Appendices

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Appendix 1

Submissions Summary

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Table A1-1
Submissions Summary

									Land use conflict			Air quality						Noise							Flora and Fauna impacts				Economic		Traffic				Amenity		Water			Company Reputation		Other					
No.	Date	Council Ref. No.	No. of Submitters	Name/s	Address	Contact Details	For or Against	No. of Concern Categories	Conflict with Council Vision	Conflict with intent of LEP zone	Incompatible with area	Dust (respiratory issues i.e. asthma)	Dust (Silica Dust)	Dust (in tank water)	Air monitoring at Sunnyside	Monitoring (inadequate current monitoring and going forward)	Accuracy of Air quality data	Noise (general)	Noise (from crushing)	Noise (from machinery)	Noise (from trucks)	Noise (increased hours)	Noise (from alarm)	Noise (from blasting)	Operational impacts Wildlife	Extent of land clearing	Rehabilitation	Bushfire	Values of surrounding property	Tourism decline	Traffic (general)	Degradation of road pavement	Traffic (increased quarry vehicles)	Traffic (safety)	Visual Amenity	General Amenity	Water sourcing / consumption	Ground water aquifers	sediment runoff	Previous EPA fine	Lack of community consultation	Management of crisis events	Clarity of extraction area	Resource is not for public projects	Blasting impact on horses	Vibration	Comment
1	12/11/2019	IDA20192487	79	Vince Sherry (representative for submission signed by 79)	N/A	Unknown	Against	9			1		1			1	1		1	1	1			1												1											Submission by large number of community members. Wide range of concerns. Makes recommendations.
2	15/11/2019	IDA20192592	1	Yoichi Takayama	308C Mount Lindesay Road, Tenterfield NSW 2372	Unknown	Against	3					1																										1				1				Primarily concerned with silica dust and potential for silicosis
3	15/11/2019	IDA20192591	1	Martin I'Ons	246 Leech's Gully Road, Tenterfield NSW 2372	Unknown	Against	2					1				1																														Demonstrates good understanding of rock formation processes (Geologist / Geochemist). Concerned with Quartz/Silica Dust
4	15/11/2019	IDA20192580	2	Brett and Alison Lawrence	1277 Black Swamp Road, Tenterfield NSW 2372	Unknown	Against	3					1						1					1																							Concerned with the drought conditions causing native vegetation buffers to be reduced.
5	15/11/2019	IDA20192582	1	Jane I'Ons	246 Leech's Gully Road, Tenterfield NSW 2372	Unknown	Against	7					1				1		1								1	1			1					1											Lists a number of factors to be addressed 'if quarry is to remain in operation'
6	14/11/2019	IDA20192578	2	Pam and Sam Sammut	Unknown	0427 375 417 0427 299 788	Against	2					1																							1											Concerned for workers and residents health
7	19/11/2019	IDA20192572	2	Richard and Steven Ibbett	668 Mount Lindesay Road, Tenterfield NSW 2372	Unknown	Against	5					1				1		1					1												1											Claims to have reported quarry to EPA before for blasting.

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Table A1-1 (Cont'd)
Submissions Summary

Page 2 of 3

									Land use conflict			Air quality						Noise							Flora and Fauna impacts				Economic		Traffic				Amenity		Water			Company Reputation		Other					
No.	Date	Council Ref. No.	No. of Submitters	Name/s	Address	Contact Details	For or Against	No. of Concern Categories	Conflict with Council Vision	Conflict with intent of LEP zone	Incompatible with area	Dust (respiratory issues i.e. asthma)	Dust (Silica Dust)	Dust (in tank water)	Air monitoring at Sunnyside	Monitoring (inadequate current monitoring and going forward)	Accuracy of Air quality data	Noise (general)	Noise (from crushing)	Noise (from machinery)	Noise (from trucks)	Noise (increased hours)	Noise (from alarm)	Noise (from blasting)	Operational impacts Wildlife	Extent of land clearing	Rehabilitation	Bushfire	Values of surrounding property	Tourism decline	Traffic (general)	Degradation of road pavement	Traffic (increased quarry vehicles)	Traffic (safety)	Visual Amenity	General Amenity	Water sourcing / consumption	Ground water aquifers	sediment runoff	Previous EPA fine	Lack of community consultation	Management of crisis events	Clarity of extraction area	Resource is not for public projects	Blasting impact on horses	Vibration	Comment
8	14/11/2019	ICR20199109	2	Brett and Michelle Barney	Lots 5 & 6 Mt Lindesay Road (Cnr Cullen and Irby Streets), Tenterfield NSW 2372	bgbarney@ optusnet.com.au	Against	6					1				1		1												1					1										1	Concerns with, dust getting into tank water, management plans if dust levels are exceeded, contamination of road surfaces by trucks, vibrations, claims inaccurate data and more
9	15/11/2019	IDA90192575	2	John Rodwell and Marilyn Moballe	582 Bryans Gap Road, Tenterfield NSW 2372	Unknown	Against	6					1				1		1														1	1		1											Raises same points as group submission plus concern with traffic
10	14/11/2019	IDA20192520	2	Benjamin and Jessica Morrow	652 Mount Lindesay Road, Tenterfield NSW 2372	Unknown	Against	18		1	1	1	1	1		1	1		1	1	1	1		1					1	1	1					1					1			1			
11	15/11/2019	IDA20192568	1	Janice Michel	Unknown	Unknown	Against	9		1	1				1	1													1	1			1	1			1										Concerns surrounding silica dust.
12	12/11/2019	IDA20192494	2	Michael Barlow and Xin Wang	Unknown	Unknown	Against	10		1	1	1	1	1	1		1													1							1					1					
13	13/11/2019	IDA20192521	1	Peter Murphy	161 Logan Street, Tenterfield NSW 2372	Unknown	Against	2					1																	1																	
14	14/11/2019	IDA20192554	1	Bruce Sommerlad	1085 Black swamp Rd	Unknown	Against	6					1	1		1	1																1	1													
15	13/11/2019	IDA20192519	1	Christian Uhrig	Unknown	0439 640 512 Christian@ uhrig.com.au	Against	3					1			1		1																													
16	14/11/2019	IDA20192551	2	Marie and Fraser Ihle	315 B Old Ballandean Road, Tenterfield NSW 2372	mariefraser@ optusnet.com.au 02 6736 2794 0417 601 398	Against	6					1				1								1							1	1				1										
17	13/11/2019	IDA20192548	1	Raylee Delaney	Unknown	Unknown	Against	12		1	1		1												1	1			1	1			1				1	1		1	1						
18	12/11/2019	IDA20192509	2	David Tumbridge Robert Tumbridge	76 Welshpool Rd, Tenterfield Rd	Unknown	Against	23	1	1	1		1	1		1	1		1	1	1	1	1	1					1	1			1		1		1	1	1		1			1		1	
19	13/11/2019	IDA20192512	2	Don and Sandie Iedema	456 Mount Lindesay Road, Tenterfield NSW 2372	Unknown	Against	7					1			1					1								1				1			1					1						

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Table A1-1 (Cont'd)
Submissions Summary

									Land use conflict			Air quality						Noise							Flora and Fauna impacts				Economic		Traffic				Amenity		Water			Company Reputation		Other					
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20	23/10/2019	IDA20192510	2	Alan Russell Valerie Carmen Methven	109 & 110 Sommerlads Road, Tenterfield, NSW 2372	0418 101 483 0417 963 936	Against	6			1		1								1			1					1	1																	
21	7/11/2009	IDA20192508	2	R. Caldwell R.D. Caldwell	152 Leeches Gully Rd, Tenterfield NSW 2372	Unknown	Against	9					1				1		1	1				1		1							1						1							1	
22	12/11/2019	IDA20192497	1	Jenny McDougall	748 Mt Lindesay Road, Tenterfield NSW 2372	Unknown	Against	4					1					1												1			1														
23	12/11/2019	IDA20192493	1	Barbara and Perry Condrick	Unknown	Unknown	Against	5	1				1	1					1														1														
24	12/11/2019	IDA20192492	1	Beate Sommer	121 Rouse Street, Tenterfield Cottage, Tenterfield NSW 2372 50 Wood Street, Tenterfield NSW 2372 296 Wellington Lookout Road, Tenterfield NSW 2372	PO Box 395, Tenterfield NSW 2372 beate_sommer @bigpond.com 0408 247 965	Against	10		1	1	1	1				1									1			1	1							1					1					
25	12/11/2019	IDA20192489	1	Dianne and Murray Larsen	698 Bryans Gap Road, Tenterfield NSW 2372	02 6736 2995	Against	17	1	1	1		1	1	1	1	1					1		1					1	1			1			1	1					1				1	
26	11/11/2019	IDA20192488	2	Julia and Vince Sherry	305 Washpool Creek Road, Tenterfield NSW 2372	0417 459 737	Against	8		1	1		1			1													1	1						1									1		
27	11/11/2019	IDA20192483	1	Robyn Gray	50 Robinsons Lane, Tenterfield NSW 2372	Unknown	Against	6	1		1		1																1	1					1												
28	11/12/2019	IDA20192482	2	David Bunic Carol Jackson	676 Bryans Gap Road, Tenterfield NSW 2372	Unknown	Against	7					1	1							1			1								1	1													1	
29	8/11/2019	IDA20192469	2	G.E. Scholes L.A. Scholes	Unknown	Unknown	Against	7		1	1		1	1															1			1	1														
30	11/11/2019	IDA20192485	2	Deanne and Michael Eaton	209A Washpool Creek Road, Tenterfield NSW 2372	Unknown	Against	2			1		1																																		
31	5/11/2019	IDA20192453	2	Donna and Arthur Mullins	461 Mt Lindesay Road, Tenterfield NSW 2372	Unknown	Against	5					1	1										1					1				1														
32	4/11/2019	IDA20192430	2	Cheryl Haynes Karl Baxman	700 Bryans Gap Road, Tenterfield NSW 2372	Unknown	Against	7	1			1	1	1		1	1		1																												
Total			128					232	5	9	13	4	31	10	3	10	15	2	11	4	6	3	1	10	2	3	1	1	12	12	3	3	14	3	2	10	7	2	3	1	4	3	1	2	1	5	
										27			45			28					37					7			24			23			12			12		5				12			

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Appendix 2

Air Quality Assessment
prepared by
Northstar Air Quality Pty Ltd

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DARRYL MCCARTHY
CONSTRUCTIONS PTY LTD

ABN: 86 001 646 028

Dowe's Quarry

Air Quality Assessment

Prepared by

northstar
AIR QUALITY

March 2020

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DARRYL MCCARTHY CONSTRUCTIONS PTY LTD

ABN: 86 001 646 028

Air Quality Assessment

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Ref No: 19.1079.FR2V2

March 2020

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COMMONLY USED ACRONYMS

AADT	annual average daily traffic
ABS	Australian Bureau of Statistics
ACH	air changes per hour
AHD	Australian height datum
AQIA	air quality impact assessment
AQMS	air quality monitoring station
AWS	automated weather station
BoM	Bureau of Meteorology
°C	degrees Celsius
CO	carbon monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCP	Development Control Plan
DPE	NSW Department of Planning and Environment (from 1 July 2019 this body will form part of the NSW Department of Planning, Industry and Environment)
EETM	emission estimation technique manual
EPA	Environmental Protection Authority
FEL	front end loader
GDA	Geocentric Datum of Australia
GHG	greenhouse gas
GIS	geographical information system
K	kelvin (-273.15°C = 0 K, ±1°C = ±1 K)
kW	kilowatt
MGA	Map Grid of Australia
$mg \cdot m^{-3}$	milligram per cubic metre of air
$\mu g \cdot m^{-3}$	microgram per cubic metre of air

NCAA	National Clean Air Agreement
NEPM	National Environment Protection Measure
NO	nitric oxide
NO_X	oxides of nitrogen
NO_2	nitrogen dioxide
O_3	ozone
OEH	NSW Office of Environment and Heritage (from 1 July 2019 this body will form part of the NSW Department of Planning, Industry and Environment)
Pa	pascal
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter of 10 µm or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 µm or less
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SEE	Statement of Environmental Effects
SSD	State Significant Development
TAPM	The Air Pollution Model
TPM	total particulate matter
TSP	total suspended particulates
US EPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
VKT	vehicle kilometres travelled
VOC	volatile organic compounds

EXECUTIVE SUMMARY

A detailed air quality impact assessment has been performed to assess the potential impacts of operations to be performed as part of the ongoing and expanded Dowes Quarry operation.

The air quality impact assessment has been performed in accordance with the NSW Environment Protection Authority *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* document, and with due reference to the Secretary's Environmental Assessment Requirements, and NSW Environment Protection Authority requirements. Additional updates have been provided within this report to reflect NSW EPA and community comments on the original AQIA.

The air quality criteria applicable to the assessment have been adopted from Commonwealth and State legislation and guidance, and approval conditions. Criteria associated with silica have been adopted from Victorian Environment Protection Authority guidelines.

A modelling exercise has been performed to characterise the meteorological environment of the area surrounding the Quarry Site. A full description of the input data, modelling and validation of the outputs is presented in this report.

A detailed dispersion modelling exercise has been performed to characterise the predicted impacts from the proposed Quarry operation at a number of surrounding privately-owned receptors. A background air quality dataset has been adopted and added to those modelled impacts to determine a total, cumulative impact.

Details of the operations of the Quarry during an existing and three future operational stages have been used to generate emissions inventories characterising the operation of the Quarry. Dust control measures for emissions sources have been identified and adopted where appropriate.

For the purposes of providing 'worst-case' assessment results, with which to compare against the long and short-term air quality criteria, processing operations at the Quarry Site have been assumed to operate at a throughput of 230 000 t per annum, or a maximum of 5,000 t per day. These activity rates are significantly greater than those which are likely to be experienced as part of ongoing Quarry operations.

These conservative assumptions provide confidence that the impacts of the Quarry operation are not likely to be greater than those presented within this assessment.

<u>The dispersion modelling exercise indicates that the Quarry can operate across all stages of development with no exceedances of adopted air quality criteria.</u>

Three deposited dust gauges have been installed at the Quarry and it is proposed that continuous particulate matter monitoring would be implemented at two locations following approval. The air quality monitoring program will allow the Applicant to respond to any community complaints, monitor potential impacts from blasting at nearby residences, or provide ongoing information on any changes to the particulate environment resulting from Quarry operations. The locations for monitoring would be finalised during preparation of an update to the existing Air Quality Management Plan.

A blast management plan would be constructed prior to any expanded operations, and a brief management plan has been provided, which would be developed following approval.

A greenhouse gas assessment has been performed to examine the potential impacts of the operation of the Quarry relating to emissions of GHG. A quantitative assessment of emissions has been performed with emissions compared with total national and NSW greenhouse gas emissions for context.

Emissions associated with the Proposal are anticipated to represent a negligible percentage of Australian and NSW emissions totals. Nonetheless, greenhouse gas emissions are proposed to be reduced through the implementation of a maintenance program for all plant and equipment, and the investigation into using B5 fuel where possible.

1. INTRODUCTION

Darryl McCarthy Constructions Pty Ltd (the Applicant) operates the Dowe's Quarry (the Quarry) located approximately 8 kilometres (km) northeast of Tenterfield, in the New England region of NSW (refer to **Figure 1**). The Quarry is operated to recover quartzose material used to produce a range of ivory-coloured stone products used in the manufacture of decorative concrete and landscaping products.

The Quarry originally commenced operations in 1987 and is currently operating under a development consent originally issued by the Joint Regional Planning Panel on 19 March 2015 and subsequently amended on 21 January 2016. The Quarry has approval to extract up to 150 000 tonnes per annum (tpa) of quartzose material, disturb a total area of 6.7 hectares (ha) and store a range of fine materials generated during the processing of the material at the Applicant's processing plant at Sunnyside, located approximately 10 kilometres (km) northwest of Tenterfield (refer to **Figure 1**). The existing development consent allows a maximum of 28 truck-loads of quartzose material to be transported daily (principally Monday to Friday) from the Quarry to Sunnyside with no more than 120 truck-loads per week.

The Applicant has identified a further 4.8 million tonnes (t) of quartzose material adjacent to and beneath the current approved extraction area for which they are seeking development consent to extract. Overall, the additional activities would increase the total area of disturbance to approximately 16.4 ha of which 6.5 ha is remnant native vegetation which would need to be progressively cleared.

In addition to the above activities, the Applicant intends to increase the range of products produced from the quarried quartzose material which would also involve a proportion of the quartzose material being processed on site prior to its despatch to Sunnyside or directly to customers.

R.W. Corkery & Co. Pty. Ltd (RWC) has engaged Northstar Air Quality Pty Ltd (Northstar) on behalf of the Applicant to perform an air quality impact assessment (AQIA) and greenhouse gas (GHG) assessment to support the continued operation and extension of Dowe's Quarry (the Proposal).

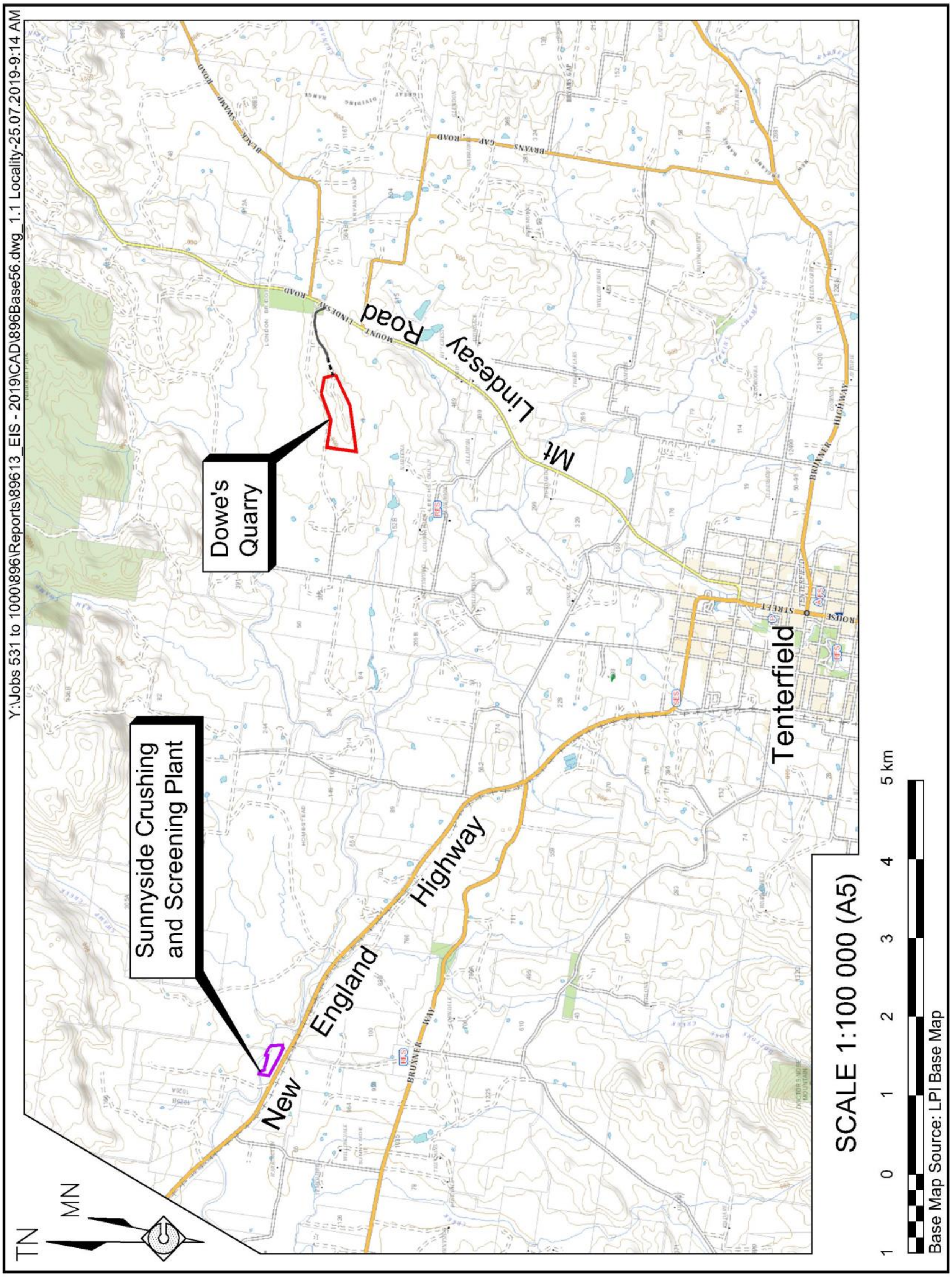
The AQIA presents an assessment of the impacts of the proposed operation of the Quarry and provides an assessment of the cumulative impacts of the Quarry with other relevant sources including general background conditions.

Of significance, the AQIA has been performed on the assumption that all 230 000 t of extracted material would be processed on-site, rather than being transported to Sunnyside for further processing. This represents a potential worst-case scenario and the actual long-term (annual average) air quality impacts are therefore likely to be significantly less than predicted.

Furthermore, in the assessment of short-term (24-hour) impacts, the processing plant has been assumed to be operating at full capacity (up to 5 000 t per day) which results in throughput being approximately 7 times greater than average. This assessment of campaign crushing at maximum possible rates provides confidence that the actual short-term particulate matter impacts are likely to be significantly less than predicted in this AQIA.

The GHG assessment provides an assessment of the potential GHG emissions during the operation of the Proposal.

Figure 1 Existing Locality Plan



1.1 ASSESSMENT REQUIREMENTS

The NSW Department of Planning and Environment (DP&E) (now Department of Planning, Industry and Environment [DPI&E]) has provided Secretary's Environmental Assessment Requirements (SEARs) for the Proposal (EAR number 1341), issue date 28 May 2019. The requirements of the SEARs in relation to air quality are presented in **Table 1**, with the relevant section(s) of this AQIA in which they have been addressed.

In the preparation of the SEARs, relevant government agencies have been consulted. The NSW Environment Protection Authority (EPA) responded on 22 May 2019 and has provided a list of requirements to be addressed in the preparation of the AQIA. These requirements are also listed in **Table 1**.

Table 1
Coverage of Issues Identified by Government Agencies for Consideration

Agency / Organisation	Paraphrased Relevant Requirement	Relevant Section(s)
Department of Planning & Environment (28/05/2019)	Include an assessment of the likely air quality impacts of the development in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW. The assessment is to give particular attention to potential dust impacts on any nearby private receivers due to construction activities, the operation of the quarry and/or road haulage;	This assessment Section 6
Environment Protection Authority (22/05/2019)	Assess and quantify air quality issues including dust generation from the operation on the surrounding landscape and community;	Section 6
	Demonstrate the proposal's ability to comply with the relevant regulatory framework, specifically the Protection of the Environment Operations (POEO) Act (1997) and the POEO (Clean Air) Regulation 2002. Particular consideration should be given to section 129 of the POEO Act concerning control of "offensive odour".	Section 3
	Include an air quality impact assessment (AQIA) carried out in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (2005),	Section 6
	Detail emission control techniques and practices that will be employed at the site and identify how the proposed control techniques and practices will meet the requirements of the POEO Act, POEO (Clean Air) Regulation and associated air quality limits or guideline criteria.	Section 6 Section 8 Annexure 3

It is noted that there are no specific requirements relating to the GHG assessment provided within the SEARs, although this has been performed in accordance with standard practice and requirements.

No specific assessment requirements have been provided by the Tenterfield Shire Council (Council) for the AQIA or GHG Assessment.

1.2 COMMENTS ON AQIA

An AQIA was submitted to support the EIS in September 2019. That AQIA was subject to detailed review by NSW EPA, who provided comments on the assessment. A number of submissions were also received from members of the surrounding community. A summary of those comments is presented in **Table 2**.

Table 2
Issues Raised in Submissions

Agency / Organisation	Paraphrased Relevant Comment
Environment Protection Authority (27/11/2019)	Model selection The AQIA is to be revised and modelling results prepared by using CALPUFF in No-Obs mode as per Section 2.3.1 of the Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved Methods and Assessments of Air Pollutant in NSW, Australia.
	Estimated emissions may have been underestimated Discrepancy in estimated emissions from loading and unloading activities Material contributions from the Sunnyside Facility Stage 3 activities Blasting activities
Mr & Mrs B Morrow Submission (09/11/2019) Group Submission (12/11/2019)	Concern for human health relating to silica, including cumulative impacts, and impacts on water supply
	Lack of management of blasting
	Concerns relating to modelling assessment Input meteorological data Lack of 3D modelling Background air quality data Accuracy of input data Suitability of emission factors Air quality monitoring

Detailed responses to each of the issues identified in **Table 2** are presented below.

