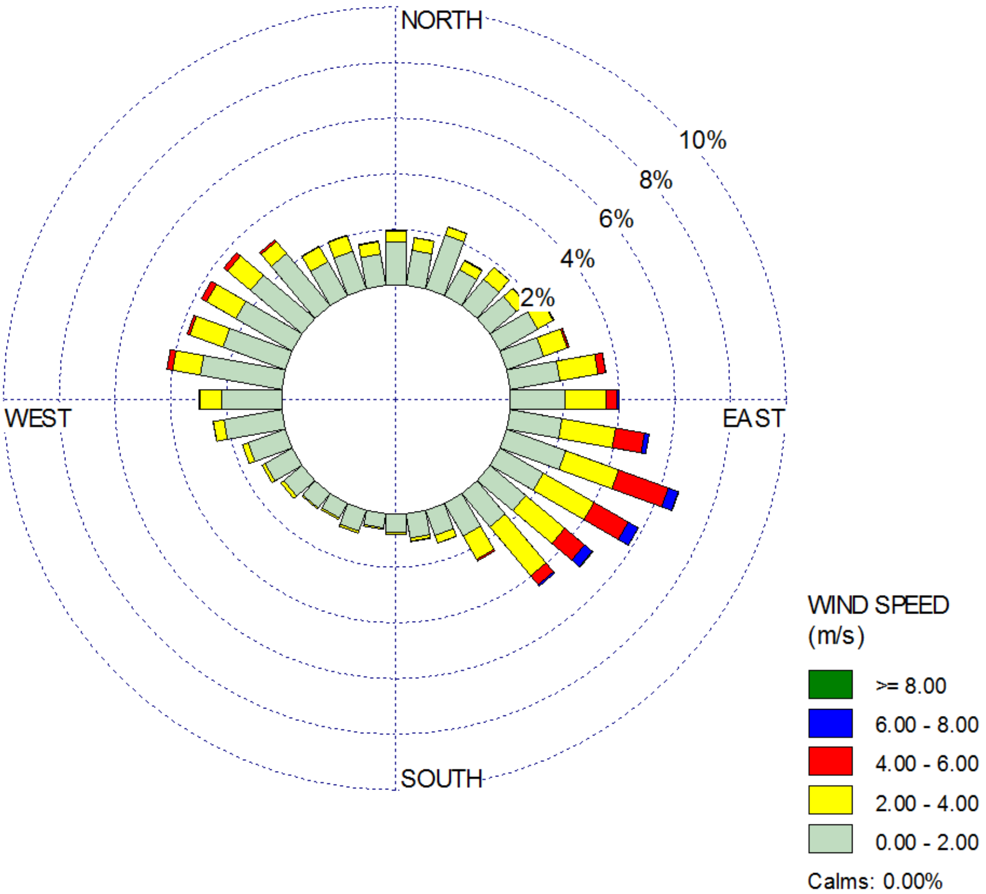


Figure A2 Wind rose for Batchelor Airport AWS 01/07/2017-30/06/2018

Appendix B – Noise monitoring sites

Site 1

Site 3

Site 4

Site 5

Site 6

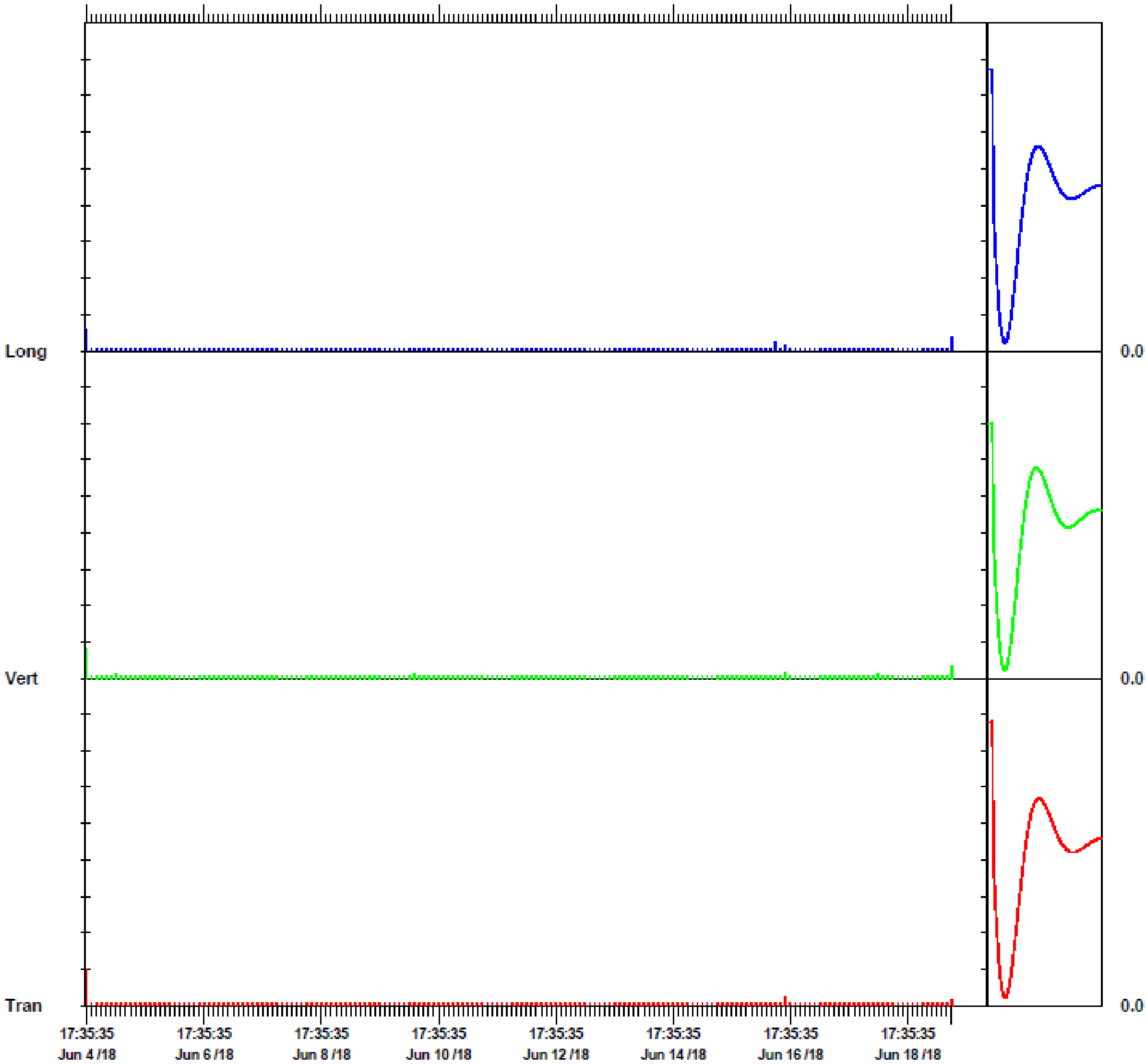
Appendix C – Vibration monitoring results

Histogram Start Time	15:35:35 June 4, 2018		**Serial Number**	UM10468 V 10-79 Micromate ISEE
Histogram Finish Time	11:26:53 June 19, 2018		**Battery Level**	3.8 Volts
Number of Intervals	1423.41 at 15 minutes		**Unit Calibration**	May 27, 2016 by Instantel
Range	Geo:254.0 mm/s		**File Name**	UM10468_20180604153535.IDFH
Sample Rate	1024sps			
Operator/Setup:	Operator/factory.MMB			

Notes
Location:
Client:
User Name:
General:

	Tran	Vert	Long	
PPV	1.017	0.804	0.591	mm/s
ZC Freq	>100	>100	>100	Hz
Date	Jun 4 /18	Jun 4 /18	Jun 4 /18	
Time	15:50:35	15:50:35	15:50:35	
Sensor Check	Passed	Passed	Passed	
Frequency	7.3	7.7	7.3	Hz
Overswing Ratio	3.1	2.9	3.3	

Peak Vector Sum 1.255 mm/s on June 4, 2018 at 15:50:35



Time Scale: 2 hours /div **Amplitude Scale:** Geo: 1.000 mm/s/div Sensor Check

Figure C1 Results of particle peak vibration monitoring, Location 1

Histogram Start Time	11:20:25 June 4, 2018	**Serial Number**	UM10469 V 10-79 Micromate ISEE
Histogram Finish Time	08:54:51 June 19, 2018	**Battery Level**	3.8 Volts
Number of Intervals	1430.29 at 15 minutes	**Unit Calibration**	May 27, 2016 by Instantel
Range	Geo:254.0 mm/s	**File Name**	UM10469_20180604112025.IDFH
Sample Rate	1024sps		
Operator/Setup:	Operator/factory.MMB		

Notes
Location:
Client:
User Name:
General:

	Tran	Vert	Long	
PPV	0.236	0.268	0.244	mm/s
ZC Freq	N/A	26	>100	Hz
Date	Jun 19 /18	Jun 19 /18	Jun 19 /18	
Time	08:50:25	08:54:51	08:35:25	
Sensor Check	Passed	Passed	Passed	
Frequency	7.1	7.3	7.1	Hz
Overswing Ratio	3.8	3.7	3.8	

Peak Vector Sum 0.310 mm/s on June 19, 2018 at 08:54:51
N/A: Not Applicable

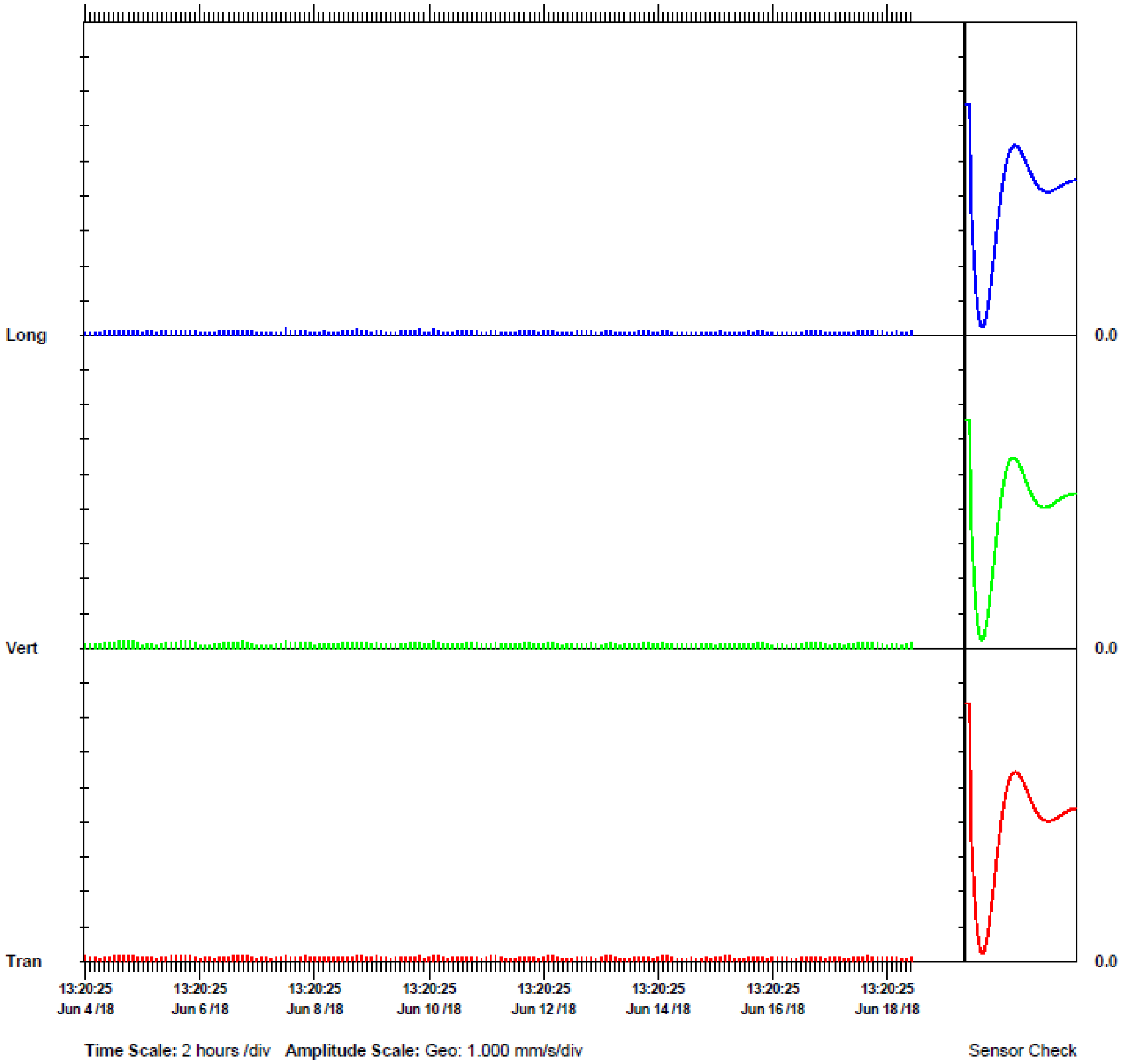


Figure C2 Results of particle peak vibration monitoring, Location 3