NSW EPA comment

"*The AQIA is to be revised and modelling results prepared by using CALPUFF in No-Obs mode as per section 2.3.1 of the Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved Methods and Assessments of Air Pollutant in NSW Australia*"[1]

[1] https://www.epa.nsw.gov.au/~/media/EPA/Corporate%20Site/resources/air/CALPUFFModelGuidance.ashx

Response

The AQIA has been revised to include model results prepared using CALPUFF/CALMET as per the required guidance. For all scenarios modelled, an individual CALMET meteorological file has been generated, using input from TAPM (i.e. No-obs mode). These individual CALMET files were generated to reflect the changing structure of the extraction area.

NSW EPA comment

"*Modelling scenarios are to be revised to include a worst-case scenario that accounts for wind erosion from all potential stockpiles and the potential handling of materials from the Sunnyside facility"*

Response

All modelling scenarios have been updated to include all areas of wind erosion anticipated at the Quarry. These cover the extraction area, product stockpiling area and overburden and fines stockpile and emplacement. The total area of those areas has been included as a wind erosion source in the model, which is considered to be a conservative assumption, given that a portion of each of those areas would be either stabilised or non-active. Temporary stockpiles will now be included within the extraction area, and these have been assessed through the inclusion of the extraction area itself as a source of wind erosion.

NSW EPA comment

The AQIA is to be revised to include potential impacts from stage 3 operations in the modelling scenarios

Response

Stage 3 operations have been included in the AQIA.

NSW EPA comment

The AQIA is to be revised to include potential impacts from all expected air pollutants from blasting operations. In addition, modelling should be used to investigate any proposed conditions for blasting that minimise potential impacts

Response

An assessment of the potential impact of blast fume has been included within the assessment. In addition, although not anticipated to occur on the day of maximum activity at the Quarry, a blast has been modelled to occur during those periods of maximum activity rates, and the 24-hour maximum particulate modelling results include the impacts of blasting.

NSW EPA comment

The emissions inventory calculations are to be revised to account for the following:

i. differences in the material loading and unloading emissions between stages 1 and 2 of the project, when the assumptions, emission factors and activity rates are the same for both stages.

ii. the exclusion of emissions from the transport and handling of material from the Sunnyside facility.

Response

An error in the wind speed adopted in stage 1 and stage 2 operations was identified which was causing the identified discrepancy. The inventories have been updated accordingly.

A screening assessment of emission rates was performed to ensure that the total site emissions associated with modelled activities was greater than that from a scenario in which no processing occurred on-site, but where additional vehicle movements were required to transport fines from Sunnyside to the Quarry for unloading and storage. That screening indicated that the modelling performed does result in a worst-case assessment and that scenario has been maintained for all stages 1, 2 and 3 presented within this revised AQIA.

NSW EPA comment

The AQIA is to be revised to include tabulated cumulative impact assessment results for all particle size fractions and averaging periods.

Response

The previous AQIA included tabulated cumulative impact assessment results for all particle size fractions and averaging periods. This approach has been maintained in the performance of this updated AQIA.

Community submission

Concern for human health relating to silica, including cumulative impacts, and impacts on water supply.

Response

An assessment of potential concentrations of silica at all surrounding residential locations has been provided.

Community submission

Concerns regarding a perceived lack of management of blasting.

Response

An additional assessment of blast fume has been performed and impacts of particulate matter and oxides of nitrogen resulting from blasting events have been included in all modelling scenarios. A brief blast management plan has also been provided which would be updated following any approval. This plan would be required to be reviewed by relevant Government agencies prior to adoption.

Community submission

The community submissions indicated a number of concerns relating to the air quality modelling assessment. These concerns were regarding:

- *Input meteorological data*
- *Lack of 3D modelling*
- *Background air quality data*
- *Accuracy of input data*
- *Suitability of emission factors*
- *Air quality monitoring*

Response

NSW EPA has reviewed the AQIA in detail and have provided a number of comments relating to the performance of the assessment. Those comments have been addressed as outlined above. These deal with the majority of the community concerns, with the exception of air quality monitoring. Discussion regarding proposed air quality monitoring is provided in Section 8.1.

1.3 PREVIOUS AQIA FOR THE QUARRY

A semi-quantitative AQIA was performed to support an EIS for a development application in 2014 (ENVIRON, 2014) for the continued operation and extension of the Quarry. At that time, the Applicant proposed to extend the (then) existing extraction area by approximately 1.4 ha to the west producing up to 100 000 t of rock per year (averaging 60 000 t per year).

The AQIA (ENVIRON, 2014) provided a quantification of likely particulate emissions resulting from a range of activities at the Quarry and compared these total annual emissions with other similar operations for which quantitative modelling results had previously been generated. Dispersion model predictions associated with the most similar development in terms of throughput and calculated annual emissions were then reviewed and conclusions drawn as to the likely incremental PM_{10} and dust deposition levels which might be expected as a result of the ongoing Quarry operation and proposed extension.

Added to those derived concentrations was a regional background concentration which enabled conclusions to be drawn as to the likely cumulative particulate impacts which might be anticipated at surrounding non-Project related receptors. In conclusion (ENVIRON, 2014) determined that it was considered highly unlikely that cumulative impacts would exceed the NSW EPA 24-hour average PM_{10} assessment criterion of 50 $\mu g \cdot m^{-3}$ and further that the proposed development would be unlikely to adversely impact upon the local air quality environment.

The development application was approved on 21 January 2016.

The AQIA presented within this report provides a full quantitative assessment of the likely incremental and cumulative impacts anticipated during the Quarry operation.

2. THE PROJECT

2.1 PROJECT BACKGROUND

The Quarry Site is located on rural land within Lots 308 and 309 DP 751540, Lots 3 and 4 DP 42044 and Lots 239 and 260 DP 751540. Under the Proposal the Quarry Site would extend into Lots 1, 2 and 3 DP1092215. This land is owned by Mr Rod Dowe and leased by the Applicant.

The activities for which the Applicant is seeking development consent would involve the following (collectively, the Proposal):

- Ongoing extraction of quartzose rock within the existing extraction area and a 4.4 ha extension of the extraction area, producing up to 230 000 tpa.
- Campaign crushing and screening on site using mobile processing equipment. On-site processing would be undertaken in response to client requirements. All on-site materials processing is proposed to be performed within the extraction area (the pit).
- Ongoing transportation of fragmented and crushed rock to the State road network, (i.e. the New England Highway), for delivery to the Sunnyside Crushing and Screening Plant, and other destinations. Material would also continue to be delivered locally within Tenterfield for Council-managed road and infrastructure activities and directly to the local community.
- Ongoing transportation of material directly to end points of use, where further processing at the Sunnyside Crushing and Screening Plant is not required.
- Ongoing backloading of clay fines and crusher fines from the Sunnyside Plant to the Quarry;
- Progressive emplacement of overburden and fines within and adjacent to the extraction area.
- Progressive and final rehabilitation of the Quarry to develop a landform suitable for native vegetation conservation.

The proposed Quarry layout is illustrated in **Figure 2**. The principal components and the respective approximate areas of disturbance within the Quarry Site are as follows:

- Extraction area (Stage 1 – 6.9 ha, Stage 2 – 10.1 ha, Stage 3 – 11.4 ha)

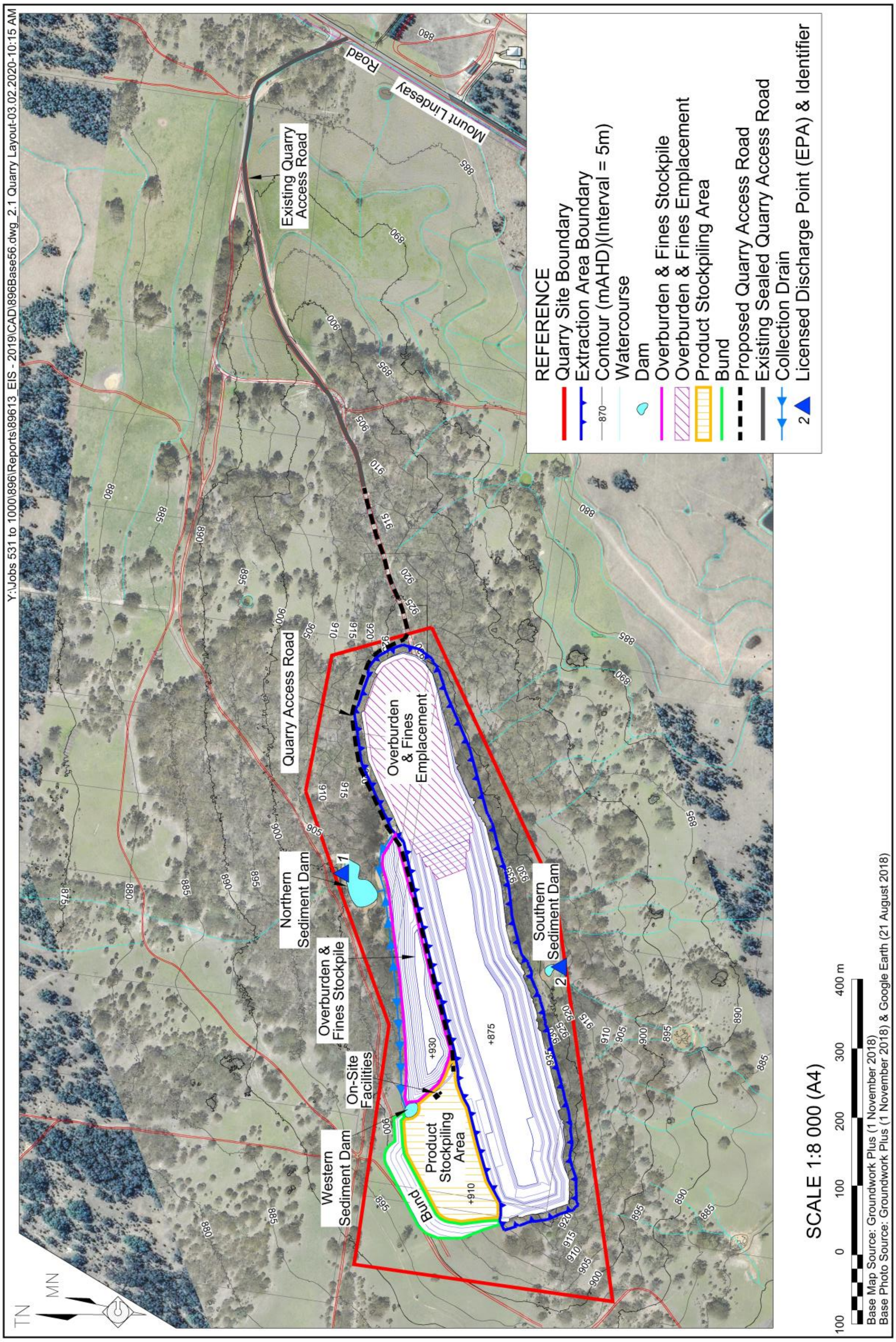
  The extraction area would be developed in three stages and would be centred on the quartzose material defined through the exploration drilling campaign undertaken by the Applicant.

  Processing of all materials is proposed to be performed within the extraction area in all future stages of development.

- Product stockpiling area (1.8 ha)

  The product stockpiling area (previously the processing area) would be located immediately to the northwest of the extraction area and would incorporate areas for the product stockpiles.

Figure 2 Proposed Quarry Layout



Source: RWC

- Bund (0.62 ha)

  A bund would be constructed to the north and west of the product stockpiling area principally to mitigate potential noise and visual impacts generated by operations. The bund would be constructed using overburden and topsoil stripped during the development of other Quarry components.

- Overburden and fines stockpile (Stage 1 – 3.2 ha, Stage 2 – 2.6 ha, Stage 3 – 1.6 ha)

  The overburden and fines stockpile would be progressively developed using overburden removed during extraction and fines backloaded from Sunnyside or produced on site. The overburden and fines stockpile would be located immediately to the north of the extraction area. No new material would be added to this area from midway through Stage 2 of operations. As the extraction area is developed to the north, material from the overburden and fines stockpile would be progressively relocated to the completed areas in the eastern section of the extraction area. This would allow for the extension of the extraction area to the north and west.

- Overburden and fines emplacement (Stage 2 – 1.9 ha, Stage 3 – 2.9 ha)

  The overburden and fines emplacement would be developed in the eastern section of the extraction area from midway through Stage 2 using material moved from the overburden and fines stockpile and overburden generated during the extension of the extraction area. It would be developed to an ultimate height of approximately 920 m AHD (effectively ground level).

- Quarry access road (1.7 km)

  The Quarry access road would provide long-term vehicular access to the product stockpiling area. An approximately 750 m portion of this road is paved from Mt Lindesay Road.

- Sediment dams (0.2 ha)

  The northern sediment dam is located to the north of the overburden and fines stockpile and would contain all surface water runoff from the overburden and fines stockpile and other disturbed areas to the north of the extraction area.

  The southern sediment dam is located to the south of the extraction and would contain all surface water runoff from disturbed areas to the south of the extraction area.

The total area to be designated as the Quarry Site would be approximately 26.8 ha of which the maximum area of disturbance would be 16.4 ha. Approximately 6.5 ha of remnant native vegetation would be disturbed during the development of the Quarry Site.

2.2 OVERVIEW AND PURPOSE

The purpose of the AQIA is to identify and quantify the potential air quality risks to human health or the natural environment from the operation of the Proposal and identify potential mitigation measures that may be required, in order to manage those risks to acceptable levels.

An important consideration for any AQIA is to identify and quantify the discrete impacts from the Proposal being assessed and place those potential impacts in context of the prevailing conditions at that location. In terms of air quality studies, that requirement includes a consideration of the general background conditions on a regional scale (performed by examination of available sources of air quality monitoring that may reasonably be compared to the Quarry Site location) and more localised emissions to air from more proximate activities that need to be considered in aggregation to the anticipated Proposal impacts. This consideration is typically called a 'cumulative impact assessment' and is a requirement of the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (NSW EPA, 2017).

The geographical scale of the required cumulative impact assessment depends on the nature of proposed activities at the site under assessment and the likely impact footprint of those emissions. Further discussion relating to likely cumulative impacts is provided in Section 4.4.

The aim of the GHG assessment is to provide an assessment of the potential GHG emissions during the operation of the Proposal and identify how those emissions may be managed in accordance with best practice.

2.3 SPECIFIC OPERATIONAL DETAILS

The specific operational details are succinctly presented in **Table 3**. The indicative site layout is presented in **Figure 2**.

Processing is not currently undertaken within the Quarry Site with all quartzose rock extracted from the Quarry transported to the New England Highway and then principally to the Sunnyside Crushing and Screening Plant or other destinations. The Applicant intends to increase the range of products produced from the quartzose material, which would also involve a proportion of the quartzose material being processed on site prior to its despatch to Sunnyside or directly to customers. On-site processing would produce a range of 5 mm to 24 mm crushed rock products and crusher dust/fines for use in a variety of construction and infrastructure applications. On-site processing is to occur within the extraction area (i.e. within the pit).

For the purposes of this AQIA, it has been assumed that all extracted material would be processed at the Quarry Site. The results of the assessment can therefore provide confidence that the operations can be performed at their maximum potential rates without resulting in adverse impacts on the surrounding environment.

Table 3
Indicative Key Proposal Components

Project Component	Summary Description
Extraction Method	Drill and blast in a three-stage extraction area covering up to approximately 6.9 ha for Stage 1, 10.1 ha for Stage 2 and 11.4 ha for Stage 3.
Resource	Quartzose rock in a wide (25 m to 50 m) lens.
Disturbance Area	Disturbance of approximately 16.4 ha.
Total Recoverable Resource	Approximately 4.8 million tonnes of quartzose rock (conservative estimate).
Annual Production	Up to 230 000 tonnes per year of quartzose rock.
Project Life	Up to 30 years.
Processing	Crushing and screening either on-site at a rate up to 470 tonnes per hour, or at the Sunnyside Crushing and Screening Plant or other destinations.
Product Storage	Temporary stockpiling of products in the product stockpiling area prior to loading and despatch. Stockpiles would generally contain between 5 000 t and 10 000 t of material.
Waste Management	Overburden and fines generated to be stored in overburden and fines stockpile to the north of the extraction area (Stage 1, Stage 2 and Stage 3), or in the overburden and fines emplacement within the extraction area (Stage 2 and Stage 3)
Hours of Operation	Extraction and processing operations 7:00am – 5:00pm Monday to Saturday Blasting 10:00am – 3:00pm Monday to Saturday Transport operations 7:00am – 5:00pm Monday to Friday Maintenance operations 24hrs Monday to Saturday
Equipment	Operations 1 x Hydraulic Drill Rig (Atlas Copco T35 or equivalent) – used typically one day per month for drilling blast holes. 2 x Excavator (Komatsu PC300 or equivalent) – permanently on site and used for loading trucks, clearing vegetation, soil removal, excavation of overburden and secondary breakage of oversize blasted rock. 1 x Haul Truck (22 m^3 / 40 t) – used periodically on site for transfer of raw material, soil and overburden. Processing 1 x Jaw Crusher (Kleemann MC120Z PRO or equivalent) 1 x Cone Crusher (Kleemann MC011 PRO or equivalent) 1 x Mobile Screen (Kleemann MC953 EVO or equivalent)

2.4 IDENTIFIED POTENTIAL FOR EMISSIONS TO AIR

The key emissions to air during the operational phase are considered to include:

- Particulate emissions from the extraction, processing and storage of the resource and product;
- Wheel-generated particulate emissions from the haulage of recovered and product materials on unpaved and paved road surfaces;
- Blasting emissions of particulate and oxides of nitrogen; and,
- Wind erosion of exposed surfaces.
- Emissions of blast fume (including particulates and oxides of nitrogen) may also be anticipated, and these impacts have been quantified and are presented in Section 6.4. Details of how blasts may be managed to minimise the potential impact of emissions to air are provided in Section 8.2.
- Emissions of greenhouse gases (GHG) would also be generated through the combustion of fuel in mobile plant and equipment during the operation of the Quarry. Emissions of GHG may also be generated through the off-site transport of product to markets and through employee vehicle use.

3. LEGISLATION, REGULATION AND GUIDANCE

As outlined in Section 2.4, the emissions of most concern during the operation of the Proposal will be particulate matter from vehicle movements, the operation of plant and machinery, and wind erosion. The following sections outline the Commonwealth and State air quality criteria relevant to those emissions. Also outlined are relevant legislation and guidance related to GHG emissions.

3.1 COMMONWEALTH AIR QUALITY STANDARDS AND REGULATIONS

3.1.1 National Environment Protection (Ambient Air Quality) Measure

- The *National Environment Protection (Ambient Air Quality) Measure* (Ambient Air Quality NEPM) was promulgated in July 1998 and established ambient air quality standards for six key pollutants across Australia and provides a standard method for monitoring and reporting on air quality. Air quality standards and performance monitoring goals for the six key air pollutants include:
  - Carbon monoxide (CO);
  - Lead (Pb);
  - Nitrogen dioxide (NO_2);
  - Particles (particulate matter with an aerodynamic equivalent diameter of 10 microns (µm) or less (PM_{10});
  - Photochemical oxidants, as ozone (O_3); and,
  - Sulphur dioxide (SO_2).

The Ambient Air Quality NEPM was varied in July 2003 to include advisory reporting standards for fine particulate matter with an aerodynamic equivalent diameter of 2.5 microns (µm) or less ($PM_{2.5}$) and in February 2016 (NEPC, 2016), introducing varied standards for PM_{10} and $PM_{2.5}$.

The air quality standards and goals as set out in the (revised) Ambient Air Quality NEPM for the pollutants considered within this assessment are presented in **Table 4**.

Table 4
National Environment Protection (Ambient Air Quality) Measure Standards and Goals

Pollutant	Averaging Period	Criterion	Allowable Exceedance per Year
Particulates (as PM_{10})	1 day	50 $\mu g \cdot m^{-3}$	None
	1 year	25 $\mu g \cdot m^{-3}$	None
Particulates (as $PM_{2.5}$)	1 day	25 $\mu g \cdot m^{-3}$	None
	1 year	8 $\mu g \cdot m^{-3}$	None
Nitrogen dioxide (NO_2)	1 hour	246 $\mu g \cdot m^{-3}$	1 day a year
	1 year	62 $\mu g \cdot m^{-3}$	None

3.1.2 National Clean Air Agreement

The National Clean Air Agreement (NCAA) was agreed by Australia's Environment Ministers on 15 December 2015. The NCAA establishes a framework and work plans for the development and implementation of various policies aimed at improving air quality across Australia.

Regarding air quality standards with relevance to this report, the Work Plan 2018-2020 of the NCAA sets an objective to review scientific evidence in relation to annual average PM_{10} standards.

The Work Plan 2015-2017 sought to strengthen particle reporting standards for PM_{10} and $PM_{2.5}$ which came into effect on 4 February 2016. These standards have been adopted as part of this assessment.

3.2 NSW AIR QUALITY STANDARDS AND REGULATIONS

3.2.1 NSW EPA Approved Methods

State air quality guidelines adopted by the NSW EPA are published in the '*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*' (the Approved Methods (NSW EPA, 2017)) which has been consulted during the preparation of this assessment report.

The Approved Methods lists the statutory methods that are to be used to model and assess emissions of criteria air pollutants from stationary sources in NSW. Section 7.1 of the Approved Methods clearly outlines the impact assessment criteria for the project.

The criteria listed in the Approved Methods are derived from a range of sources (including NHMRC, NEPC, DoE and WHO) and are the defining ambient air quality criteria for NSW. The standards adopted to protect members of the community from health impacts in NSW are presented in **Table 5** and these criteria have been applied within this AQIA.

Table 5
NSW EPA air quality standards and goals

Pollutant	Averaging period	Units	Criterion	Notes
Particulates (as PM_{10})	24 hours	$\mu g \cdot m^{-3}$ (a)	50	Numerically equivalent to the AAQ NEPM(b) standards and goals.
	1 year	$\mu g \cdot m^{-3}$	25	
Particulates (as $PM_{2.5}$)	24 hours	$\mu g \cdot m^{-3}$	25	
	1 year	$\mu g \cdot m^{-3}$	8	
Particulates (as TSP)	1 year	$\mu g \cdot m^{-3}$	90	
Particulates (as dust deposition)	1 year(c)	$g \cdot m^{-2} \cdot month^{-1}$	2	Assessed as insoluble solids as defined by AS 3580.10.1
	1 year(d)	$g \cdot m^{-2} \cdot month^{-1}$	4	
Nitrogen dioxide (NO_2)	1 hour	$\mu g \cdot m^{-3}$	246	Numerically equivalent to the AAQ NEPM(b) standards and goals.
	1 year	$\mu g \cdot m^{-3}$	62	

Notes: (a): micrograms per cubic metre of air (b): National Environment Protection (Ambient Air Quality) Measure
(c): maximum increase in deposited dust level (d): Maximum total deposited dust level

Although not required to be specifically assessed within the SEARs, it is understood that there is some community concern with regard to respirable crystalline silica. NSW EPA do not provide air quality criteria for this pollutant, although VIC EPA in their State Environmental Planning Policy (SEPP) Protocol for Environmental Management: Mining and Extractive Industries (PEM) (VIC EPA, 2007) do include a criterion for respirable crystalline silica (as $PM_{2.5}$) as 3 $\mu g \cdot m^{-3}$ (annual average), which has been adopted from the California EPA Office for Environmental Health Hazard Assessment Reference Exposure Levels. The maximum free silica content of the extracted material is approximately 98 % and to provide a conservative assessment of impacts has been assumed to be 100 %. Respirable crystalline silica is generally an occupational health and safety issue rather than an environmental issue when considering quarries of a similar nature to the Project. Respirable crystalline silica would be considered in the operation of the Site in regard to occupational health through consideration of occupational dust control measures.

3.2.2 NSW Statutory Frameworks

3.2.2.1 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations* (POEO) *Act* (1997) sets the statutory framework for managing air quality in NSW, including establishing the licensing scheme for major industrial premises and a range of air pollution offences and penalties.

Should the Proposal be approved, an updated Environment Protection Licence (EPL) would be issued which would contain a range of requirements related to minimisation of emissions from the Quarry Site, operations at which would be defined as a scheduled activity under the POEO Act.

As required to be considered by NSW EPA (refer Table 1), the POEO Act emphasises the importance of preventing 'offensive odour'. For reference, "offensive odour" is defined within the POEO Act as:

> *an odour:*
> *(a) that, by reason of its strength, nature, duration, character or quality, or the time at which it is emitted, or any other circumstances:*
> *(i) is harmful to (or is likely to be harmful to) a person who is outside the premises from which it is emitted, or*
> *(ii) interferes unreasonably with (or is likely to interfere unreasonably with) the comfort or repose of a person who is outside the premises from which it is emitted, or*
> *(b) that is of a strength, nature, duration, character or quality prescribed by the regulations or that is emitted at a time, or in other circumstances, prescribed by the regulations.*

Operations at the Quarry Site have limited capacity to emit odour. Given the distances between the Quarry Site and nearest receptor locations (refer Section 4.2), any emitted odour is unlikely to cause adverse impact at those locations and odour has not been considered further within this AQIA.

3.2.2.2 Protection of the Environment (Clean Air) Regulation 2010

The Protection of the Environment (Clean Air) Regulation 2010 (POEO (Clean Air) Regulation) sets standards of concentration for emissions to air from both scheduled and non-scheduled activities. For the activities to be performed at the Quarry Site, the POEO (Clean Air) Regulation covers emissions from motor vehicles and motor vehicle fuels and also provides general standards of concentration for scheduled premises which are presented in **Table 6** for the pollutants of relevance to this assessment.

Table 6
POEO (Clean Air) Regulation – Standards of Concentration

Air Impurity	Activity	Standard of Concentration (Group 6)
Solid particles (total)	Any activity or plant (except as listed below)	50 $mg \cdot m^{-3}$
	Any crushing, grinding, separating or materials handling activity	20 $mg \cdot m^{-3}$

Further to the requirements in **Table 6**, Part 4 Clause 15 of the POEO (Clean Air) Regulation requires that motor vehicles do not emit excessive air impurities which may be visible for a period of more than 10-seconds when determined in accordance with the relevant standard.

As part of the Proposal operation, all vehicles, plant and equipment to be used either at the Quarry Site or to transport materials to and from the Quarry Site, will be maintained regularly and in accordance with manufacturers' requirements. No burning of materials would be performed as part of the ongoing operation of the Proposal.

3.3 GREENHOUSE GAS LEGISLATION AND GUIDANCE

The Australian Government Clean Energy Regulator administers schemes legislated by the Australian Government for measuring, managing, reducing or offsetting Australia's carbon emissions.

Schemes administered by the Clean Energy Regulator include:

- National Greenhouse and Energy Reporting Scheme, under the *National Greenhouse and Energy Reporting Act (2007).*
- Emissions Reduction Fund, under the *Carbon Credits (Carbon Farming Initiative) Act (2011)*.
- Renewable Energy Target, under the *Renewable Energy (Electricity) Act (2000)*.
- Australian National Registry of Emissions Units, under the *Australian National Registry of Emissions Units Act (2011)*.

3.3.1 National Greenhouse and Energy Reporting Scheme

The National Greenhouse and Energy Reporting (NGER) scheme, established by the *National Greenhouse and Energy Reporting Act* (2007) (NGER Act), is a national framework for reporting and disseminating company information about greenhouse gas emissions, energy production, energy consumption and other information specified under NGER legislation.

The objectives of the NGER scheme are to:

- inform government policy.
- inform the Australian public.
- help meet Australia's international reporting obligations.
- assist Commonwealth, state and territory government programmes and activities.
- avoid duplication of similar reporting requirements in the states and territories.

Further information on the NGER scheme, specifically the definitions of various scopes and types of GHG emissions which have also been adopted for the purposes of this assessment, is provided in Section 5.2.

3.3.2 Relevant NSW Legislation

There is no specific GHG legislation administered within NSW. The NGER scheme (and other identified Commonwealth schemes in Section 3.3.1) forms the applicable legislation within NSW.

3.3.3 Guidance

The GHG accounting and reporting principles adopted within this GHG assessment are based on the following financial accounting and reporting standards:

- Australian Government Department of the Environment, Australian National Greenhouse Accounts, National Greenhouse Accounts Factors, July 2018 (DoE, 2018).
- The World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) GHG Protocol: A Corporate Accounting and Report Standard (WRI, 2004).
- ISO 14064-1:2006 (Greenhouse Gases – Part 1: Specification with guidance at the organisation level for quantification and reporting of GHG emissions and removal).
- ISO 14064-2:2006 (Greenhouse Gases – Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of GHG emission reductions or removal enhancements).
- ISO 14064-3:2006 (Greenhouse Gases – Part 3: Specification with guidance for the validation and verification of GHG assertions) guidelines (internationally accepted best practice).

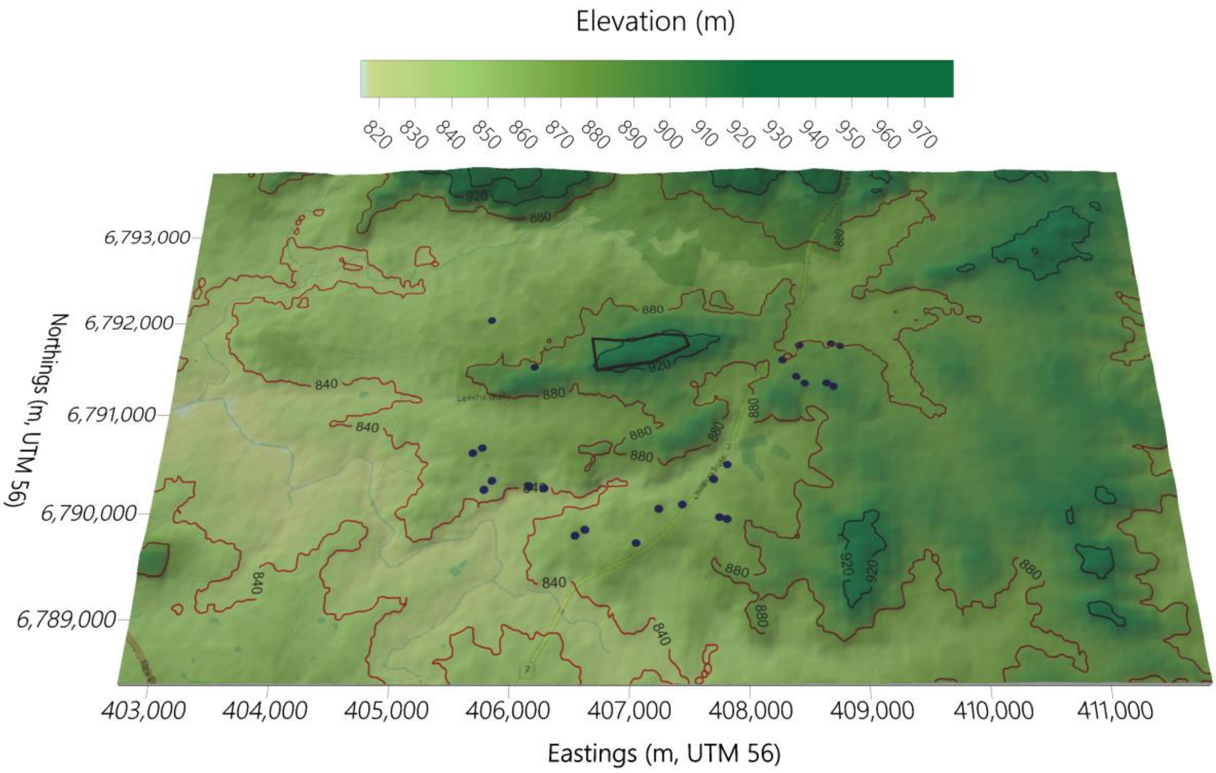
4. EXISTING CONDITIONS

This section provides an overview and description of the existing environment surrounding the Quarry Site.

4.1 TOPOGRAPHY

The Quarry Site is located in an area of relatively flat plain topography containing some ridge formations, as illustrated in **Figure 3**. The Quarry Site is located at an elevation of approximately 890 m to 945 m Australian Height Datum (AHD), however it is noted that the ridge that the Quarry Site occupies has been partially excavated by the Applicant and has since reduced in elevation.

Figure 3 Topography Surrounding the Quarry Site



Source: Northstar Air Quality, derived from NASA SRTM 1-arc second data

Figure 3 additionally shows the relevant site boundary and sensitive receptor locations (see Section 4.2). These are illustrated in the figure to show how topography varies between the Quarry Site and the various sensitive receptor locations used in the AQIA, which is an important consideration in AQIA studies. The topography between the sensitive receptor locations and the Quarry Site can be considered 'uncomplicated' (in AQIA study terms).

4.2 SENSITIVE LAND USE AND LAND OWNERSHIP

AQIA studies typically use a desk-top mapping study to identify 'discrete receptor locations', or 'sensitive receptors', which are intended to represent a selection of locations that may be susceptible to changes in air quality. In broad terms, the identification of sensitive receptors refers to places at which humans may be present for a period representative of the averaging period for the pollutant being assessed.

Typically, these locations are identified as residential properties although other sensitive land uses may include schools, medical centres, places of employment, recreational areas or ecologically sensitive locations.

It is important to note that the selection of discrete receptor locations is not intended to represent a fully inclusive selection of all sensitive receptors across the study area. The location selected should be considered to be representative of its location and may be reasonably assumed to be representative of the immediate environs.

It is further noted that in addition to the identified 'discrete' receptor locations, the entire modelling area is gridded with 'uniform' receptor locations that are used to generate graphical plots of the predicted impacts, and as such the non-inclusion of a location sensitive to changes in air quality does not render the AQIA invalid, or otherwise incapable of assessing those potential risks.

In accordance with the requirements of the Approved Methods (NSW EPA, 2017), a number of receptor locations representing surrounding residences have been identified and these receptors adopted for use within this AQIA are presented in **Table 7** and illustrated in **Figure 4**. **Figure 4** also presents the Lot boundaries associated with the relevant Lot owners.

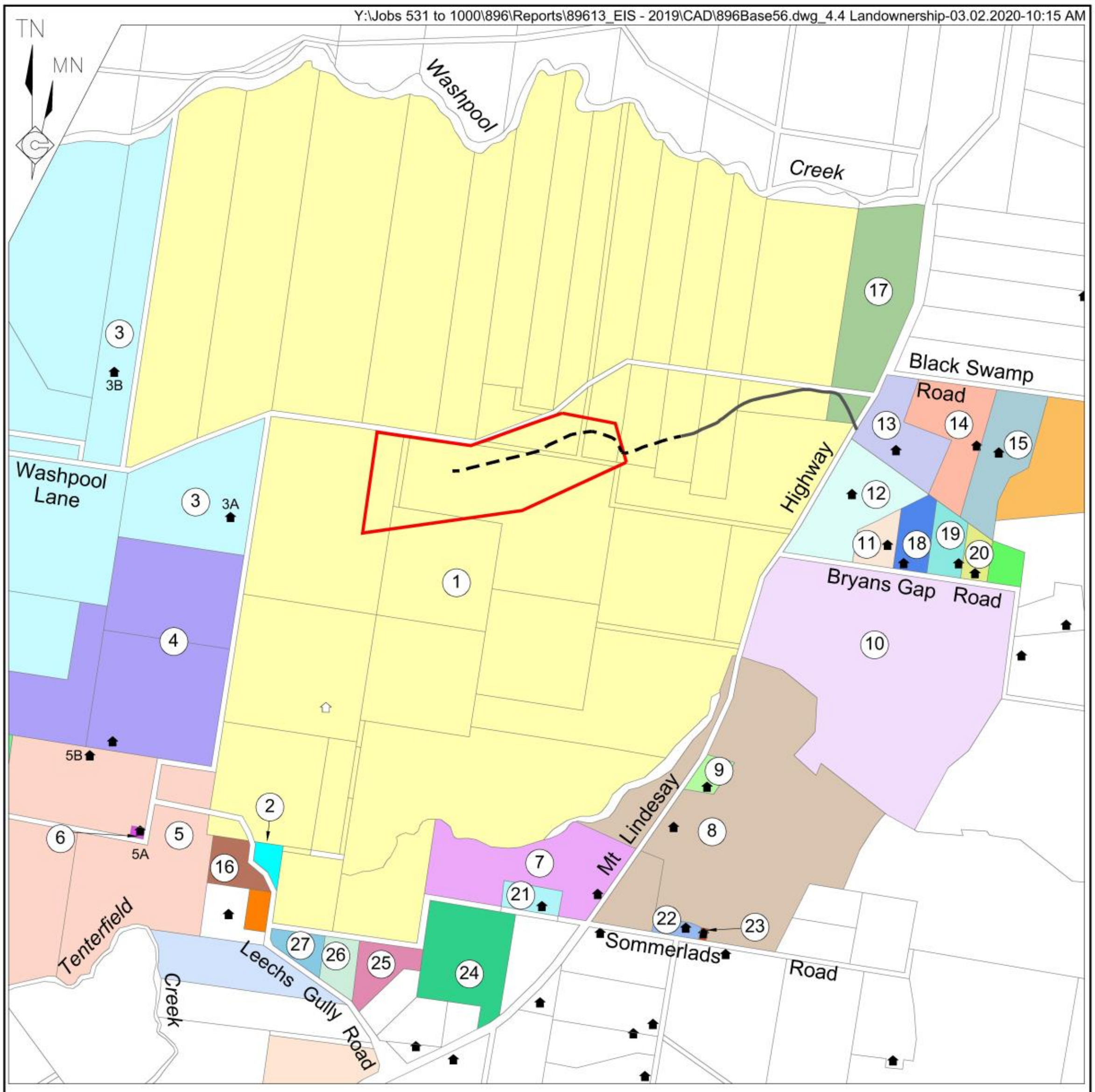
The land surrounding the Site is predominantly zoned as 'primary production' (RU1) in the Tenterfield Local Environmental Plan (2013). To the north-west of the Quarry the land is zoned as 'national parks and nature reserves' (E1) in the suburb of Boonoo Boonoo.

Table 7
Sensitive Receptor Locations

Landowner Ref. No.	Landowner	Co-ordinates UTM		Distance from Site boundary (km)
		m E	m S	
2	JP Jacquet, MJ Bielski	406 218	6 790 241	1.3
3A	RF & LL Tumbridge	406 085	6 791 470	0.6
3B	RF & LL Tumbridge	405 655	6 792 008	1.0
4	RL Caldwell	405 648	6 790 638	1.3
5A	GL & JM Smith	405 684	6 790 223	1.6
5B	GL & JM Smith	405 564	6 790 586	1.4
6	DB Weir, GR Smith, WF Marsden	405 750	6 790 308	1.4
7	JM Dowe	407 446	6 790 072	1.5
8	RB & CA Sewell	407 727	6 790 321	1.3
9	MJ & NJ Lewis, RB & CA Sewell	407 851	6 790 470	1.2
11	KH Baxman & CC Haynes	408 506	6 791 372	1.0
12	BL & JA Morrow	408 388	6 791 555	0.9
13	RM Ibbett, S Ibbett	408 551	6 791 718	1.0
14	GM O'Reilley, MP Watt	408 850	6 791 735	1.3
15	AJ & BW Lawrence	408 932	6 791 710	1.4
16	PJ Della & TM Curry	406 084	6 790 258	1.3
18	MN & DN Larsen	408 580	6 791 299	1.1
19	GB & DK Phillips	408 783	6 791 298	1.3
20	CA Jackson, D Bunic	408 844	6 791 262	1.4
21	DM & AJ Mullins	407 239	6 790 027	1.5
22	JP & SL Doyle	407 772	6 789 947	1.7
23	LD Merchant	407 838	6 789 927	1.7
24	Harewood Investments Pty Limited	407 041	6 789 697	1.8
25	D Puglisi	406 593	6 789 829	1.6
26	BJ & RL Tom	406 508	6 789 770	1.7

Source: RWC

Figure 4 Land Owner – Sensitive Receptor Locations



Ref	Landowner	Ref	Landowner
1	RSH & MO Dowe	15	AJ & BW Lawrence
2	JP Jacquet, MJ Bielski	16	PJ Della & TM Curry
3A,3B	RF & LL Tumbridge	17	The State of New South Wales
4	RL Caldwell	18	MN & DN Larsen
5A,5B	GL & JM Smith	19	GB & DK Phillips
6	DB Weir, GR Smith, WF Marsden	20	CA Jackson, D Bunic
7	JM Dowe	21	DM & AJ Mullins
8	RB & CA Sewell	22	JP & SL Doyle
9	MJ & NJ Lewis, RB & CA Sewell	23	LD Merchant
10	KR & LA Willcocks	24	Harewood Investments Pty Limited
11	KH Baxman & CC Haynes	25	D Puglisi
12	BL & JA Morrow	26	BJ & RL Tom
13	RM Ibbett, S Ibbett	27	BJ Tom & Brad Tom Investments Pty Ltd
14	GM O'Reilly, MP Watt		

Source: RWC

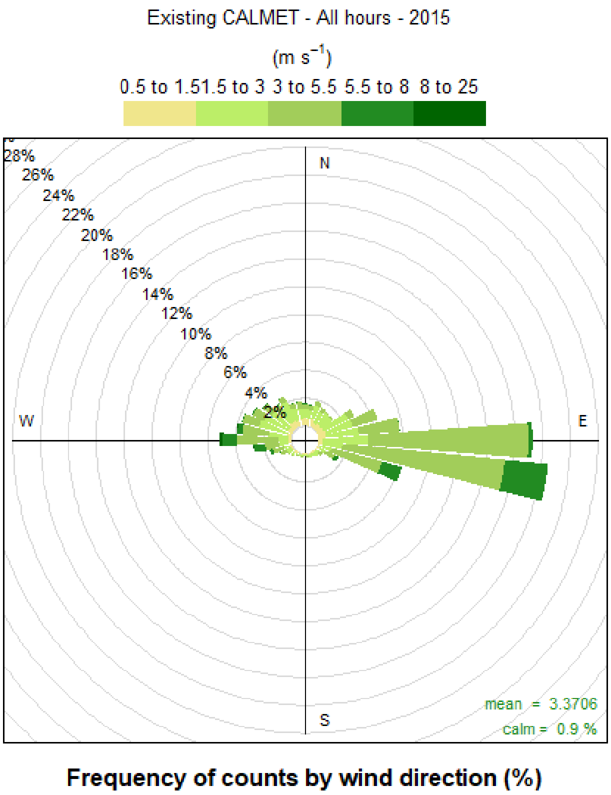
4.3 METEOROLOGY

The meteorology experienced within a given area can influence the generation (in the case of wind dependent emission sources), dispersion, transport and eventual fate of pollutants in the atmosphere. The meteorological conditions in the area of the Quarry Site have been characterised using data collected by the Australian Government Bureau of Meteorology (BoM) at surrounding Automatic Weather Stations (AWS). A full description and analysis are presented in **Annexure 1**.

To provide a characterisation of the meteorology which would be expected at the Quarry Site, a meteorological modelling exercise has been performed. A full description of the modelling exercise, methods and input data used, and a validation exercise using available observational data is also presented in **Annexure 1**. The meteorological modelling has considered the changes in topography between an operational scenario reflecting existing operations, and through the proposed Stage 1, 2 and 3. Full details are presented in **Annexure 1**.

A summary of the wind conditions predicted by the CALMET model under an existing extraction area design at the Quarry Site for 2015 is presented in **Figure 5**. These data have been used in the dispersion modelling exercise, as described in Section 5.1. All CALMET generated wind roses are similar under all extraction area designs, for all modelled scenarios.

Figure 5 CALMET Predicted Wind Conditions – Quarry Site, 2015



4.4 AIR QUALITY

The air quality experienced at any location will be a result of emissions generated by natural and anthropogenic sources on a variety of scales (local, regional and global). The relative contributions of sources at each of these scales to the air quality at a given location will vary based on a wide number of factors including the type, location, proximity and strength of the emission source(s), prevailing meteorology, land uses and other factors affecting the generation, dispersion and fate of those emissions.

When assessing the potential impact of any particular source of emissions on the air quality at a location, the impact of all other sources of an individual pollutant should also be assessed. This 'background' air quality will vary depending on the pollutants to be assessed and can often be characterised by using representative air quality monitoring data.

The NSW DPI&E operates air quality monitoring stations (AQMS) in regional centres and as part of the Rural Air Quality Monitoring Network. In regard to this AQIA study, the Quarry is not located in close proximity to any AQMS. The locations of the closest available sources of air quality monitoring data are presented in **Table 8** and in **Figure 6**. **Table 8** additionally provides a summary of the scope of monitoring performed at each AQMS and whether it was operating during 2015 (contemporaneous with the meteorological period used in the dispersion modelling component of this AQIA).

Table 8
Closest DPI&E AQMS to the Quarry Site

AQMS Location	Distance to Site (km)	Screening Parameters				
		Network(1)	2015 Data	Measurements		
				PM_{10}	$PM_{2.5}$	TSP
Armidale	171.3	RAQMN	×	×	×	✓
Moree	220.5	RAQMN	×	×	×	✓
Tamworth	258.2	Regional	✓	✓	×	×
Narrabri	259.7	Regional	✓	✓	×	×
Gunnedah	579.2	Regional	✓	✓	×	×
Gunnedah South East	282.5	RAQMN	×	×	×	✓

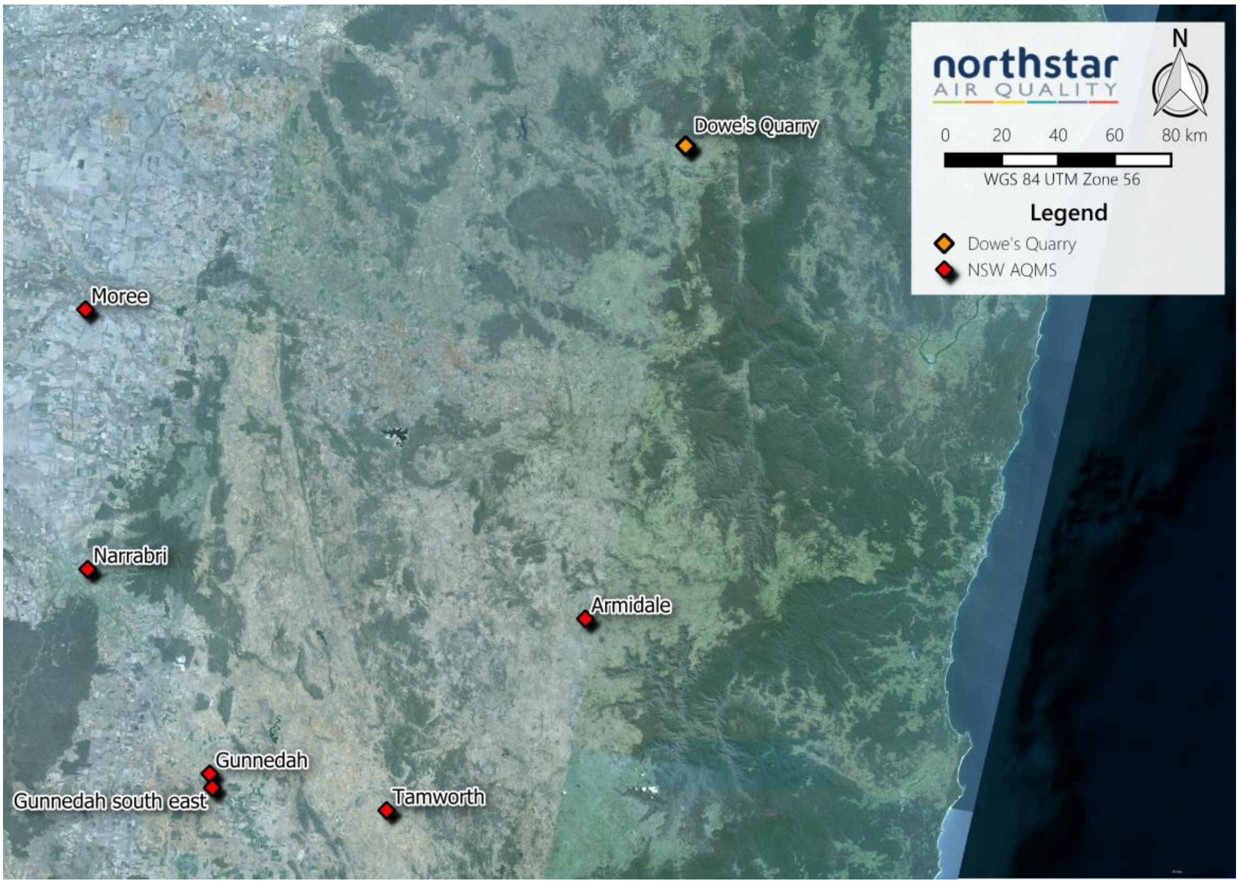
Note: (1) RAQMN – Regional Air Quality Monitoring Network, Regional – Regional centre

The closest identified AQMS to the Quarry Site with continuous data which is able to be adopted for use in this AQIA is located at Tamworth. It is noted that the AQMS located at Armidale and Moree, both of which are more proximate to the Quarry, do not measure PM_{10}, which is of critical importance to this AQIA.