Appendix D – Palmerston AQMS

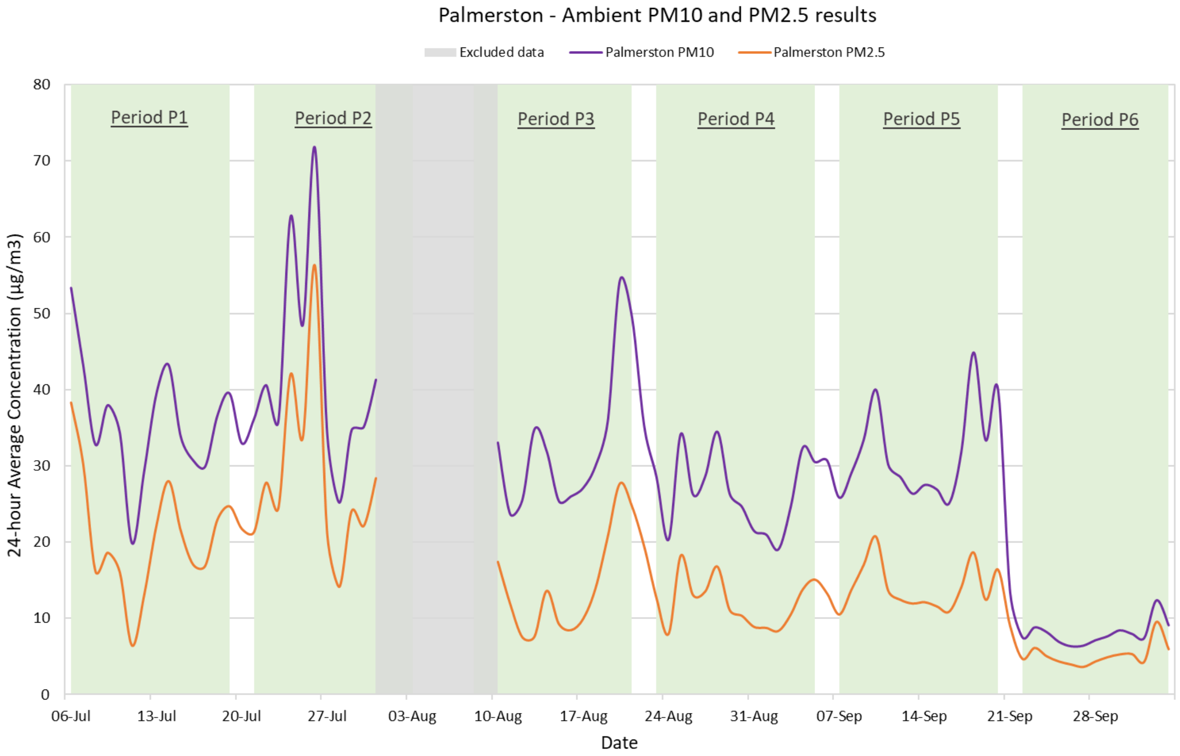


Figure D1 Palmerston - Ambient PM_{10} and $PM_{2.5}$

Appendix E – Nearby AQMS

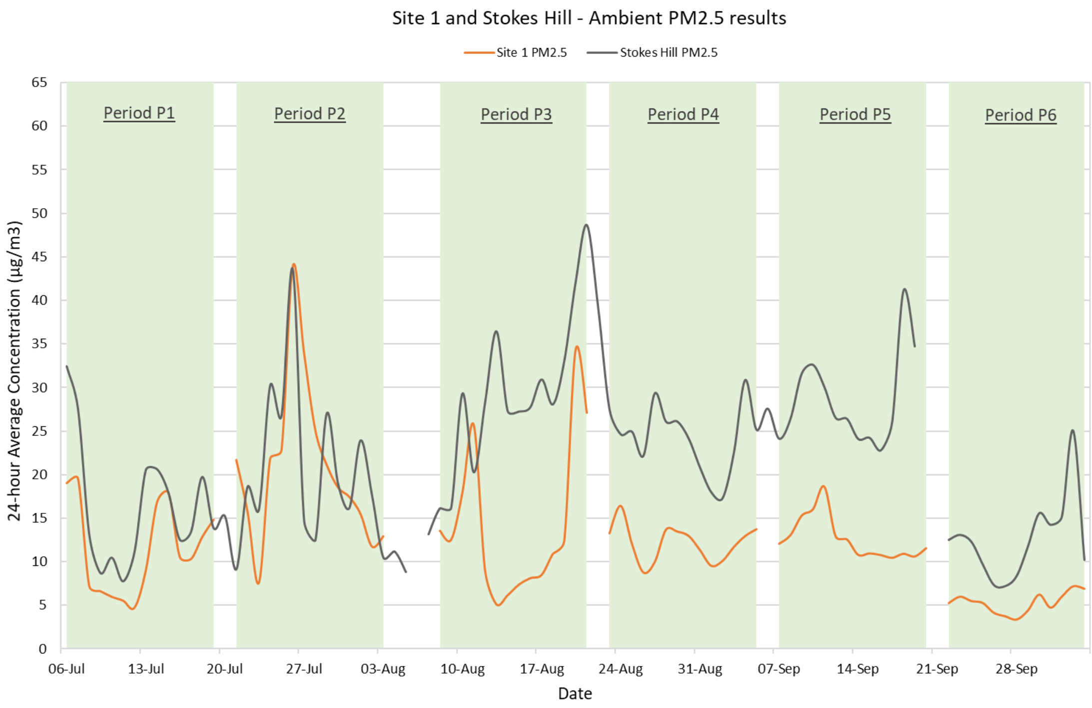


Figure E1 Site 1 and Stokes Hill - Ambient $PM_{2.5}$

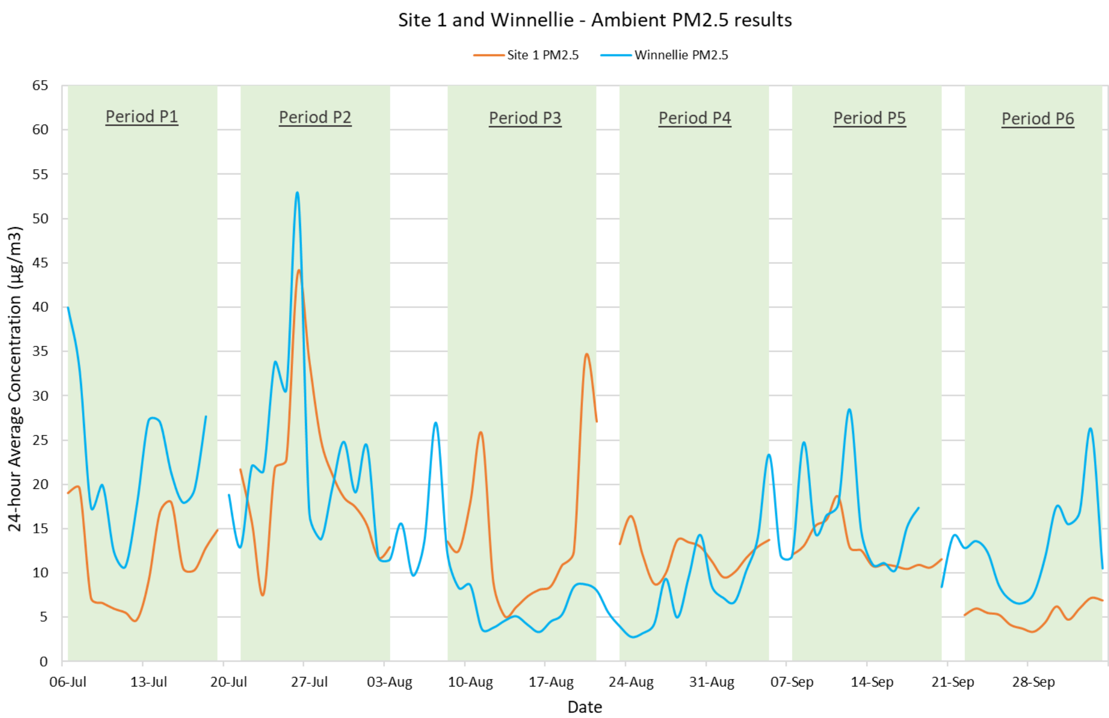


Figure E2 Site 1 and Winnellie - Ambient $PM_{2.5}$

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4322841-32308/https://projects.ghd.com/oc/NorthernTerritory/rumjungle2aairnoisev/Delivery/Documents/4322841_REP_Baseline Monitoring Report.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	D.Craggs S.Materia	M.Asimakis M.Sheikh	[signature]	P.Abbott	[signature]	05/12/18
1	D.Craggs S.Materia	M.Asimakis M.Sheikh	[signature]	P.Abbott	[signature]	07/05/19

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