None of the identified AQMS measured $PM_{2.5}$ in 2015, and subsequently proxy data has been calculated from the ratio of measured PM_{10} : $PM_{2.5}$ data from Tamworth in 2016. This ratio was then applied to the Tamworth PM_{10} data from 2015 to determine the proxy $PM_{2.5}$ data for 2015.

Annexure 2 provides a detailed assessment of the background air quality monitoring data collected at Tamworth AQMS.

Figure 6 Air quality monitoring stations surrounding the Quarry Site



Source: Northstar Air Quality Pty Ltd

It is noted that as part of the NSW DPI&E Regional Air Quality Monitoring Network there are AQMS that measure TSP, however access to that data is not available at the time of reporting. Based upon long-term historic monitoring data, a numerical relationship between TSP and PM_{10} measurements has been established for the Lower Hunter, Sydney Metropolitan and Illawarra regions of NSW. Although not site specific, based upon the available data measured within the Lower Hunter region, a relationship between ambient concentrations of TSP : PM_{10} of 2.3404 : 1 has been used to approximate background annual average TSP concentrations. This relationship is established and is used frequently in AQIA to approximate background annual average TSP concentrations (see **Annexure 2**).

A detailed summary of the background air quality is presented in **Annexure 2**, and a summary of the air quality monitoring data used in this assessment is presented in **Table 9**.

It is noted that the Approved Methods (NSW EPA, 2017) requires that background concentrations as provided above are added to dispersion model predictions to determine a 'cumulative' impact.

The AQIA has been performed to assess the contribution of the Proposal to the air quality of the surrounding area. A full discussion of how the Proposal impacts upon air quality is presented in Section 6.

Table 9
Summary of background air quality used in the AQIA

Pollutant	Averaging Period	Value	Data Source
PM_{10}	24-hour	Hourly varying	Tamworth 2015
	Annual	14.1 µg·m^{-3}	Tamworth 2015
$PM_{2.5}$	24-hour	Hourly varying	Proxy calculated from Tamworth PM_{10}:$PM_{2.5}$ ratio 2016
	Annual	7.2 µg·m^{-3}	Proxy calculated from Tamworth PM_{10}:$PM_{2.5}$ ratio 2016
TSP	Annual	33.0 µg·m^{-3}	Estimated on TSP:PM_{10} ratio of 2.3404:1 for Tamworth 2015
Dust Deposition	Monthly	2 g·m^{-2}·month^{-1}	Approved Methods

4.5 POTENTIAL FOR CUMULATIVE IMPACTS

A desktop study has been performed to determine the potential for cumulative impacts from similar particulate generating operations conducted in proximity to the Quarry. Environment Protection Licences (EPL) currently in effect within the area of Tenterfield LGA have been reviewed[2] and ten operations with a current EPL (other than the Quarry) were identified as summarised in **Table 10** and shown in **Figure 7**. From review of **Table 10** and as shown in **Figure 7**, the closest activity to the Quarry Site which may result in cumulative impacts is the crushing and screening plant operated by the Applicant (Sunnyside, EPL number 20664) which is located approximately 7.5 km to the west. Given the large separation distance, cumulative impacts associated with this activity have been considered to be negligible.

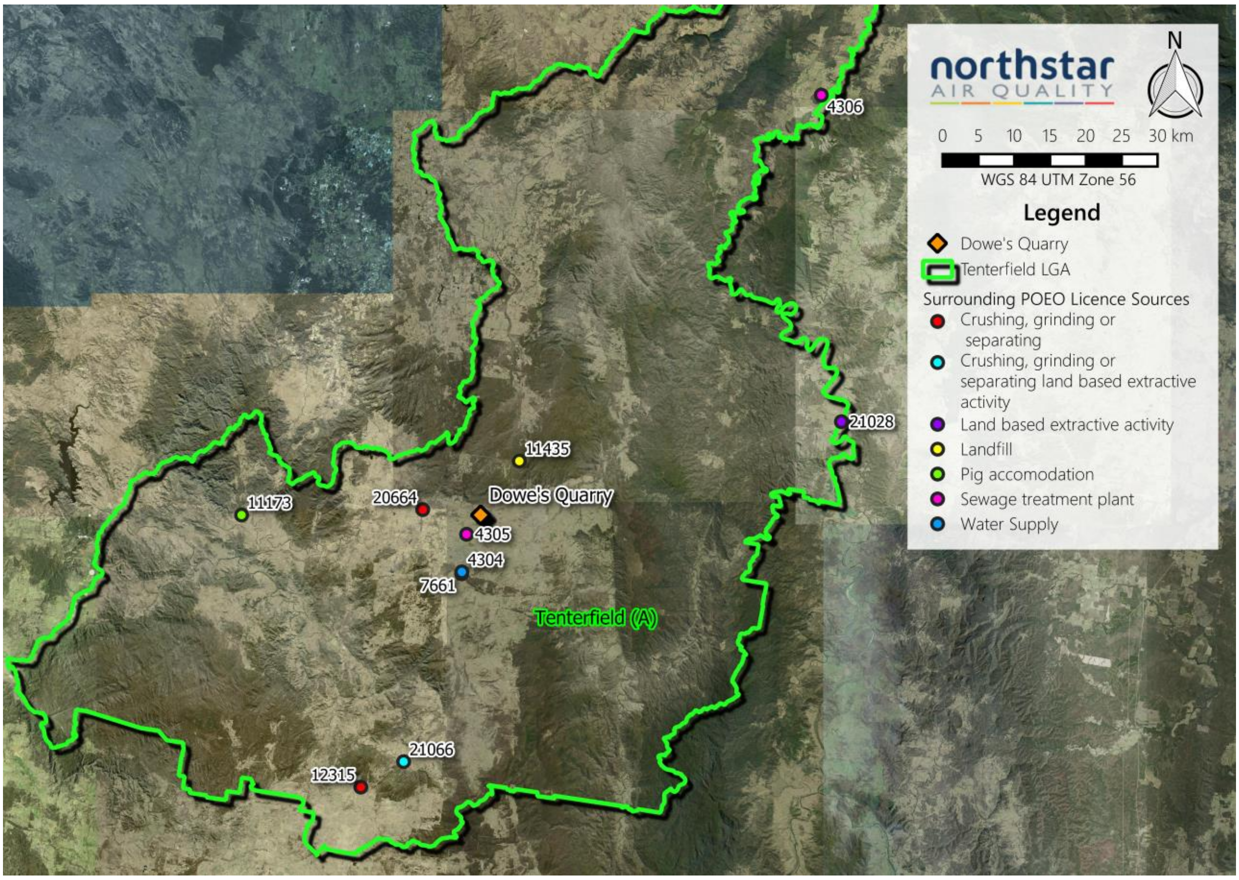
As discussed in the previous AQIA performed for the Quarry (ENVIRON, 2014) emissions from industrial sources in the Tenterfield LGA would not likely cause significant direct cumulative impacts with emissions from the Quarry, but would contribute to regional air pollution levels. These have been considered through the adoption of background air quality data as discussed in Section 4.4.

Table 10
Summary of Activities in Tenterfield LGA Currently Licenced under the POEO Act

EPL Number	Licence Holder	Activity Type (as defined in the EPL)	Distance from Quarry (km)
4305	Tenterfield Shire Council	Sewage treatment processing - small plants	2.9
4304	Tenterfield Shire Council	Miscellaneous licensed discharge to waters (supply works)	8.1
7661	Tenterfield Shire Council	Other activities (water supply dam)	8.3
11435	Tenterfield Shire Council	Waste disposal by application to land	8.9
11173	John Parmjit Singh	Pig accommodation	32.9
20664	Darryl McCarthy Constructions Pty Ltd	Crushing, grinding or separating	7.5
21066	Georgiou Group Pty Ltd	Crushing, grinding or separating, land based extractive activity (including blasting)	35.8
12315	Wayne McCarthy Earthmoving Pty Ltd	Crushing, grinding or separating	41.2
21028	Delaney Civil Pty Ltd	Land based extractive activity	51.5
4306	Tenterfield Shire Council	Sewage treatment processing - small plants	75.1

[2] https://apps.epa.nsw.gov.au/prpoeoapp/

Figure 7 Locations of Activities in Tenterfield LGA Currently Licenced under the POEO Act



Source: Northstar Air Quality Pty Ltd

4.6 GREENHOUSE GAS

Emissions of GHG are tracked by the Commonwealth of Australia via the Australian National Greenhouse Accounts program. This program, and the reports and data submitted as part of the program, fulfils Australia's international and domestic reporting requirements. Carbon emission totals by State and Territory by year and by sector are reported in the 'State and Territory Greenhouse Gas Inventories' report each year.

These data are used to:

- meet Australia's reporting commitments under the United Nations Framework Convention on Climate Change (UNFCCC);
- track progress against Australia's emission reduction commitments; and,
- inform policy makers and the public.

Data from the 2017 report for Australia (DEE, 2019a) and NSW (DEE, 2019b) have been obtained for the purposes of this GHG assessment. These reports are the most recent available at the time of reporting.

Emissions of GHG from Australia in 2017 across all economic sectors were 530.8 Mt carbon dioxide equivalent (CO_2-e). Emissions from the quarrying industry sector (including metal ore and non-metallic mineral mining and quarrying) accounted for 8.3 Mt CO_2-e, or 1.6 % of total emissions (DEE, 2019b).

State and Territory shares of national emissions (including emissions and removals from land use, land use change and forestry (LULCF) activities) comprised:

- 24.7 % from New South Wales;
- 30.3 % from Queensland;
- 20.7 % from Victoria;
- 16.6 % from Western Australia;
- 4.1 % from South Australia;
- 3.1 % from the Northern Territory
- 0.2 % from Tasmania;
- 0.2 % from the Australian Capital Territory (a partial estimate only, as some sectors are included within NSW); and,
- 0.01 % from External Territories.

GHG emissions in NSW in 2017 were 131.5 Mt CO_2-e with emissions from the mining sector (no information on quarrying available) being 17.2 Mt CO_2-e, or 13.1 % (DEE, 2019b).

5. APPROACH TO ASSESSMENT

5.1 AIR QUALITY ASSESSMENT

The following provides a brief description of the methodology used to assess the potential air quality impacts resulting from the operation of the Project.

As described in Section 2.4, the key emissions to air anticipated during the operation of the Project are:

- Particulate emissions from the clearance of vegetation;
- Particulate emissions from the extraction, processing and storage of the resource;
- Wheel-generated particulate emissions from the haulage of recovered and product materials on unpaved and paved road surfaces;
- Blasting emissions of particulate and oxides of nitrogen; and,
- Wind erosion of exposed surfaces.

The calculation of emissions of particulate matter from these processes is discussed in detail in **Annexure 3**.

A quantitative assessment has been performed to assess the impact of these emissions on surrounding sensitive receptor locations.

5.1.1 Modelling Approach

A dispersion modelling assessment has been performed using the NSW EPA approved CALPUFF atmospheric dispersion model. The modelling has been performed in CALPUFF 3-dimensional (3-D) mode using a no-obs (no observations) approach, as recommended in Barclay & Scire (2011).

The generation of appropriate meteorological data is discussed in detail in **Annexure 1**. Meteorological modelling using The Air Pollution Model (TAPM, v 4.0.5) and CALMET has been performed to predict the meteorological parameters required for input to CALPUFF.

TAPM predicts wind speed and direction, temperature, pressure, water vapour, cloud, rain water and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate site-specific hourly meteorological observations at user-defined levels within the atmosphere.

In the simplest terms, CALMET is a meteorological model that develops hourly wind and temperature fields on a three-dimensional gridded domain. Associated two-dimensional fields such as mixing height, surface characteristics, and dispersion properties are also included in the file produced by CALMET.

CALPUFF is a transport and dispersion model that advects "puffs" of material emitted from modelled sources (refer **Annexure 3**), simulating dispersion and transformation processes along the way. The primary output files from CALPUFF contain either hourly concentrations or deposition fluxes evaluated at selected receptor locations.

CALPOST is used to process the CALPUFF output files, producing tabulations that summarise the results of the simulation (refer Section 6) (Scire, Strimaitis, & Yamartino, 2000).

In March 2011, NSW OEH (now part of DPI&E) published generic guidance and optimal settings associated with the CALPUFF modelling system for inclusion in the Approved Methods (Barclay & Scire, 2011). These guidelines and settings have been considered in the performance of this assessment.

5.1.2 Modelling Scenarios

An assessment of the impacts of the operation of activities at the Quarry Site has been performed which characterises the likely day-to-day operation of the Proposal, approximating average and likely maximum operational characteristics which are appropriate to assess against longer term (annual average) and shorter term (24-hour, 1-hour) criteria for particulate matter and nitrogen dioxide (respectively).

Three operational scenarios have been selected for dispersion modelling. Full emissions inventories for each modelled operation at each stage of operation are provided in **Annexure 3**. Additionally, a scenario reflecting the current operations at the Quarry Site have been characterised and subject to an assessment using a dispersion modelling technique.

No assessment of potential impacts associated with construction has been performed. Construction activities will be limited to the construction of the product stockpiling area pad and bund through cut and fill with material sourced from existing overburden stockpiles. Given that the long and short term impacts associated with particulate matter have been assessed on the assumption that the processing plant would be operating at a throughput of 230 000 tpa, or 5 000 t·day-1, respectively, it is considered that these scenarios appropriately cover any movement and placement of material used to construct the product stockpiling area.

The Quarry Site layout during both existing operations, and Stage 1, Stage 2, and Stage 3 of proposed operations is presented in **Figure 8**, **Figure 9**, **Figure 10**, and **Figure 11**, respectively.

The modelling scenarios provide an indication of the air quality impacts of the activities being performed as part of the Proposal. Added to these impacts are those associated with regional background air quality (refer Section 4.4) which together represent the air quality which may be expected within the area surrounding the Quarry Site.

Figure 8 Existing Operations

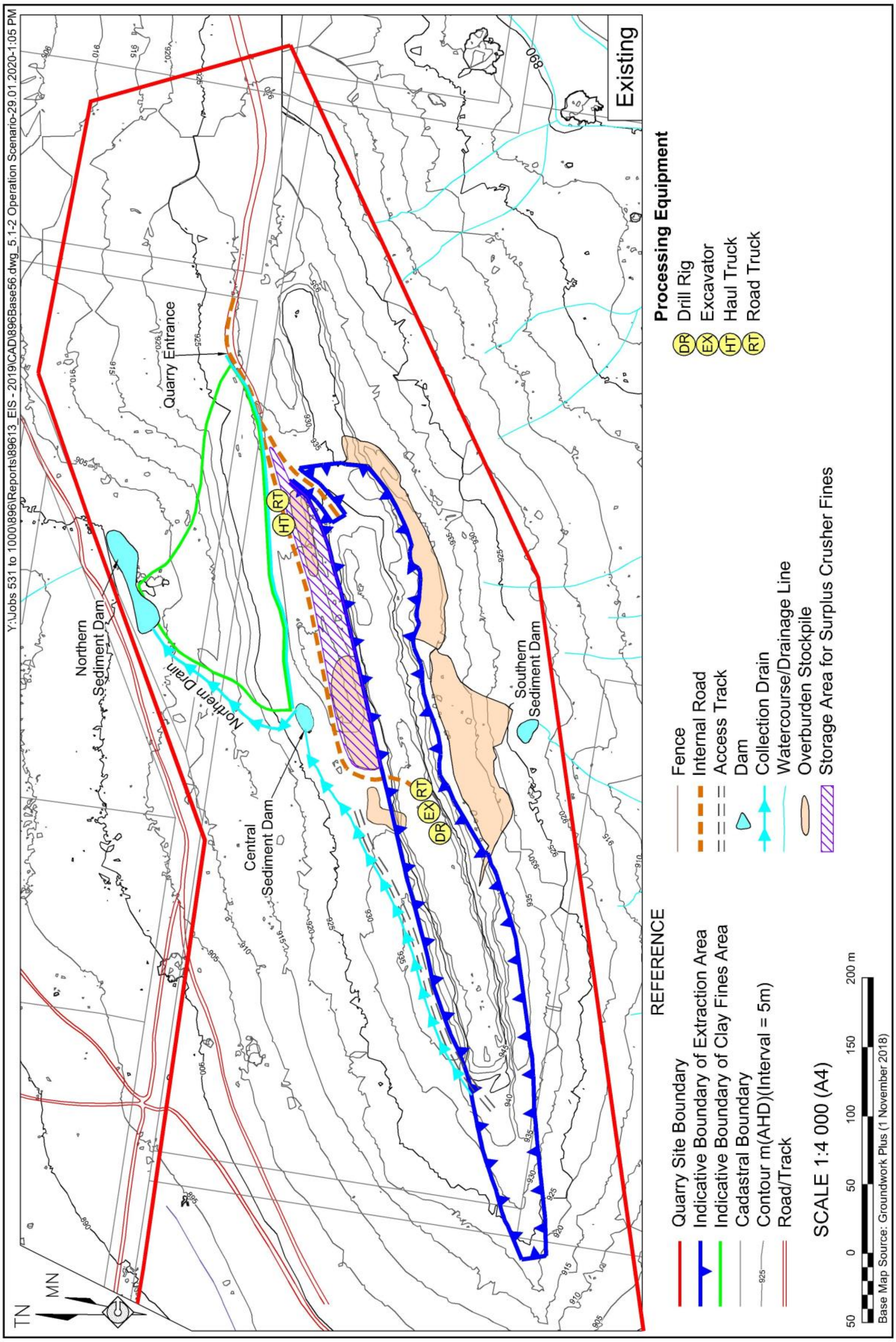


Figure 9 Stage 1 Operations

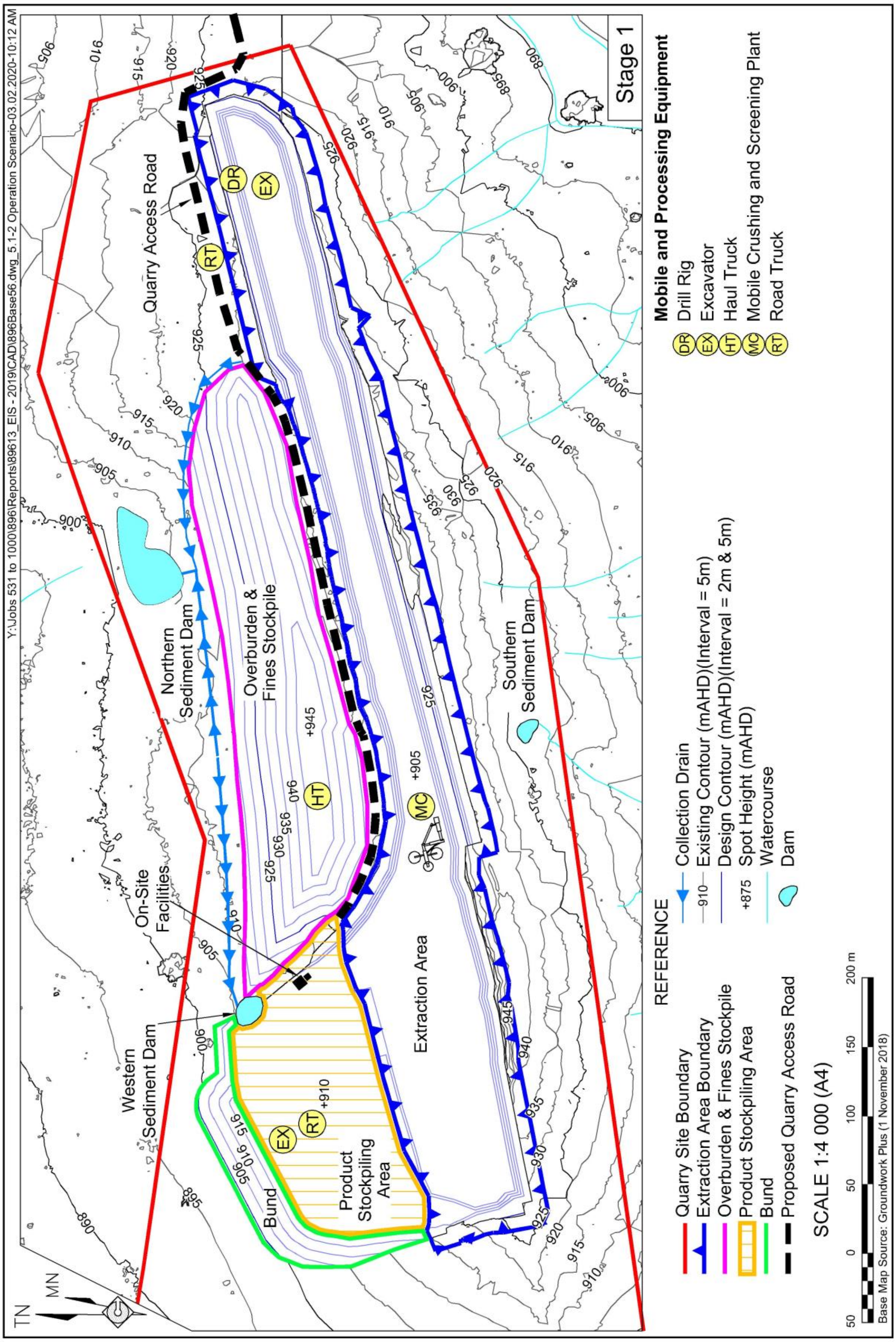


Figure 10 Stage 2 Operations

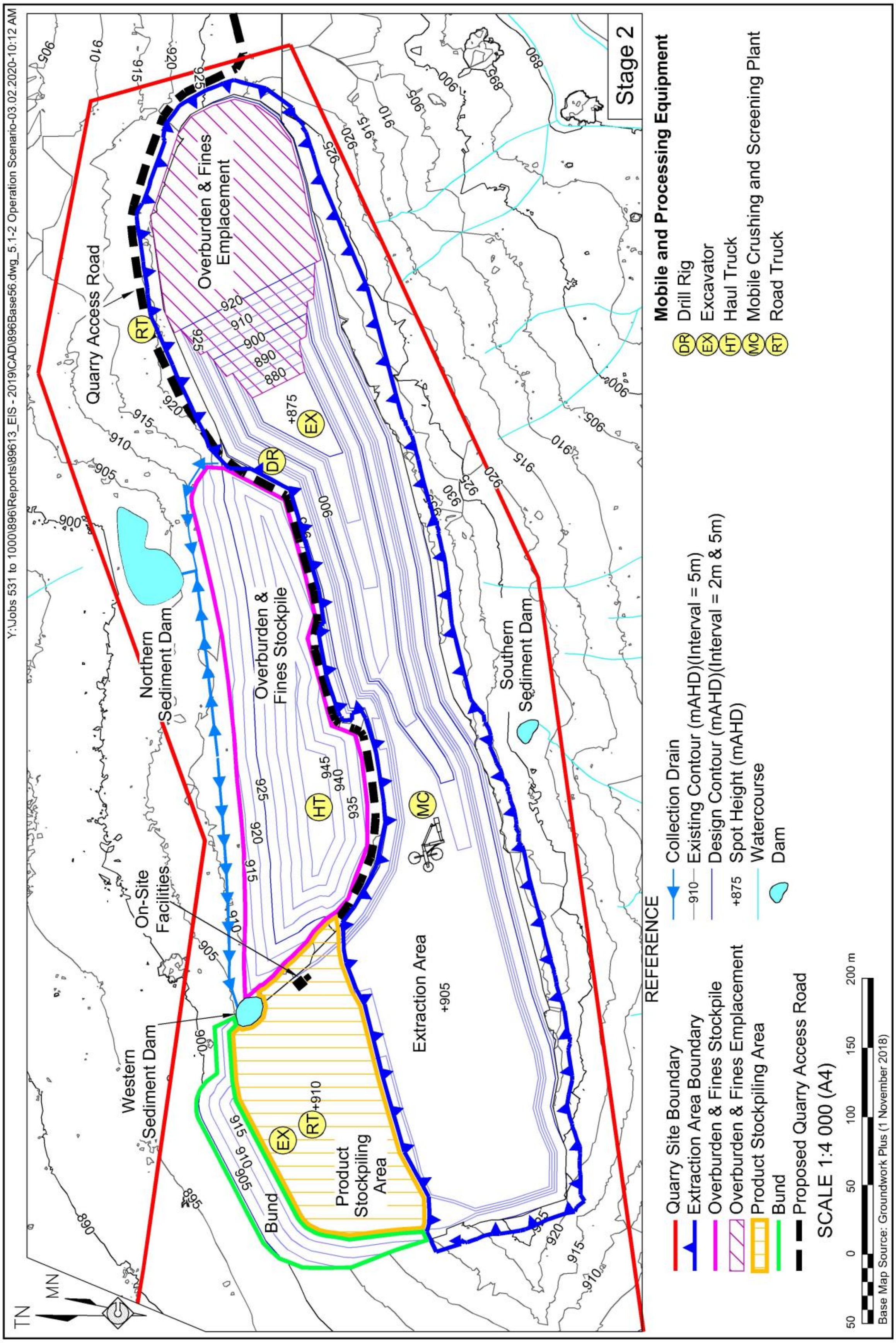
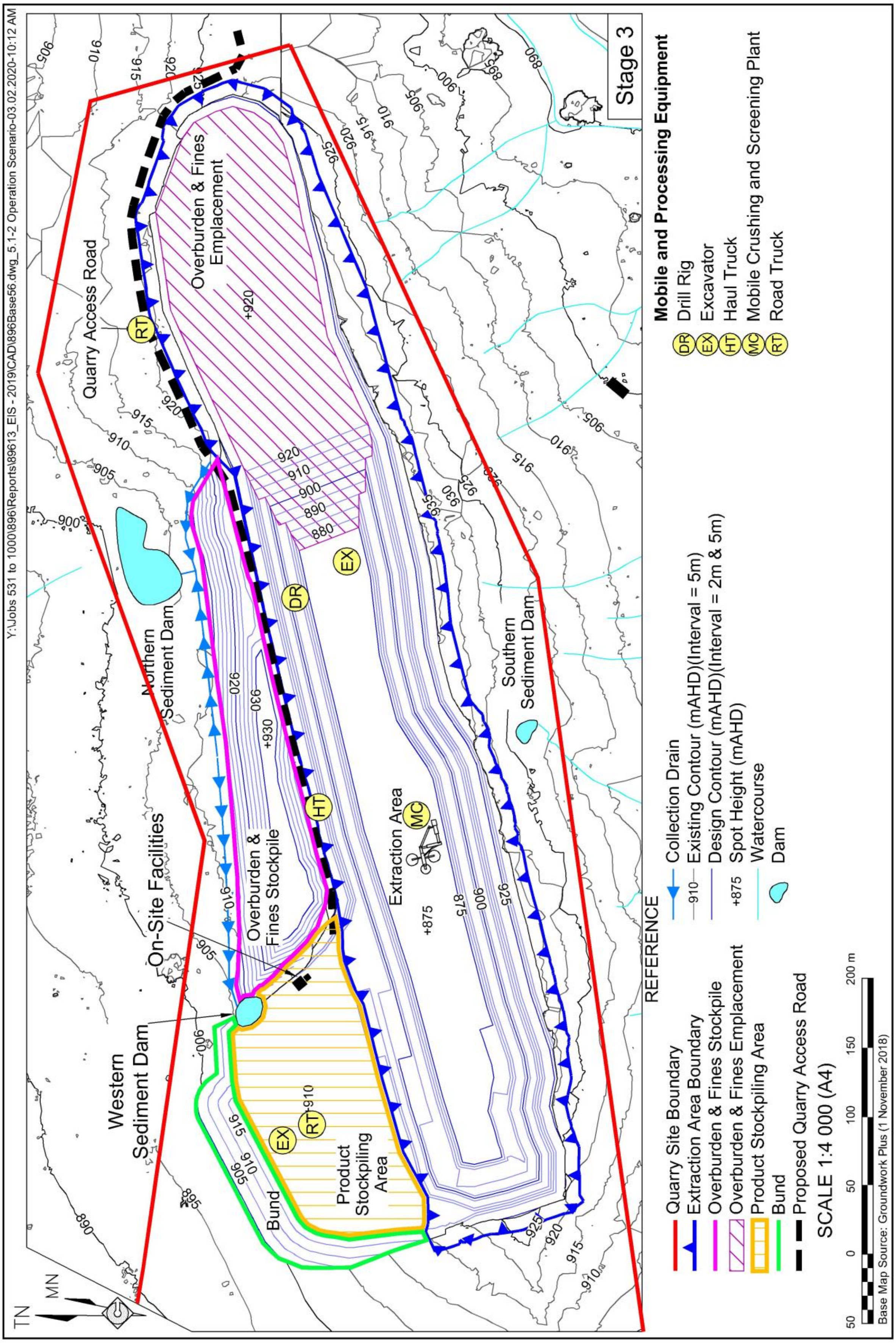


Figure 11 Stage 3 Operations



5.1.3 Model Set Up

The following section outlines the dispersion model set-up and includes details of modelled source characteristics, source locations etcetera to provide full transparency in the modelling performed.

A detailed discussion of the generation and validation of meteorological data used in dispersion modelling is provided in **Annexure 1**.

In relation to the CALPUFF modelling performed as part of this AQIA, two of the three sources types have been used. Volume sources have been used to characterise emissions from drilling, blasting, materials handling, haulage routes, and materials processing. Area sources have been used to characterise emissions from sources of wind erosion such as the extraction area, overburden and fines emplacement area, overburden and fines stockpile and product stockpiling area (including product stockpiles). Point sources (i.e. stack emissions) have not been used as there are no such sources proposed at the Quarry Site during any stage of development.

Presented in **Table 11** are the source characteristics adopted for each source type across each modelling scenario. The *sigma y* and *sigma z* values provide an initial estimation of the horizontal and vertical spread of the modelled plume, respectively.

Table 11
Source Characteristics – CALPUFF Modelling – All Scenarios

Source	Parameter		
	Height (m AGL)	**Sigma Y (m)**	**Sigma Z (m)**
Volume: Excavator, drilling, truck loading/unloading, crushing, screening	2	1.16	2
Volume: Transport of materials around Quarry Site in haul trucks	2	1.16	2
Volume: Transport of materials from Quarry Site in road trucks	3.65	28.6	3.4
Volume: Blasting	2	1.16	2
Area: Wind erosion	0	-	0

5.2 GREENHOUSE GAS ASSESSMENT

The Greenhouse Gas Assessment has been performed with reference to:

- Australian Government Department of the Environment, Australian National Greenhouse Accounts, National Greenhouse Accounts Factors, July 2018 (DoE, 2018);
- The World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) GHG Protocol: A Corporate Accounting and Report Standard (WRI, 2004);

- ISO 14064-1:2006 (Greenhouse Gases – Part 1: Specification with guidance at the organisation level for quantification and reporting of GHG emissions and removal;
- ISO 14064-2:2006 (Greenhouse Gases – Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of GHG emission reductions or removal enhancements); and,
- ISO 14064-3:2006 (Greenhouse Gases – Part 3: Specification with guidance for the validation and verification of GHG assertions) guidelines (internationally accepted best practice).

The purpose of the GHG assessment is to examine the potential impacts of the operation of the Project relating to emissions of GHG. A quantitative assessment of emissions is performed with direct emissions compared with total national and NSW GHG emissions for context (refer Section 4.6).

The scope of the GHG assessment is to provide a quantitative assessment of GHG emissions arising from the operation of the Proposal. This report does not provide a definitive quantification of GHG emissions arising from the Proposal but provides the general context of the likely quantum of emissions.

Opportunities for reduction of GHG emissions are discussed.

5.2.1 Emission Types

The Australian Government Department of the Environment (DoE) document, "National Greenhouse Accounts Factors" Workbook (NGA Factors) (DoE, 2018) defines two types of GHG emissions (see **Table 12**), namely 'direct' and 'indirect'. This assessment considers both direct emissions and indirect emissions resulting from the Proposal operation.

Table 12
Greenhouse Gas Emission Types

Emission Type	Definition
Direct	Produced from sources within the boundary of an organisation and as a result of that organisation's activities (e.g. consumption of fuel in on-site vehicles)
Indirect	Generated in the wider economy as a consequence of an organisation's activities (particularly from its demand for goods and services), but which are physically produced by the activities of another organisation (e.g. consumption of purchased electricity).
Note: Adapted from NGA Factors Workbook (DoE, 2018)	

5.2.2 Emission Scopes

The NGA Factors (DoE, 2018) identifies two 'scopes' of emissions for GHG accounting and reporting purposes as shown in **Table 13**.

Table 13
Greenhouse Gas Emission Scopes

Emission Scope	**Definition**
Scope 1	Direct (or point-source) emission factors give the kilograms of carbon dioxide equivalent (CO_2-e) emitted per unit of activity at the point of emission release (i.e. fuel use, energy use, manufacturing process activity, mining activity, on-site waste disposal, etc.). These factors are used to calculate Scope 1 emissions.
Scope 2	Indirect emission factors are used to calculate Scope 2 emissions from the generation of the electricity purchased and consumed by an organisation as kilograms of CO_2-e per unit of electricity consumed. Scope 2 emissions are physically produced by the burning of fuels (coal, natural gas, etc.) at the power station.
Note: Adapted from NGA Factors Workbook (DoE, 2018)	

Electricity is to be generated at the Quarry Site through the use of a generator operated on diesel fuel and therefore Scope 2 emissions have not been considered further within this assessment.

A third scope of emissions, Scope 3 Emissions, are also recognised in some GHG assessments. The Greenhouse Gas Protocol (GHG Protocol) (WRI, 2004) defines Scope 3 emissions as "other indirect GHG emissions":

> *"Scope 3 is an optional reporting category that allows for the treatment of all other indirect emissions. Scope 3 emissions are a consequence of the activities of the company but occur from sources not owned or controlled by the company. Some examples of Scope 3 activities are extraction and production of purchased materials; transportation of purchased fuels; and use of sold products and services."*

Scope 3 emissions related to the extraction and transport of fuels, and the use of fuels in employee transport have been considered.

Emissions associated with the transport of materials to and from the Quarry Site are considered in this assessment as Scope 1 emissions as they are under the operational control of the Applicant.

5.2.3 Source Identification and Boundary Definition

The geographical boundary set for the GHG assessment covers the Quarry Site but also includes the transport of materials from the Quarry Site to and from Sunnyside.

All Scope 1 and Scope 3 emissions within the defined boundary have been identified and reported as far as possible.

5.2.4 Emission Source Identification

The GHG emission sources associated with the existing operations and the operation of the Project have been identified through review of the activities as described in Section 2.4.

The activities/operations being performed as part of the Proposal which have the potential to result in emissions of GHG are presented in **Table 14**. Emissions of GHG resulting from land clearance have not been estimated, given that the Quarry Site will be rehabilitated at the end of the extraction period.

Table 14
Greenhouse Gas Emission Sources

Proposal Component	Scope	Emission Source Description
Consumption of diesel fuel in mobile plant and equipment at the Quarry Site	1,3	Emissions from combustion of fuel (scope 1) Emissions associated with extraction and processing of fuel (scope 3)
Consumption of diesel fuel / unleaded fuel for material transport purposes	1,3	Emissions from combustion of fuel (scope 1) Emissions associated with extraction and processing of fuel (scope 3)
Consumption of diesel fuel / unleaded fuel for employee transport purposes	3	Emissions associated with the extraction and processing of fuels

5.2.5 Emissions Estimation

Emissions of GHG from each of the sources identified in **Table 14** have been calculated using activity data for each source per annum (e.g. kL diesel fuel) and the relevant emission factor for each source.

The assumptions used in the calculation of activity data for each emissions source are presented below. Emission factors are presented in the following section.

5.2.5.1 Activity Data

Information relating to the quantities of diesel and unleaded fuel used as part of the Proposal have been provided by the Applicant. In the calculation of certain values, assumptions have been made based on the levels of activity at the Quarry Site. These data and assumptions are outlined in **Table 15**.

Table 15
Calculated Activity Data

Project Component	Assumptions	Activity	Units
Consumption of diesel fuel in mobile plant and equipment at the Quarry Site	Information provided by the Applicant indicates the diesel fuel use to be 20 000 L per month which includes diesel used in a camping style generator for power generation	240	$kL \cdot annum^{-1}$
Consumption of diesel fuel / unleaded fuel for employee transport purposes	Eight full-time equivalent positions to be generated by the Quarry (including 2 to 3 truck drivers). Assume employees reside in Tenterfield (20 km as a two-way journey) 312 days per year 10.6 L per 100km fuel efficiency (DEE, 2017a)	5.3	$kL \cdot annum^{-1}$
Consumption of diesel fuel / unleaded fuel for material transport purposes	Laden trucks to travel 15.15 km to Sunnyside and 13.6 km on return (28.75 km total) Up to 4 600 return trips each year (230 000 / 50 t capacity) 56.3 L per 100 km fuel efficiency (ABS, 2017)	74.5	$kL \cdot annum^{-1}$

5.2.6 Emission Factors

Emissions factors used for the assessment of GHG emissions associated with existing operations and the operation of the Project have been sourced from the NGA Factors (DoE, 2018) (refer to **Table 16**).

Table 16
Greenhouse Gas Emission Factors

Emission Scope	Emission Source	Emission Factor	Energy Content Factor
Scope 1	Diesel fuel for mobile plant and equipment	70.2 kg CO_2-e GJ^{-1}	38.6 $GJ \cdot kL^{-1}$
	Diesel fuel for material transport	70.5 kg CO_2-e GJ^{-1}	38.6 $GJ \cdot kL^{-1}$
Scope 3	Diesel fuel for mobile plant and equipment	3.6 kg CO_2-e GJ^{-1}	38.6 $GJ \cdot kL^{-1}$
	Unleaded fuel for employee transport	3.6 kg CO_2-e GJ^{-1}	34.2 $GJ \cdot kL^{-1}$
	Diesel fuel for material transport	3.6 kg CO_2-e GJ^{-1}	38.6 $GJ \cdot kL^{-1}$

6. AIR QUALITY IMPACT ASSESSMENT

The following section provides the results of the dispersion modelling exercise described in Section 5.1, with all input data provided in **Annexure 3**. Results are provided as tables which provide the predicted concentrations at a particular point, and as isopleth (contour) plots which provide a visualisation of predicted impacts in the area around the Quarry Site.

It is important to note that dispersion modelling provides an assessment of risk, and includes an inherent uncertainty, no matter how accurate the modelling inputs may be. Barclay & Scire (2011) state:

"The sources of uncertainty in model predictions can be significantly reduced by collecting the proper input data, preparing the input files correctly, checking and re-checking for errors, correcting for 'odd' model behaviour, insuring that errors in the measured data are minimised and applying the correct model to suit each application. As well as user 'error' inputs there is some 'inherent uncertainty' in model predictions which occurs in all dispersion models' due to the uncertainty of atmospheric behaviour.

Consider the following general statements on model performance which have been derived from the EPA 2003 and are to be considered in their totality, i.e., altogether.

- Models are more reliable for estimating longer time averaged concentrations than for estimating short-term concentrations at specific locations
- Estimates of concentrations that occur at a specific time and site are poorly correlated with actual observed concentrations (paired in space and time) and are less reliable (mostly due to reducible uncertainty such as error in plume location due to a wind direction error).
- Models are reasonably reliable in estimating the highest concentrations occurring sometime, somewhere in an area. Model certainty is expected to be in the range of a factor of 2."

6.1 SUMMARY OF RESULTS

The dispersion modelling assessment indicates that all adopted air quality criteria are achieved at all sensitive receptor locations surrounding the Quarry Site during all four operational stages modelled (one current and three proposed). One exceedance of the 24-hour average PM_{10} criterion is predicted, although it is shown that the existing background conditions on that particular day are already in exceedance of the criterion, and the Proposal contributes a minimal impact.

It should be noted that the model predictions are based on worst case assumptions, most notably that the full 230 000 tpa of extracted material would be processed at the Quarry Site. In reality, a substantial amount of the material would be transported to Sunnyside and processed at that location.

In the case of the prediction of maximum 24-hour particulate impacts, it has been assumed that 5 000 $t \cdot day^{-1}$ of extracted material would be processed at the Quarry Site each and every day of the year.

The results can be viewed as worst-case and have been presented in this way to provide confidence that the Proposal can be operated in both modelled stages with minimal risk of exceedance of the relevant air quality criteria at all surrounding receptor locations.

Results associated with existing operations are presented in the following sections although are not discussed in detail. These results are provided to allow comparison of current operations with potential future scenarios.

6.2 ANNUAL AVERAGE TSP, PM_{10}, $PM_{2.5}$ AND DUST DEPOSITION

In the case of annual average predictions, all criteria are predicted to be met at surrounding residential locations during both Stage 1, Stage 2 and Stage 3 operations. Contributions from these activities are shown in all cases to result in minimal / negligible impact at all receptor locations.

Presented in **Table 17** are dispersion model predictions of annual average TSP concentrations. The maximum predicted increment resulting from Stage 1, Stage 2 and Stage 3 operations is 2.0 $\mu g \cdot m^{-3}$, at receptor 3A. This represents less than (<) 2.5 % of the annual average TSP criterion.

The addition of background air quality results in total cumulative impacts of TSP during both Stage 1, Stage 2 and Stage 3 operations being <40 % of the criterion at all surrounding receptor locations.

Presented in **Table 18** are dispersion model predictions of annual average PM_{10} concentrations. The maximum predicted increment resulting from Stage 1, Stage 2 and Stage 3 operations is 1.3 $\mu g \cdot m^{-3}$ (receptor 3A) which represents <6 % of the annual average PM_{10} criterion.

The addition of background air quality results in total cumulative impacts of PM_{10} during Stage 1, Stage 2 and Stage 3 operations phase being <62 % of the criterion.

Presented in **Table 19** are dispersion model predictions of annual average $PM_{2.5}$ concentrations. The maximum predicted increment resulting from Stage 1, Stage 2 and Stage 3 operations is 0.2 $\mu g \cdot m^{-3}$ (receptor 3A) which represents 2.5 % of the annual average $PM_{2.5}$ criterion.

The addition of background air quality results in total cumulative annual average impacts of $PM_{2.5}$ during Stage 1 and Stage 2 operations being 93 % of the criterion, of which the background alone contributes 90% of the criterion

In relation to impacts associated with silica, on the assumption that 100 % of $PM_{2.5}$ is in the form of silica, maximum annual average concentrations of silica resulting from the operation of the Quarry in any of Stage 1, Stage 2 or Stage 3 would be 0.2 $\mu g \cdot m^{-3}$, or < 7 % of the VIC EPA criterion (refer Section 3). The existing background concentrations of silica in the area surrounding the Quarry Site are not known, although given that the Quarry is predicted to contribute <7 % to annual average concentrations, as a worst case, increases in impacts associated with silica due to the Quarry are likely to be minimal.

Presented in **Table 20** are dispersion model predictions of annual average dust deposition rates. The maximum predicted increment resulting from Stage 1, Stage 2 and Stage 3 operations is <0.1 $g \cdot m^{-2} \cdot month^{-1}$ (receptor 3A) which represents <5 % of the incremental annual average dust deposition criterion.

The addition of background air quality results in total cumulative impacts of dust deposition during Stage 1, Stage 2 and Stage 3 operations being 50 % of the cumulative criterion.

Given the predicted low incremental annual average impacts of particulate matter, no concentration or deposition rate isopleth plots are provided.

Table 17
Predicted Annual Average TSP Concentrations

	Annual Average TSP Concentration (µg·m^{-3})											
	Existing			Stage 1			Stage 2			Stage 3		
Recep.	Incr.	Bg.	Cumul.	Incr.	Bg.	Cumul.	Incr.	Bg.	Cumul.	Incr.	Bg.	Cumul.
2	<0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1
3A	0.5	33.0	33.5	1.5	33.0	34.5	2.0	33.0	35.0	2.0	33.0	35.0
3B	0.4	33.0	33.4	1.1	33.0	34.1	1.1	33.0	34.1	1.1	33.0	34.1
4	0.1	33.0	33.1	0.2	33.0	33.2	0.2	33.0	33.2	0.2	33.0	33.2
5A	<0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1
5B	0.1	33.0	33.1	0.1	33.0	33.1	0.2	33.0	33.2	0.2	33.0	33.2
6	<0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1	0.2	33.0	33.2
7	<0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1
8	0.1	33.0	33.1	0.1	33.0	33.1	0.2	33.0	33.2	0.2	33.0	33.2
9	0.1	33.0	33.1	0.2	33.0	33.2	0.2	33.0	33.2	0.2	33.0	33.2
11	0.3	33.0	33.3	0.6	33.0	33.6	0.6	33.0	33.6	0.6	33.0	33.6
12	0.4	33.0	33.4	0.9	33.0	33.9	0.9	33.0	33.9	0.9	33.0	33.9
13	0.4	33.0	33.4	0.8	33.0	33.8	0.8	33.0	33.8	0.8	33.0	33.8
14	0.2	33.0	33.2	0.6	33.0	33.6	0.5	33.0	33.5	0.5	33.0	33.5
15	0.2	33.0	33.2	0.5	33.0	33.5	0.5	33.0	33.5	0.5	33.0	33.5
16	<0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1
18	0.2	33.0	33.2	0.5	33.0	33.5	0.5	33.0	33.5	0.6	33.0	33.6
19	0.2	33.0	33.2	0.4	33.0	33.4	0.5	33.0	33.5	0.5	33.0	33.5
20	0.2	33.0	33.2	0.4	33.0	33.4	0.4	33.0	33.4	0.4	33.0	33.4
21	<0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1
22	<0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1
23	<0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1
24	<0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1
25	<0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1
26	<0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1	0.1	33.0	33.1
Criterion	-	-	90	-	-	90	-	-	90	-	-	90

Table 18
Predicted Annual Average PM_{10} Concentrations

	Annual Average PM_{10} Concentration ($\mu g \cdot m^{-3}$)											
	Existing			Stage 1			Stage 2			Stage 3		
Recep.	**Incr.**	**Bg.**	**Cumul.**	**Incr.**	**Bg.**	**Cumul.**	**Incr.**	**Bg.**	**Cumul.**	**Incr.**	**Bg.**	**Cumul.**
2	<0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2	<0.1	14.1	14.2
3A	0.3	14.1	14.4	0.8	14.1	14.9	1.2	14.1	15.3	1.3	14.1	15.4
3B	0.2	14.1	14.3	0.5	14.1	14.6	0.5	14.1	14.6	0.5	14.1	14.6
4	<0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2
5A	<0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2	<0.1	14.1	14.2
5B	<0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2
6	<0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2
7	<0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2
8	<0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2
9	<0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2	0.2	14.1	14.3
11	0.1	14.1	14.2	0.3	14.1	14.4	0.3	14.1	14.4	0.4	14.1	14.5
12	0.2	14.1	14.3	0.4	14.1	14.5	0.4	14.1	14.5	0.5	14.1	14.6
13	0.2	14.1	14.3	0.3	14.1	14.4	0.3	14.1	14.4	0.4	14.1	14.5
14	0.1	14.1	14.2	0.2	14.1	14.3	0.2	14.1	14.3	0.3	14.1	14.4
15	0.1	14.1	14.2	0.2	14.1	14.3	0.2	14.1	14.3	0.3	14.1	14.4
16	0.0	14.1	14.1	0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2
18	0.1	14.1	14.2	0.3	14.1	14.4	0.3	14.1	14.4	0.3	14.1	14.4
19	0.1	14.1	14.2	0.2	14.1	14.3	0.3	14.1	14.4	0.3	14.1	14.4
20	0.1	14.1	14.2	0.2	14.1	14.3	0.3	14.1	14.4	0.3	14.1	14.4
21	<0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2
22	<0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2	<0.1	14.1	14.2
23	<0.1	14.1	14.2	0.1	14.1	14.2	0.1	14.1	14.2	<0.1	14.1	14.2
24	<0.1	14.1	14.2	<0.1	14.1	<14.1	0.1	14.2	14.2	<0.1	14.1	14.2
25	<0.1	14.1	14.2	<0.1	14.1	14.2	0.1	14.1	14.2	<0.1	14.1	14.2
26	<0.1	14.1	14.2	<0.1	14.1	14.2	0.1	14.1	14.2	<0.1	14.1	14.2
Criterion	-	-	25	-	-	25	-	-	25	-	-	25

Table 19
Predicted Annual Average $PM_{2.5}$ Concentrations

	Annual Average $PM_{2.5}$ Concentration ($\mu g \cdot m^{-3}$)											
	Existing			Stage 1			Stage 2			Stage 3		
Recep.	**Incr.**	**Bg.**	**Cumul.**	**Incr.**	**Bg.**	**Cumul.**	**Incr.**	**Bg.**	**Cumul.**	**Incr.**	**Bg.**	**Cumul.**
2	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
3A	<0.1	7.2	7.3	0.1	7.2	7.3	0.2	7.2	7.4	0.2	7.2	7.4
3B	<0.1	7.2	7.3	0.1	7.2	7.3	0.1	7.2	7.3	0.1	7.2	7.3
4	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
5A	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
5B	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
6	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
7	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
8	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
9	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
11	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	0.1	7.2	7.3
12	<0.1	7.2	7.3	<0.1	7.2	7.3	0.1	7.2	7.3	0.1	7.2	7.3
13	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	0.1	7.2	7.3
14	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
15	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
16	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
18	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
19	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
20	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
21	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
22	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
23	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
24	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
25	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
26	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3	<0.1	7.2	7.3
Criterion	-	-	8	-	-	8	-	-	8	-	-	8

Table 20
Predicted Annual Average Dust Deposition Rates

	Annual Average Dust Deposition Rate ($g \cdot m^{-2} \cdot month^{-1}$)											
	Existing			Stage 1			Stage 2			Stage 3		
Recep.	**Incr.**	**Bg.**	**Cumul.**	**Incr.**	**Bg.**	**Cumul.**	**Incr.**	**Bg.**	**Cumul.**	**Incr.**	**Bg.**	**Cumul.**
2	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
3A	<0.1	2.0	2.1	0.1	2	2.1	0.1	2	2.1	0.1	2.0	2.1
3B	<0.1	2.0	2.1	0.1	2	2.1	0.1	2	2.2	0.1	2.0	2.1
4	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
5A	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
5B	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
6	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
7	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
8	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
9	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
11	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
12	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
13	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
14	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
15	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
16	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
18	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
19	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
20	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
21	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
22	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
23	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
24	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
25	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
26	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1	<0.1	2.0	2.1
Criterion	2.0	-	4.0	2.0	-	4.0	2.0	-	4.0	2.0	-	4.0

6.3 MAXIMUM 24-HOUR AVERAGE PM_{10} AND $PM_{2.5}$

The maximum predicted incremental 24-hour average PM_{10} concentrations resulting from activities during Stage 1, Stage 2 and Stage 3 operations are presented in **Table 21**. These predictions indicate that the activities during operations could potentially result in incremental impacts up to 19.9 $\mu g \cdot m^{-3}$ at the modelled receptor locations (receptor 3A), which represents <40 % of the relevant criterion.

Note that these predicted concentrations would only be reached during campaign crushing at peak rates and are likely to be significantly lower.

Table 21
Predicted Maximum 24-hour Average Incremental PM_{10} Concentrations

Receptor	Maximum Incremental 24-hour PM_{10} Concentration ($\mu g \cdot m^{-3}$)			
	Existing	Stage 1	Stage 2	Stage 3
2	0.9	2.8	3.1	3.1
3A	4.8	12.1	15.6	19.9
3B	2.1	5.8	5.9	7.0
4	1.1	2.5	2.9	3.5
5A	0.9	2.2	2.3	2.3
5B	1.0	2.3	2.7	3.2
6	1.0	2.3	2.4	2.5
7	1.2	2.8	2.9	2.9
8	0.9	2.3	2.1	2.2
9	0.7	1.8	1.8	2.0
11	1.7	4.1	4.5	5.4
12	2.8	6.1	6.1	7.5
13	2.6	7.3	6.7	5.8
14	2.0	5.4	5.0	4.4
15	2.0	5.2	4.8	4.6
16	0.9	2.5	2.7	2.7
18	1.3	3.5	3.5	4.1
19	1.3	3.1	3.4	3.9
20	1.2	2.9	3.0	3.4
21	1.2	2.6	3.0	3.1
22	0.8	2.1	2.0	1.9
23	0.8	1.9	1.9	1.7
24	1.0	2.2	2.5	2.6
25	0.8	2.1	2.2	2.3
26	0.7	2.0	2.1	2.1
Criterion	50	50	50	50

The predicted maximum 24-hour average PM_{10} concentrations resulting from the operation of Stage 1, Stage 2 and Stage 3 of the Project, with background included are presented in the following tables.

Results are presented for the receptor at which the highest incremental impacts have been predicted (receptor 3A). The left side of the tables show the predicted concentration on days with the highest background, and the right side shows the total predicted concentration on days with the highest predicted incremental concentrations.

In all three proposed stages of operation, one exceedance of the 24-hour average impact assessment criterion for PM_{10} is predicted although no additional exceedances are shown to eventuate because of the operation of the Project. The predicted exceedance (highlighted in **bold**) is driven by the background air quality (i.e. existing sources) and is not contributed to by the proposed operations at the Quarry Site.

The maximum incremental concentrations are not shown to be coincidental with sufficiently high background conditions to result in exceedance of the relevant air quality criterion. Once again, it is noted that these high increments are associated with a worst-case scenario where all material crushing occurs on site.

Table 22
Summary of Contemporaneous Impact and Background - 24-hour Average PM_{10} – Existing

	24-hour average PM_{10} concentration (μg·m^{-3})				**24-hour average PM_{10} concentration (μg·m^{-3})**		
Date	**Incr.**	**BG**	**Cumul.**	**Date**	**Incr.**	**BG**	**Cumul.**
6/05/2015	1.2	**52.7**	**53.9**	30/06/2015	4.8	20.5	25.3
26/11/2015	0.4	48.0	48.4	26/02/2015	4.4	18.0	22.4
7/05/2015	0.7	31.6	32.3	16/04/2015	3.7	29.2	32.9
21/11/2015	0.2	30.8	31.0	17/04/2015	3.6	19.7	23.2
27/11/2015	<0.1	30.9	31.0	30/06/2015	3.2	21.6	24.8
7/10/2015	<0.1	29.6	29.7	21/08/2015	2.9	26.1	29.0
21/08/2015	<0.1	29.2	29.3	26/05/2015	2.7	26.7	29.4
6/10/2015	<0.1	29.0	29.1	22/07/2015	2.5	18.5	21.1
8/03/2015	<0.1	28.4	28.5	13/10/2015	2.5	17.2	19.7
20/11/2015	0.5	27.1	27.5	15/04/2015	2.5	16.5	19.0
Criterion	50			Criterion	50		
These data represent the highest cumulative impact 24-hour PM_{10} predictions as a result of the operation of the project.				These data represent the highest incremental impact 24-hour PM_{10} predictions as a result of the operation of the project.			
Note: Incr. = incremental impact, BG = background concentration, Cumul. = cumulative impact							

Table 23
Summary of Contemporaneous Impact and Background - 24-hour Average PM_{10} – Stage 1

Date	24-hour average PM_{10} concentration ($\mu g \cdot m^{-3}$)			Date	24-hour average PM_{10} concentration ($\mu g \cdot m^{-3}$)		
	Incr.	BG	Cumul.		Incr.	BG	Cumul.
6/05/2015	2.4	**52.7**	**55.1**	30/06/2015	12.1	20.5	32.6
26/11/2015	1.0	48.0	49.0	26/02/2015	11.5	18.0	29.4
7/05/2015	1.0	31.6	32.7	16/04/2015	9.9	21.6	31.6
21/11/2015	0.6	30.8	31.4	17/04/2015	9.4	29.2	38.6
27/11/2015	<0.1	30.9	31.0	30/06/2015	8.7	18.5	27.2
7/10/2015	<0.1	29.6	29.7	21/08/2015	8.4	19.7	28.1
21/08/2015	<0.1	29.2	29.3	26/05/2015	8.0	26.7	34.7
6/10/2015	0.1	29.0	29.1	22/07/2015	7.6	8.9	16.5
8/03/2015	<0.1	28.4	28.5	13/10/2015	7.1	16.5	23.6
20/11/2015	1.0	27.1	28.1	15/04/2015	7.0	15.6	22.6
Criterion	50			Criterion	50		
These data represent the highest cumulative impact 24-hour PM_{10} predictions as a result of the operation of the project.				These data represent the highest incremental impact 24-hour PM_{10} predictions as a result of the operation of the project.			
Note: Incr. = incremental impact, BG = background concentration, Cumul. = cumulative impact							

Table 24
Summary of Contemporaneous Impact and Background - 24-hour Average PM_{10} – Stage 2

Date	24-hour average PM_{10} concentration ($\mu g \cdot m^{-3}$)			Date	24-hour average PM_{10} concentration ($\mu g \cdot m^{-3}$)		
	Incr.	BG	Cumul.		Incr.	BG	Cumul.
6/05/2015	3.3	**52.7**	**56.0**	30/06/2015	15.6	20.5	36.1
26/11/2015	0.6	48.0	48.6	26/02/2015	15.0	18.0	32.9
7/05/2015	1.3	31.6	33.0	16/04/2015	11.9	21.6	33.6
21/11/2015	0.6	30.8	31.4	17/04/2015	11.7	19.7	31.4
27/11/2015	0.1	30.9	30.9	30/06/2015	10.8	22.1	32.9
7/10/2015	<0.1	29.6	29.7	21/08/2015	10.3	26.7	37.0
21/08/2015	<0.1	29.2	29.3	26/05/2015	10.2	18.5	28.7
6/10/2015	0.1	29.0	29.1	22/07/2015	10.1	29.2	39.3
8/03/2015	<0.1	28.4	28.5	13/10/2015	9.1	16.5	25.7
20/11/2015	1.1	27.1	28.2	15/04/2015	8.6	25.0	33.6
Criterion	50			Criterion	50		
These data represent the highest cumulative impact 24-hour PM_{10} predictions as a result of the operation of the project.				These data represent the highest incremental impact 24-hour PM_{10} predictions as a result of the operation of the project.			
Note: Incr. = incremental impact, BG = background concentration, Cumul. = cumulative impact							

Table 25
Summary of Contemporaneous Impact and Background - 24-hour Average PM_{10} – Stage 3

Date	24-hour average PM_{10} concentration ($\mu g \cdot m^{-3}$)			Date	24-hour average PM_{10} concentration ($\mu g \cdot m^{-3}$)		
	Incr.	BG	Cumul.		Incr.	BG	Cumul.
6/05/2015	3.8	**52.7**	**56.5**	30/06/2015	19.9	20.5	40.4
26/11/2015	0.8	48.0	48.7	26/02/2015	15.9	18.0	33.8
7/05/2015	1.8	31.6	33.5	16/04/2015	12.5	19.7	32.1
21/11/2015	0.6	30.8	31.4	17/04/2015	12.3	29.2	41.5
27/11/2015	0.2	30.9	31.0	30/06/2015	12.3	21.6	33.9
7/10/2015	<0.1	29.6	29.7	21/08/2015	11.5	18.5	30.0
21/08/2015	<0.1	29.2	29.3	26/05/2015	11.2	17.2	28.4
6/10/2015	0.1	29.0	29.1	22/07/2015	10.7	26.7	37.4
8/03/2015	<0.1	28.4	28.5	13/10/2015	9.8	16.5	26.3
20/11/2015	1.0	27.1	28.1	15/04/2015	9.8	12.3	22.1
Criterion	50			Criterion	50		
These data represent the highest cumulative impact 24-hour PM_{10} predictions as a result of the operation of the project.				These data represent the highest incremental impact 24-hour PM_{10} predictions as a result of the operation of the project.			
Note: Incr. = incremental impact, BG = background concentration, Cumul. = cumulative impact							

Figure 12, Figure 13, **Figure 14**, and **Figure 15** present the maximum predicted 24-hour average incremental PM_{10} concentrations associated with existing operations, and Stage 1, Stage 2 and Stage 3 operations, respectively.

Figure 12
Predicted Incremental Maximum 24-hour Average PM_{10} Concentrations – Existing

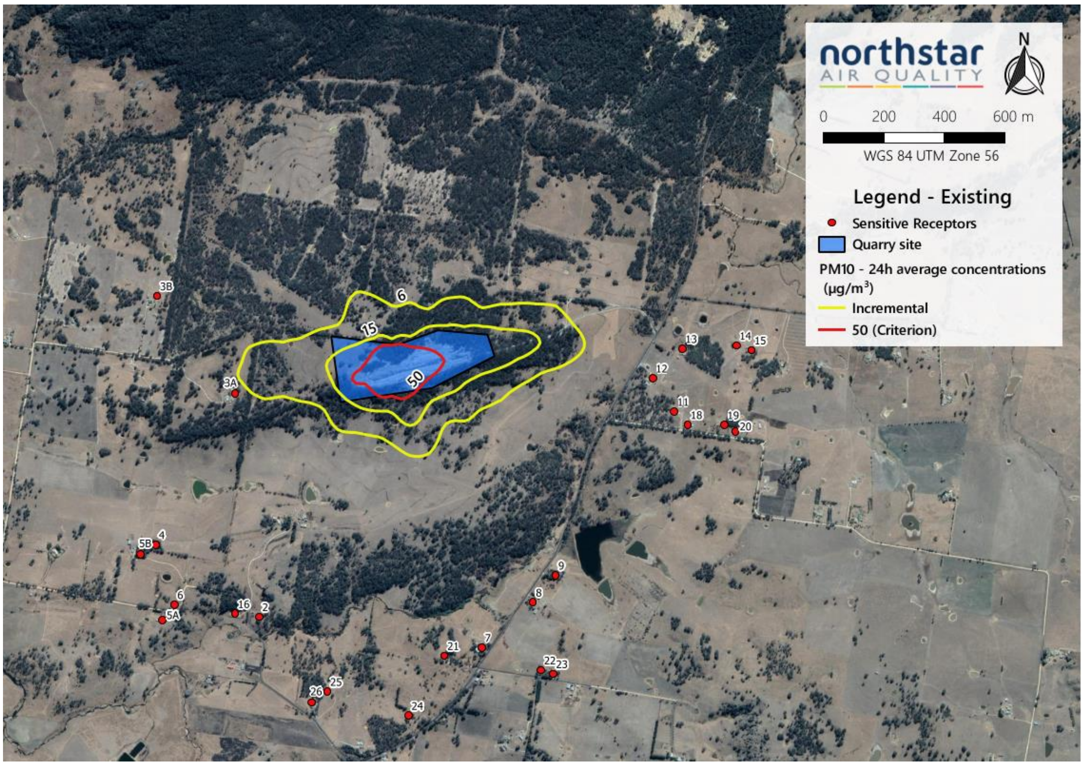


Figure 13
Predicted Incremental Maximum 24-hour Average PM_{10} Concentrations – Stage 1

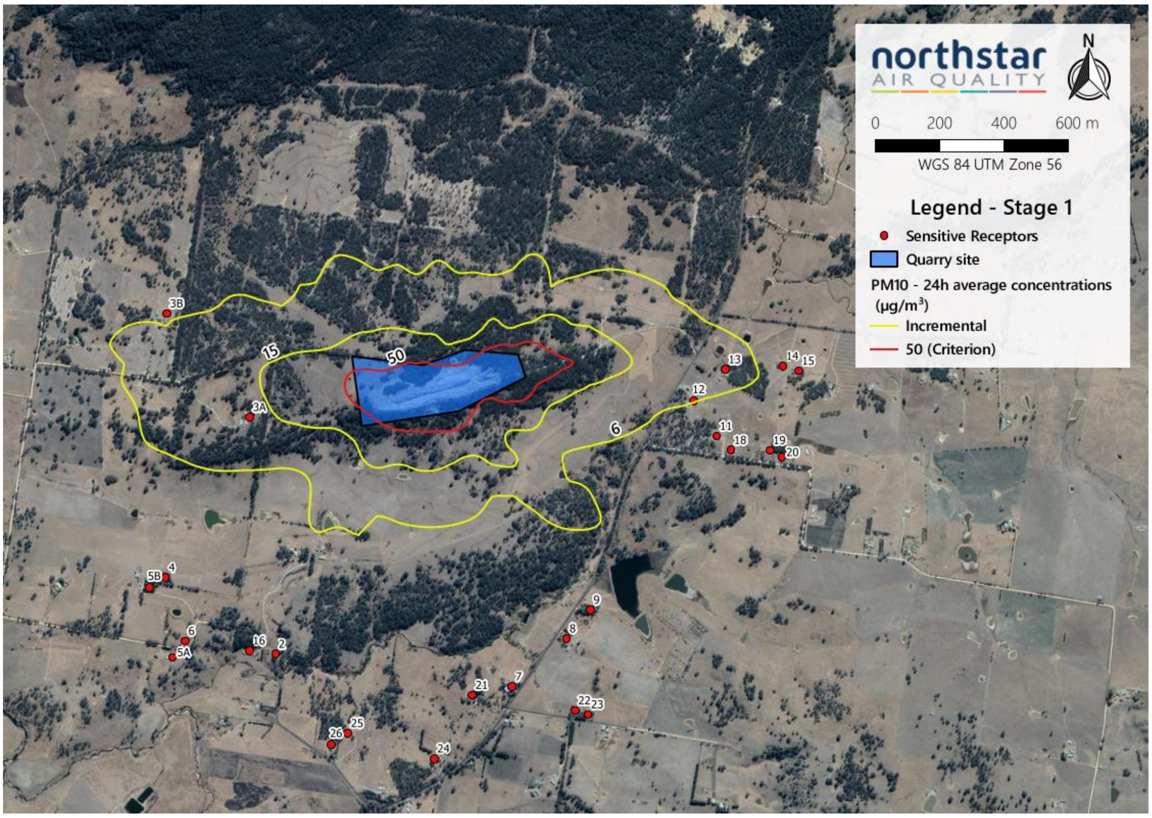


Figure 14
Predicted Incremental Maximum 24-hour Average PM_{10} Concentrations – Stage 2

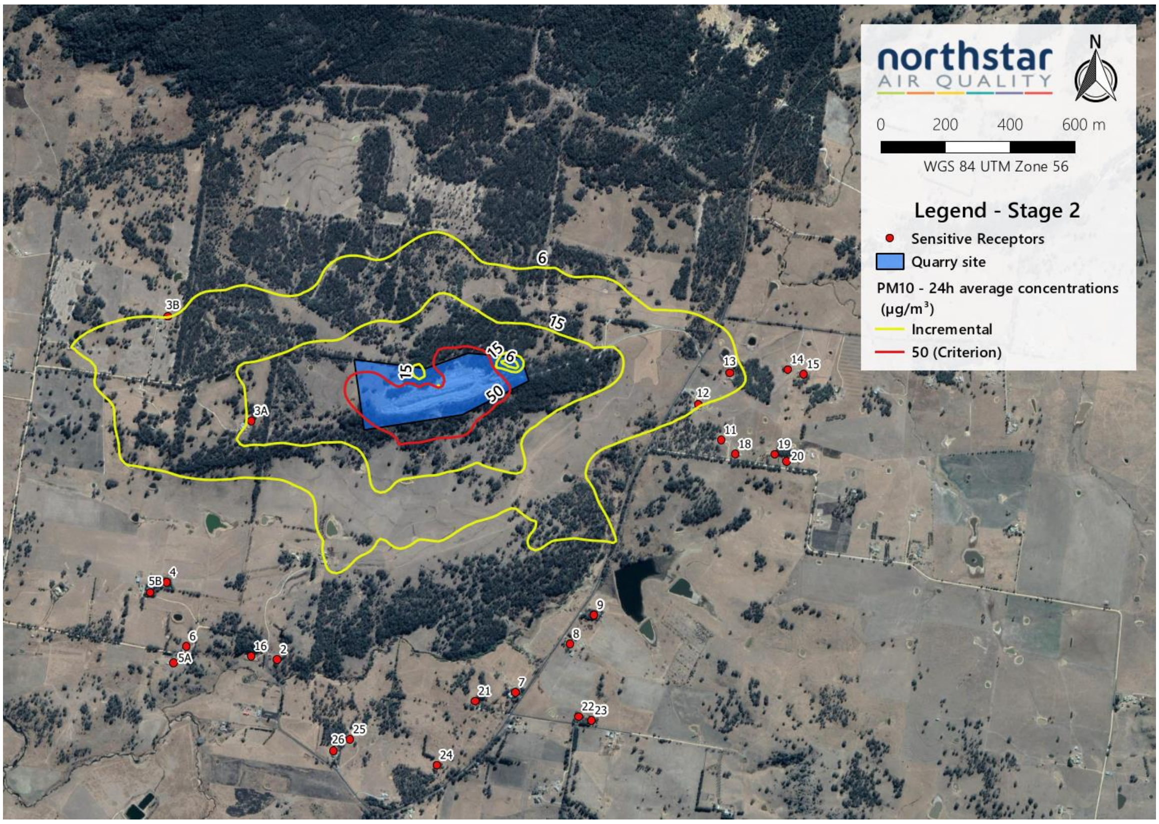
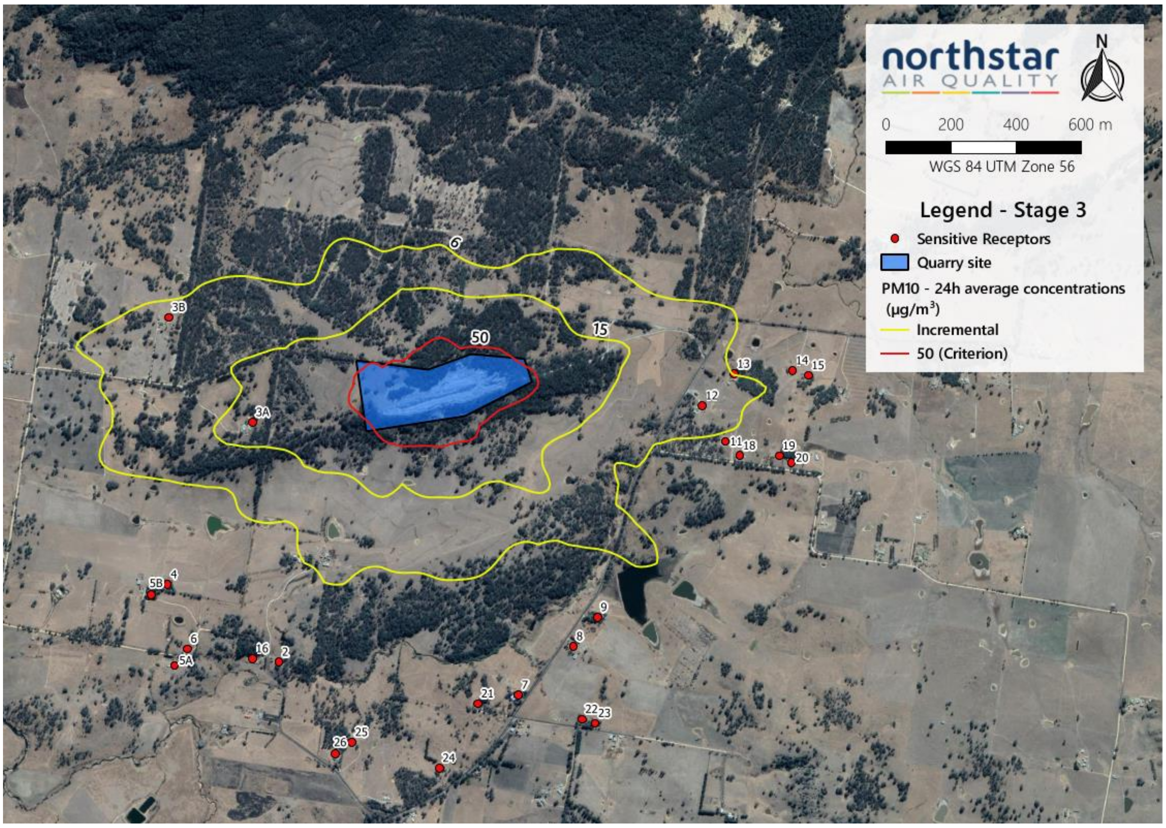


Figure 15

Predicted Incremental Maximum 24-hour Average PM_{10} Concentrations – Stage 3



The maximum predicted incremental 24-hour average $PM_{2.5}$ concentrations resulting from activities during Stage 1, Stage 2 and Stage 3 operations are presented in **Table 26**. These predictions indicate that the activities during operations could potentially result in incremental impacts up to 2.9 µg·m^{-3} at the modelled receptor locations (receptor 3A), which represents <12 % of the relevant criterion.

Table 26
Predicted Maximum 24-hour Average Incremental $PM_{2.5}$ Concentrations

Receptor	Maximum Incremental 24-hour $PM_{2.5}$ Concentration ($\mu g \cdot m^{-3}$)			
	Existing	**Stage 1**	**Stage 2**	**Stage 3**
2	0.1	0.4	0.4	0.4
3A	0.6	1.7	2.2	2.9
3B	0.2	0.8	0.8	0.9
4	0.1	0.3	0.4	0.5
5A	0.1	0.3	0.3	0.3
5B	0.1	0.3	0.4	0.5
6	0.1	0.3	0.3	0.3
7	0.1	0.3	0.3	0.3
8	0.1	0.2	0.2	0.3
9	0.1	0.2	0.2	0.3
11	0.2	0.6	0.6	0.7
12	0.3	0.7	0.8	0.9
13	0.3	0.8	0.7	0.7
14	0.2	0.6	0.5	0.5
15	0.2	0.6	0.5	0.5
16	0.1	0.3	0.4	0.4
18	0.2	0.5	0.5	0.6
19	0.2	0.4	0.5	0.5
20	0.2	0.4	0.4	0.5
21	0.1	0.3	0.4	0.4
22	0.1	0.2	0.2	0.2
23	0.1	0.2	0.2	0.2
24	0.1	0.3	0.3	0.3
25	0.1	0.3	0.3	0.3
26	0.1	0.2	0.3	0.3
Criterion	25	25	25	25

The predicted maximum 24-hour average $PM_{2.5}$ concentrations resulting from the operation of Stage 1, Stage 2 and Stage 3 of the Project, with background included are presented below.

Results are presented for the receptor at which the highest incremental impacts have been predicted (receptor 3A). Again, the left side of the tables show the predicted concentration on days with the highest background, and the right side shows the total predicted concentration on days with the highest predicted incremental concentrations.

In both Stage 1, Stage 2 and Stage 3 operations, no exceedances of the 24-hour average impact assessment criterion for $PM_{2.5}$ are predicted. The maximum predicted cumulative impact at receptor 3A are likely to be <80 % of the relevant criterion, which again is dominated by high background contributions.

Table 27
Summary of Contemporaneous Impact and Background - 24-hour Average $PM_{2.5}$ – Existing

Date	24-hour average $PM_{2.5}$ concentration ($\mu g \cdot m^{-3}$)			Date	24-hour average $PM_{2.5}$ concentration ($\mu g \cdot m^{-3}$)		
	Incr.	BG	Cumul.		Incr.	BG	Cumul.
6/05/2015	0.2	19.4	19.6	30/06/2015	0.6	9.2	9.9
26/11/2015	0.0	17.9	17.9	26/02/2015	0.5	8.4	8.9
7/05/2015	0.1	12.8	12.9	16/04/2015	0.4	9.0	9.4
27/11/2015	0.0	12.5	12.5	17/04/2015	0.4	12.0	12.4
21/11/2015	0.0	12.5	12.5	30/06/2015	0.3	9.6	9.9
7/10/2015	0.0	12.1	12.1	21/08/2015	0.3	8.2	8.5
21/08/2015	0.0	12.0	12.0	26/05/2015	0.3	8.0	8.3
6/10/2015	0.0	11.9	11.9	22/07/2015	0.3	11.2	11.5
8/03/2015	0.0	11.7	11.7	13/10/2015	0.3	7.2	7.4
20/11/2015	0.0	11.3	11.3	15/04/2015	0.3	11.0	11.3
Criterion	25			Criterion	25		
These data represent the highest cumulative impact 24-hour $PM_{2.5}$ predictions as a result of the operation of the project.				These data represent the highest incremental impact 24-hour $PM_{2.5}$ predictions as a result of the operation of the project.			
Note: Incr. = incremental impact, BG = background concentration, Cumul. = cumulative impact							

Table 28
Summary of Contemporaneous Impact and Background - 24-hour Average $PM_{2.5}$ – Stage 1

Date	24-hour average $PM_{2.5}$ concentration ($\mu g \cdot m^{-3}$)			Date	24-hour average $PM_{2.5}$ concentration ($\mu g \cdot m^{-3}$)		
	Incr.	BG	Cumul.		Incr.	BG	Cumul.
6/05/2015	0.4	19.4	19.8	30/06/2015	1.7	9.2	10.9
26/11/2015	0.1	17.9	18.0	26/02/2015	1.5	8.4	9.9
7/05/2015	0.2	12.8	12.9	16/04/2015	1.3	9.6	10.9
21/11/2015	0.1	12.5	12.5	17/04/2015	1.2	12.0	13.2
27/11/2015	0.0	12.5	12.5	30/06/2015	1.1	9.0	10.1
7/10/2015	0.0	12.1	12.1	21/08/2015	1.1	8.6	9.7
21/08/2015	0.0	12.0	12.0	26/05/2015	1.1	11.2	12.3
6/10/2015	0.0	11.9	11.9	22/07/2015	1.0	5.6	6.5
8/03/2015	0.0	11.7	11.7	13/10/2015	1.0	8.0	8.9
20/11/2015	0.1	11.3	11.4	15/04/2015	0.9	9.7	10.7
Criterion	25			Criterion	25		
These data represent the highest cumulative impact 24-hour $PM_{2.5}$ predictions as a result of the operation of the project.				These data represent the highest incremental impact 24-hour $PM_{2.5}$ predictions as a result of the operation of the project.			
Note: Incr. = incremental impact, BG = background concentration, Cumul. = cumulative impact							

Table 29
Summary of Contemporaneous Impact and Background - 24-hour Average $PM_{2.5}$ – Stage 2

Date	24-hour average $PM_{2.5}$ concentration (µg·m^{-3})			Date	24-hour average $PM_{2.5}$ concentration (µg·m^{-3})		
	Incr.	BG	Cumul.		Incr.	BG	Cumul.
6/05/2015	0.5	19.4	19.9	30/06/2015	2.2	9.2	11.4
26/11/2015	0.1	17.9	18.0	26/02/2015	2.0	8.4	10.5
7/05/2015	0.2	12.8	13.0	16/04/2015	1.6	9.0	10.6
21/11/2015	0.1	12.5	12.6	17/04/2015	1.6	9.6	11.2
27/11/2015	0.0	12.5	12.5	30/06/2015	1.6	9.7	11.3
7/10/2015	0.0	12.1	12.1	21/08/2015	1.4	11.2	12.6
21/08/2015	0.0	12.0	12.0	26/05/2015	1.3	12.0	13.3
6/10/2015	0.0	11.9	11.9	22/07/2015	1.3	8.6	9.9
8/03/2015	0.0	11.7	11.7	13/10/2015	1.3	8.0	9.2
20/11/2015	0.1	11.3	11.4	15/04/2015	1.2	10.6	11.8
Criterion	25			Criterion	25		
These data represent the highest cumulative impact 24-hour $PM_{2.5}$ predictions as a result of the operation of the project.				These data represent the highest incremental impact 24-hour $PM_{2.5}$ predictions as a result of the operation of the project.			
Note: Incr. = incremental impact, BG = background concentration, Cumul. = cumulative impact							

Table 30
Summary of Contemporaneous Impact and Background - 24-hour Average $PM_{2.5}$ – Stage 3

Date	24-hour average $PM_{2.5}$ concentration (µg·m^{-3})			Date	24-hour average $PM_{2.5}$ concentration (µg·m^{-3})		
	Incr.	BG	Cumul.		Incr.	BG	Cumul.
6/05/2015	0.6	19.4	20.0	30/06/2015	2.9	9.2	12.2
26/11/2015	0.1	17.9	18.0	26/02/2015	2.2	8.4	10.6
7/05/2015	0.3	12.8	13.0	16/04/2015	1.8	9.0	10.7
21/11/2015	0.1	12.5	12.6	17/04/2015	1.7	8.2	9.9
27/11/2015	0.0	12.5	12.5	30/06/2015	1.6	12.0	13.6
7/10/2015	0.0	12.1	12.1	21/08/2015	1.6	9.6	11.2
21/08/2015	0.0	12.0	12.0	26/05/2015	1.5	8.6	10.1
6/10/2015	0.0	11.9	11.9	22/07/2015	1.5	11.2	12.6
8/03/2015	0.0	11.7	11.7	13/10/2015	1.4	8.0	9.3
20/11/2015	0.1	11.3	11.4	15/04/2015	1.3	6.7	8.0
Criterion	25			Criterion	25		
These data represent the highest cumulative impact 24-hour $PM_{2.5}$ predictions as a result of the operation of the project.				These data represent the highest incremental impact 24-hour $PM_{2.5}$ predictions as a result of the operation of the project.			
Note: Incr. = incremental impact, BG = background concentration, Cumul. = cumulative impact							

Figure 16, **Figure 17**, **Figure 18**, and **Figure 19** present the maximum predicted 24-hour average incremental $PM_{2.5}$ concentrations associated with Stage 1, Stage 2 and Stage 3 operations, respectively.

Figure 16
Predicted Incremental Maximum 24-hour Average $PM_{2.5}$ Concentrations – Existing

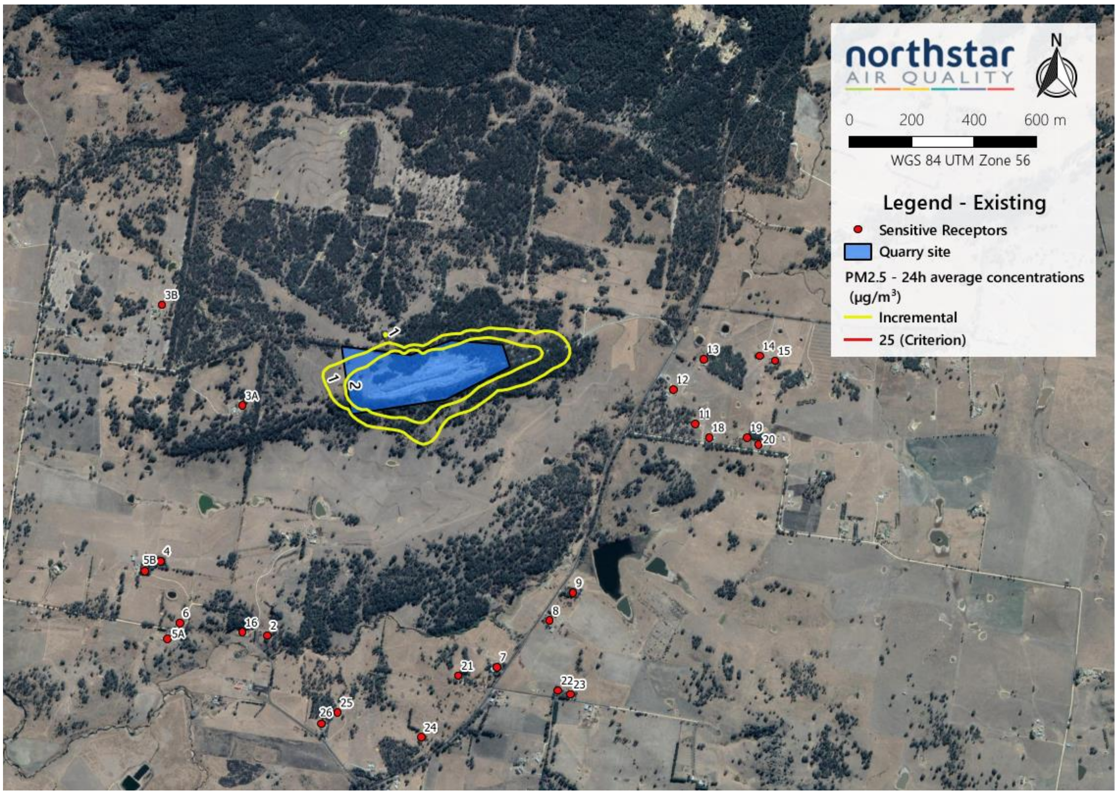


Figure 17
Predicted Incremental Maximum 24-hour Average $PM_{2.5}$ Concentrations – Stage 1

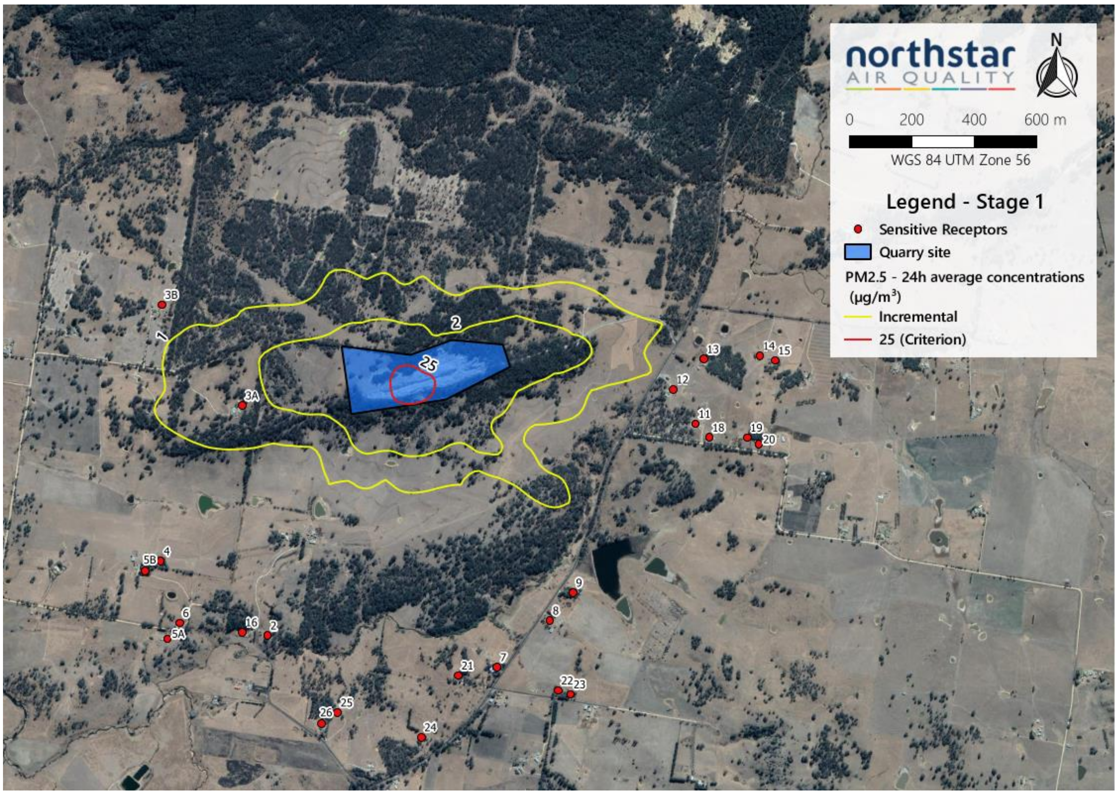


Figure 18
Predicted Incremental Maximum 24-hour Average $PM_{2.5}$ Concentrations – Stage 2

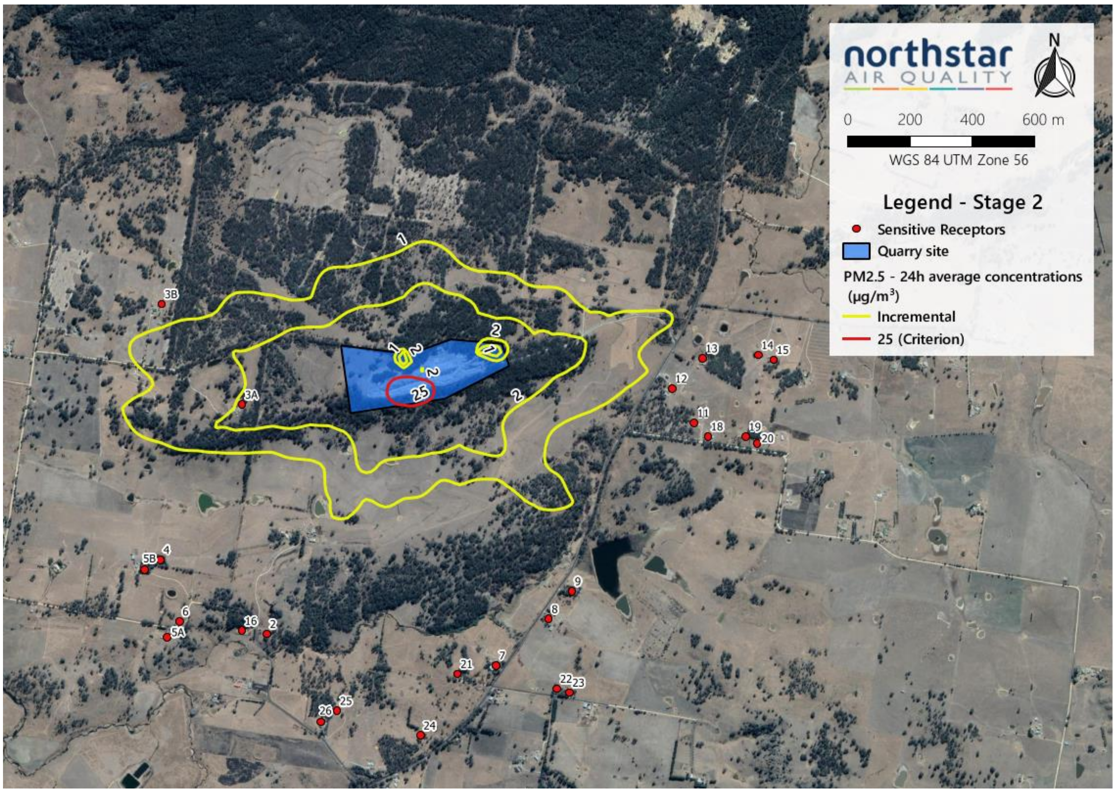
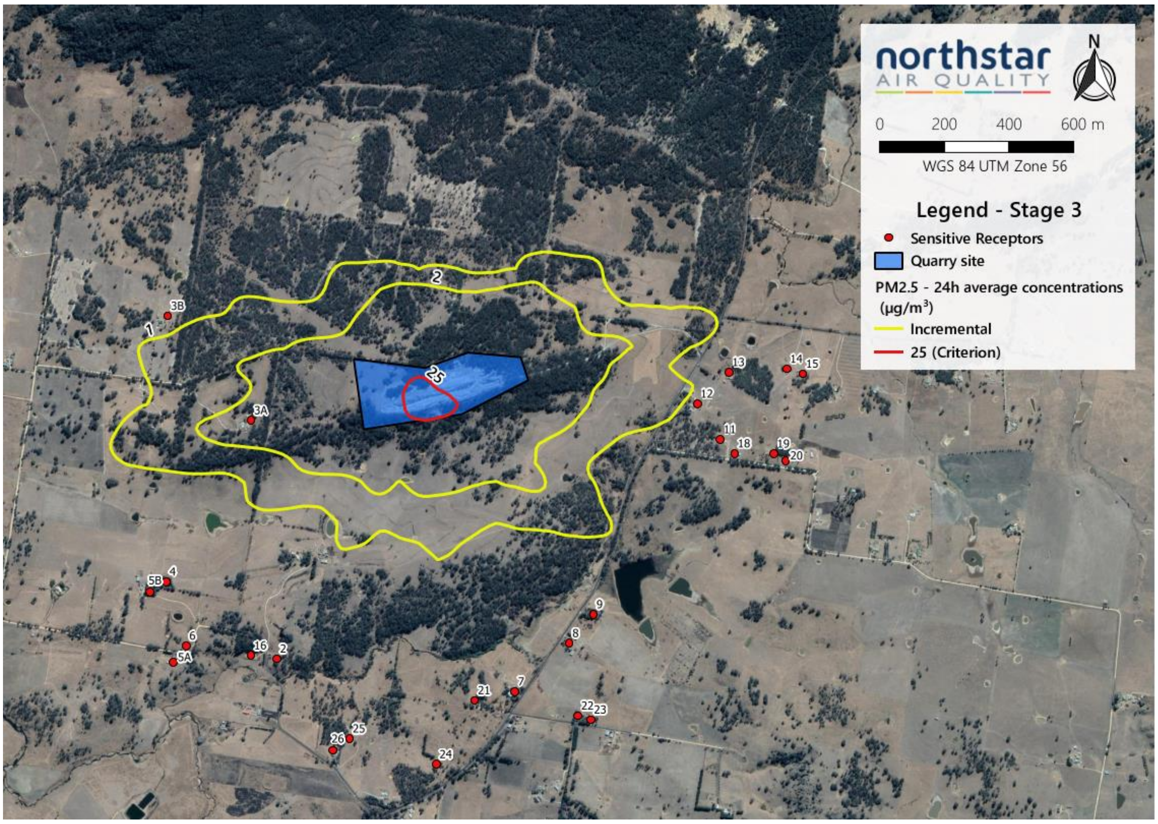


Figure 19
Predicted Incremental Maximum 24-hour Average $PM_{2.5}$ Concentrations – Stage 3



6.4 BLAST FUME ASSESSMENT

A blast fume assessment has been performed to assess the potential impact of NO_2 resulting from blasting activities, on surrounding receptor locations. Short-term impacts of NO_2 have been assessed, as given the low numbers of blasts each year (12), impacts over the longer term would be minimal.

Information provided by the Applicant indicates that approximately 15 t of explosive are used for each blast, and a NO_X emission rate of 3.8 $kg \cdot t^{-1}$ explosive was adopted, as per (DEE, 2016) for holes of diameter <102 mm. The emission rate is associated with Ammonium Nitrate Fuel Oil (ANFO), although the blast report provided by the Applicant indicates that WALA explosives are used at the Quarry Site. This is a new type of gel-based explosive, designed to be water resistant and reduce post blast fuming[3]. It would be anticipated that NO_X emissions from the use of WALA explosives would be less than that assumed within this assessment, although to provide a conservative assessment, the use of ANFO has been assumed.

NO_X concentrations have been predicted using the dispersion modelling approach as outlined in Section 5. One scenario has been modelled which has included one blast emissions estimates as outlined in **Annexure 3**. The conversion of NO_X to NO_2 has been performed using the method 2, level 1 approach as outlined in the NSW EPA 'Approved Methods' document. That approach follows the following steps (from the 'Approved Methods'):

1. *Use a dispersion model to predict 1-hour average and annual ground-level concentrations of NOx (as NO_2).*
2. *Assume 100% of the NOx emitted is converted to NO_2 ($[NOx]_{pred}$ in Equation 8.1).*
3. *Determine the maximum 1-hour and annual average background concentrations of NO_2 and O_3 ($[NO_2]_{bkgd}$ and $[O_3]_{bkgd}$ respectively in Equation 8.1).*
4. *Determine the maximum total 1-hour and annual average ground-level concentrations of NO_2 ($[NO_2]_{total}$ in Equation 8.1) by substituting $[NOx]_{pred}$, $[NO_2]$bkgd and $[O_3]_{bkgd}$ into Equation 8.1.*

Equation 8.1

$$[NO_2]_{total} = \{0.1 \times [NOx]_{pred}\} + MIN\{(0.9) \times [NOx]_{pred} \text{ or } (46/48) \times [O_3]_{bkgd}\} + [NO_2]_{bkgd}$$

where:

$[NO_2]_{total}$ = *the predicted concentration of NO_2 in $\mu g/m^3$*

$[NOx]_{pred}$ = *the dispersion model prediction of the ground-level concentration of NOx in $\mu g/m^3$*

MIN = the minimum of the two quantities within the braces

$[O_3]_{bkgd}$ = *the background ambient O_3 concentration in $\mu g/m^3$*

(46/48) = the molecular weight of NO_2 divided by the molecular weight of O_3 in $\mu g/m^3$

$[NO_2]_{bkgd}$ = *the background ambient NO_2 concentration in $\mu g/m^3$*

[3] http://www.sunminingservices.com.au/products/wala

Ozone (O_3) and NO_2 concentrations were not measured at Tamworth during 2015 and an alternative data source to represent regional concentrations of those pollutants was required. In the absence of any information from more proximate locations, data measured at the Gunnedah AQMS by NSW DPI&E in 2019 was obtained. Although not contemporaneous with the assessment year of 2015 adopted throughout this report, the use of maximum incremental NO_X predictions does not require the use of a contemporaneous dataset and this approach is considered to be valid. The results of the assessment are presented in **Table 31**.

Table 31
Predicted Maximum 1-hour NO_2 Concentrations

Receptor	Maximum 1-hour NO_2 Concentration ($\mu g \cdot m^{-3}$)		
	Increment	Background	Cumulative
2	2.9	73.8	76.7
3A	6.2	73.8	80.0
3B	10.8	73.8	84.6
4	2.8	73.8	76.6
5A	4.3	73.8	78.1
5B	2.8	73.8	76.6
6	4.3	73.8	78.1
7	7.7	73.8	81.5
8	6.3	73.8	80.1
9	5.8	73.8	79.6
11	9.7	73.8	83.5
12	20.2	73.8	94.0
13	23.8	73.8	97.6
14	17.0	73.8	90.8
15	16.0	73.8	89.8
16	3.4	73.8	77.2
18	12.4	73.8	86.2
19	6.0	73.8	79.8
20	5.9	73.8	79.7
21	6.7	73.8	80.5
22	5.5	73.8	79.3
23	4.8	73.8	78.6
24	5.3	73.8	79.1
25	2.0	73.8	75.8
26	1.9	73.8	75.7
Criterion	246	246	246

The maximum 1-hour incremental NO_2 concentration is predicted to be 23.8 $\mu g \cdot m^{-3}$ (at Receptor 13). With the addition of the maximum background NO_2 concentration, the cumulative impacts are anticipated to be 97.6 $\mu g \cdot m^{-3}$, or <40% of the criterion.

Further discussion of blast management is provided in Section 8.2.

7. GREENHOUSE GAS ASSESSMENT

7.1 CALCULATION OF GHG EMISSIONS

Based on the activity data and emissions factors outlined in Section 5.2, **Table 32** presents the calculated Scope 1 and 3 GHG emissions associated with the Proposal. Note that no Scope 2 emissions have been calculated given that electricity is anticipated to be generated through a small diesel generator.

Table 32
Greenhouse Gas Emissions

Emission Scope	Emission Source	Emission Factor	Energy Content Factor	Activity Rate	Emissions ($t\ CO_2\text{-}e{\cdot}yr^{-1}$)
Scope 1	Diesel fuel for mobile plant and equipment	70.2 kg CO_2-e GJ^{-1}	38.6 GJ·kL^{-1}	240 kL·$annum^{-1}$	650.3
	Diesel fuel for material transport	70.5 kg CO_2-e GJ^{-1}	38.6 GJ·kL^{-1}	74.5 kL·$annum^{-1}$	202.7
				Total Scope 1	**853.1**
Scope 2	Electricity consumption	0.82 kg CO_2-e kWh^{-1}	-	0 kWh·$annum^{-1}$	0.0
				Total Scope 2	**0.0**
Scope 3	Diesel fuel for mobile plant and equipment	3.6 kg CO_2-e GJ^{-1}	38.6 GJ·kL^{-1}	240 kL·$annum^{-1}$	33.4
	Unleaded fuel for employee transport	3.6 kg CO_2-e GJ^{-1}	34.2 GJ·kL^{-1}	5.3 kL·$annum^{-1}$	0.7
	Diesel fuel for material transport	3.6 kg CO_2-e GJ^{-1}	38.6 GJ·kL^{-1}	74.5 kL·$annum^{-1}$	10.4
				Total Scope 3	**44.4**

7.2 COMPARISON WITH NATIONAL TOTALS

A comparison of the calculated GHG emissions associated with the Proposal, and NSW and Australian emissions in 2017 is presented in **Table 33**.

Table 33
Greenhouse Gas Emissions in Context

Emission Scope	Proposal total ($t\ CO_2\text{-}e{\cdot}yr^{-1}$)	Emissions ($Mt\ CO_2\text{-}e{\cdot}yr^{-1}$)	
		Australia (2017) (excluding LULUCF) 530.8 Mt	NSW (2017) 131.5Mt
Scope 1	853.1	0.00016%	0.00065%

Note: LULUCF = Land Use Land Use Change and Forestry

These data indicate that the operation of the Proposal would contribute up to 0.00065% of NSW total GHG emissions and up to 0.00016% of Australian total GHG emissions in 2017.

7.3 MANAGEMENT OF GHG EMISSIONS

The above assessment indicates that GHG emissions resulting from the operation of the Proposal are anticipated to be small, although emissions could be further reduced through the application of a number of measures:

- All vehicles/plant and machinery should be turned off when not in use and regularly serviced to ensure efficient operation, including the optimisation of tyre pressures;
- Truck routes and loading capacity should be designed to reduce the distance and effort required by the vehicles;
- Maintenance of roads in good condition to avoid meandering of vehicles;
- Reducing gradients around site where feasible; and
- Where possible, B5 fuel should be used in plant and equipment.

8. AIR QUALITY MONITORING AND MANAGEMENT

The results of the air quality impact assessment presented in Section 6 indicate that the Proposal can be operated without resulting in exceedances of the relevant air quality criteria. It is noted that a number of conservative assumptions, particularly related to materials processing, result in predicted impacts being significantly greater than those likely during actual operation of the Proposal.

Given the level of community concern, ongoing air quality monitoring is considered to be required as part of the Proposal. The Air Quality Management Plan (AQMP) (DMC, 2015) for the current operations at the Quarry includes a section relating to air quality monitoring and concludes that the need for implementation of air quality monitoring should arise only following a substantiated air quality complaint. This AQMP would be updated following approval and would include detail on the air quality monitoring program to be performed. The AQMP would be updated to reflect the current air quality criteria applicable to the Proposal as outlined in Section 3.

The following sections outline the broad approach to air quality monitoring. The aim of this section is to provide some comfort to NSW EPA and the local community that there are plans to perform ongoing monitoring to assess the performance of the Proposal.

8.1 AIR QUALITY MONITORING

The Applicant is currently in discussions regarding the exact equipment which would be deployed to measure particulate concentrations at a location(s) surrounding the Quarry Site. It is considered at this time that a continuous particulate matter monitor utilising a light scattering device (e.g. an E-Sampler or Dusttrak) is likely to be deployed on site. The use of a solar-powered power supply would allow the equipment to be deployed around the Quarry Site to, for example, respond to any community complaints, monitor potential impacts from blasting at nearby residences, or provide ongoing information on any changes to the particulate environment resulting from Quarry operations.

A continuous air quality monitor can provide a range of useful information and can be set-up to provide triggers to alert site personnel should particulate concentrations be approaching pre-determined levels at identified locations. These data can assist with the management of site activities to ensure that particulate generating activities are modified or ceased in a hierarchical and responsive manner to minimise the risk of exceeding the relevant air quality criteria to protect human health.

Three deposited dust gauges have been installed at the Quarry and monitoring of deposited dust would continue during operations.

A weather station with real-time reporting capabilities will be installed at the Quarry to assist in the proactive management of operations, such as blasting or processing. The weather station would also provide information which may assist in the review of air quality monitoring data, or any complaints which may be received.

The locations for monitoring would be finalised during preparation of an update to the existing Air Quality Management Plan.

8.2 BLAST MANAGEMENT PLAN

The dispersion modelling study presented in Section 6.4 is necessarily conservative and assumes that a blast occurs on each hour of the year, and that during each blast, winds act to transport those emissions towards the location of each sensitive receptor. The results presented in Section 6.4 are therefore highly conservative.

Prior to the commencement of Stage 1, a Blast Management Plan would be prepared, which would outline all the measures to be implemented to ensure that impacts associated with dust and fume emissions at all surrounding sensitive receptor locations are minimised. The Blast Management Plan would be supported by a dispersion modelling study that examines the influence of on-site meteorological conditions on the propagation of blast fume. That study would provide a tiered risk assessment appraisal of those conditions such that blasting emissions may be managed (or controlled, delayed or postponed) during the respective prevailing conditions. That decision process would be recorded in the Blasting Report.

The control of blast fume would be managed through the application of the following controls:

- Fine material collected during drilling will not be used for blast stemming;
- All blast holes would be adequately stemmed with aggregate;
- Blasts would be limited to one event per day;
- Blasting to only occur between the hours 10.00 am and 4.00 pm, Monday to Friday; and,
- In excessive wind events (i.e. prolonged visual dust observed in a particular area), temporary halting of blasting activities and resuming when weather conditions have improved following appropriate assessment of weather conditions.

A professional contractor would be hired to survey the blast area, create a Blasting Plan and to conduct the blast. Blasting would only occur following appropriate assessment of weather conditions by the Environment Coordinator (or equivalent role) (as described briefly above) and the professional and suitably qualified Drill and Blast Superintendent to ensure that wind speed and direction will not result in the transport of excess fume (or dust) emissions from the site in the direction of the sensitive receptor locations. This measure will be effective in controlling off-site impacts due to fumes released during blasting operations.

Additionally, the design for each blast will aim to maximise the blast efficiency and minimise the emission of fumes (as well as dust and odour) in order to ensure compliance with site specific blasting criteria.

9. CONCLUSIONS

9.1 AIR QUALITY

A detailed air quality impact assessment (AQIA) has been performed to assess the potential impacts of existing, Stage 1, Stage 2, and Stage 3 operations to be performed as part of the ongoing and expanded Dowes Quarry operation.

The AQIA has been performed in accordance with the NSW Environment Protection Authority (EPA) *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* document (NSW EPA, 2017), and with due reference to the Secretary's Environmental Assessment Requirements (SEARs), and NSW EPA requirements (refer **Table 1**). The AQIA has been updated to take into account comments from NSW EPA and the community on the initial submission.

The air quality criteria applicable to the AQIA have been adopted from Commonwealth and State legislation and guidance, and approval conditions and are presented in Section 3. Criteria associated with silica have been adopted from Victorian Environment Protection Authority guidelines.

A modelling exercise has been performed to characterise the meteorological environment of the area surrounding the Quarry Site. A full description of the input data, modelling and validation of the outputs is presented in **Annexure 1**. Importantly, the approach to meteorological modelling has been updated to reflect NSW EPA comments.

A detailed dispersion modelling exercise has been performed to characterise the predicted impacts from the Proposal at a number of surrounding privately-owned receptors. A background air quality dataset discussed in detail in **Annexure 2** has been adopted and added to those modelled impacts to determine a total, cumulative impact.

Details of the operations of the Proposal during Stage 1, Stage 2, and Stage 3 have been used to generate emissions inventories characterising the operation of the Quarry. These are outlined in full in **Annexure 3**. Dust control measures for emissions sources have been identified and adopted where appropriate.

For the purposes of providing 'worst-case' assessment results, with which to compare against the long and short-term air quality criteria, processing operations at the Quarry Site have been assumed to operate at a throughput of 230 000 t per annum, or a maximum of 5,000 t per day during Stage 1, Stage 2 and Stage 3. These activity rates are significantly greater than those which are likely to be experienced as part of ongoing Quarry operations.

These conservative assumptions provide confidence that the impacts of the Proposal are not likely to be greater than those presented within this assessment.

<u>The dispersion modelling exercise indicates that the Proposal can operate across all stages of development with no exceedances of adopted air quality criteria.</u>

Air quality monitoring is proposed to be performed should the expanded Quarry operations gain approval. The monitoring will allow the Applicant to respond to any community complaints, monitor potential impacts from blasting at nearby residences, or provide ongoing information on any changes to the particulate environment resulting from Quarry operations.

A Blast Management Plan would be constructed prior to any expanded operations (supported by a risk assessment regarding the influence of prevailing meteorological conditions), and a brief management plan has been provided, which would be developed following approval.

9.2 GREENHOUSE GAS

A greenhouse gas (GHG) assessment has been performed to examine the potential impacts of the operation of the Proposal relating to emissions of GHG. A quantitative assessment of emissions has been performed with emissions compared with total national and NSW GHG emissions for context.

Emissions associated with the Proposal are anticipated to represent 0.00065 % of Australian and 0.00016 % of NSW emissions totals for the year 2017.

Emissions are proposed to be reduced further through the implementation of a maintenance program for all plant and equipment, and the investigation into using B5 fuel where possible.

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Annexures

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Annexure 1

Meteorology and Climatology

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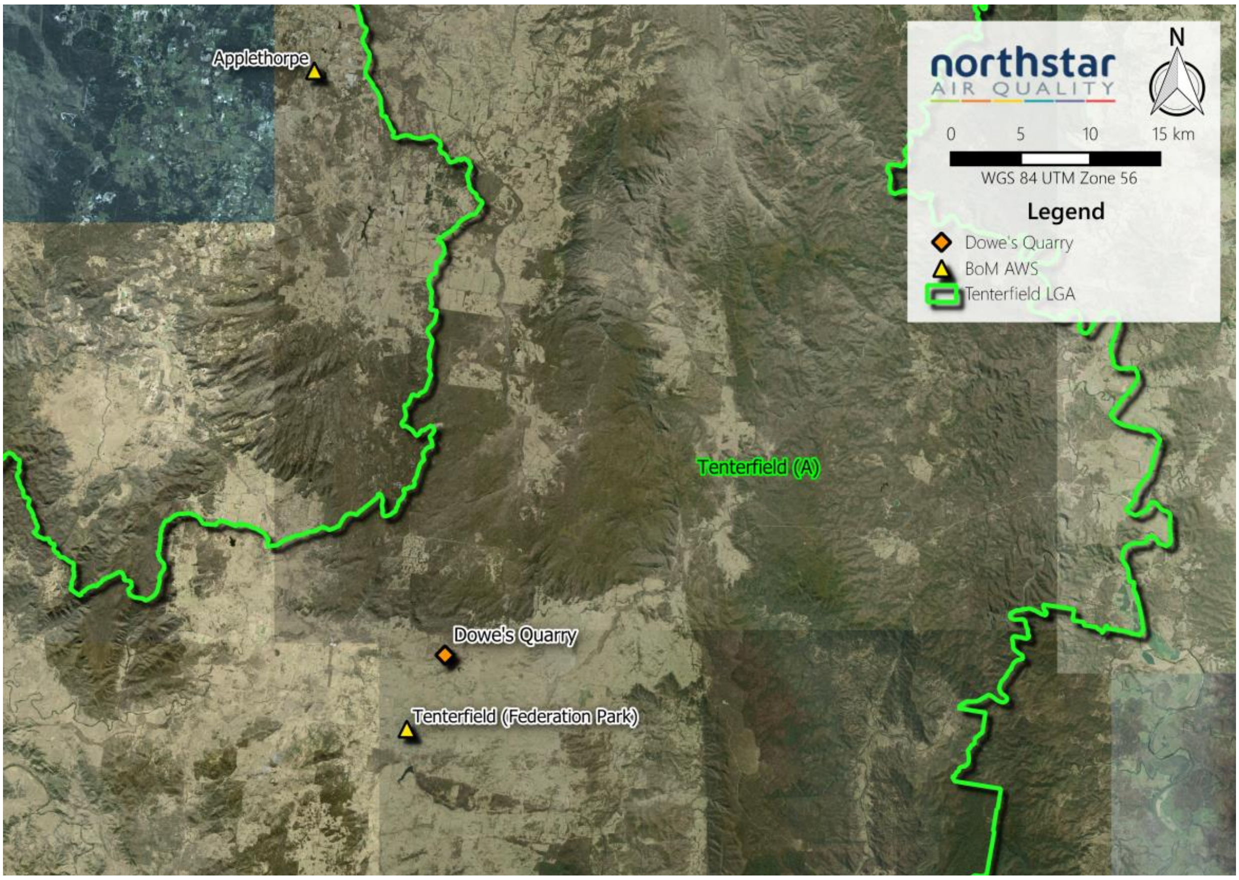
METEOROLOGY

The meteorology experienced within a given area can govern the generation (in the case of wind dependent emission sources), dispersion, transport and eventual fate of pollutants in the atmosphere. Dust generation is particularly dependent on wind speed and on the moisture budget, which is a function of evaporation and rainfall.

Meteorological parameters are not measured at the Quarry Site, and therefore data has been sourced from the Australian Government Bureau of Meteorology (BoM) to characterise the conditions which may be experienced at the Quarry Site. The closest automatic weather station (AWS) to the Quarry Site is located at Tenterfield (Federation Park) which is approximately 6.1 km to the southwest. The next closest AWS is located 42.8 km to the northwest at Applethorpe.

The location of the Tenterfield (Federation Park) and Applethorpe AWS are illustrated in **Figure 1-1**.

Figure 1-1 Meteorological monitoring stations surrounding the Proposal site



Source: Northstar Air Quality Pty Ltd

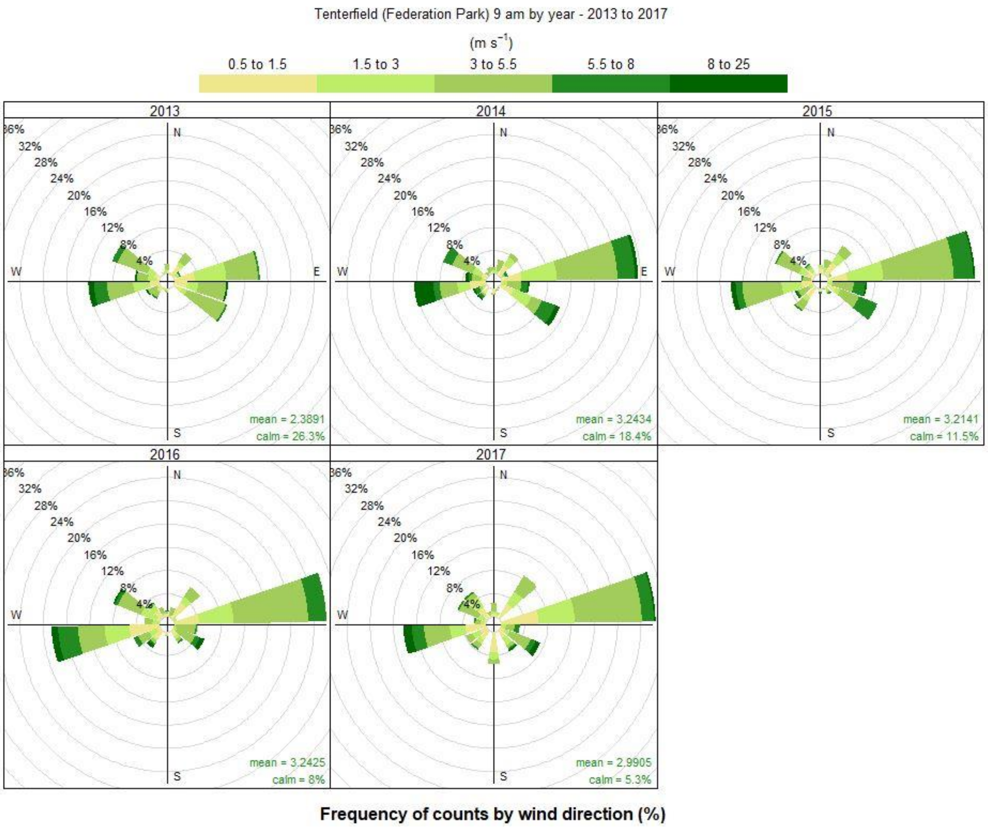
As discussed in Section 4.3 a meteorological modelling exercise has been performed to characterise the meteorology of the Quarry Site in the absence of site-specific measurements. The meteorological modelling has been validated using measurements taken at Tenterfield (Federation Park) AWS.

It is noted that the AWS at Tenterfield (Federation Park) only records 9am and 3pm wind speed and direction data. This is generally not considered appropriate for modelling validation, however, the nearest monitoring station measuring hourly wind data is over 82 km away at Glen Innes Airport AWS. Due to this distance it is not considered representative of the area where the Quarry resides, nor does it lie within an appropriate domain for meteorological modelling. Subsequently, in the absence of more suitable data, validation of meteorological modelling has been performed against the 9 am and 3 pm data sets as measured at the Tenterfield AWS.

Furthermore, it is noted that the dataset measured at the Tenterfield AWS does not contain 3 pm wind speed and direction data for 2016 and 2017. Subsequently, only 9 am data has been adopted in the assessment of longer-term trends and for validation purposes.

Meteorological conditions at the Tenterfield (Federation Park) AWS have been examined to determine a 'typical' or representative dataset for use in dispersion modelling. Annual wind roses for the most recent years at 9 am (2013 to 2017) are presented in **Figure 1-2**.

Figure 1-2 Annual wind roses for 9 am, 2013 to 2017, Tenterfield (Federation Park) AWS



The wind roses indicate that from 2013 to 2017 winds measured at the Tenterfield (Federation Park) AWS show a predominant easterly and westerly component at 9 am.

The majority of wind speeds experienced at the Tenterfield (Federation Park) AWS over the 5-year period at 9 am, are generally measured in the range of 0.5 metres per second ($m \cdot s^{-1}$) to 5.5 $m \cdot s^{-1}$ with the highest wind speeds (greater than 8 $m \cdot s^{-1}$) occurring from a westerly direction. Winds of this speed are not very common, occurring during 3.2 % of the observed hours over the 5-year period at Tenterfield AWS. Calm winds (<0.5 m·s^{-1}) occur during 14.0 % of hours on average across the 5-year period.

Given the wind distribution across the years examined, data for the year 2015 has been selected as being appropriate for further assessment, as it best represents the general trend across the 5-year period studied.

Presented in **Figure 1-3** are the 9 am annual wind rose for the 2013 to 2017 period and the year 2015 and in **Figure 1-4** the annual wind speed distribution for the Tenterfield (Federation Park) AWS.

It is noted that these observations have not been used to characterise the meteorology at the Quarry Site, but a meteorological modelling exercise has been performed which is discussed in detail in the following section.

Figure 1-3 Annual wind roses for 9am, 2013 to 2017, and 2015 Tenterfield (Federation Park) AWS

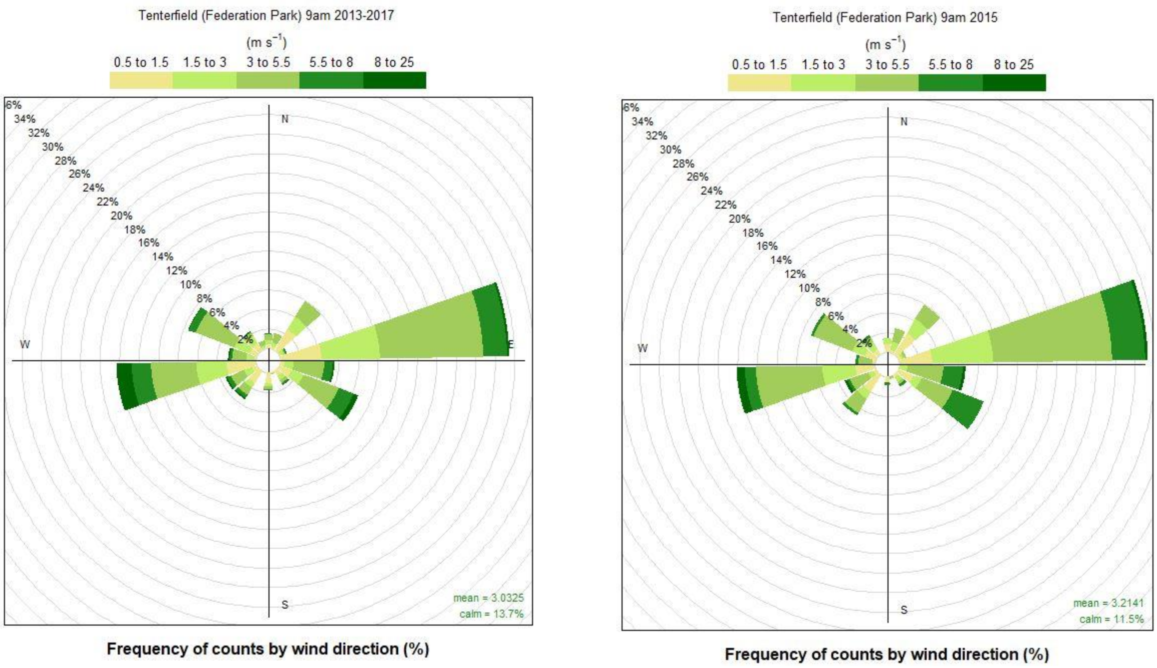
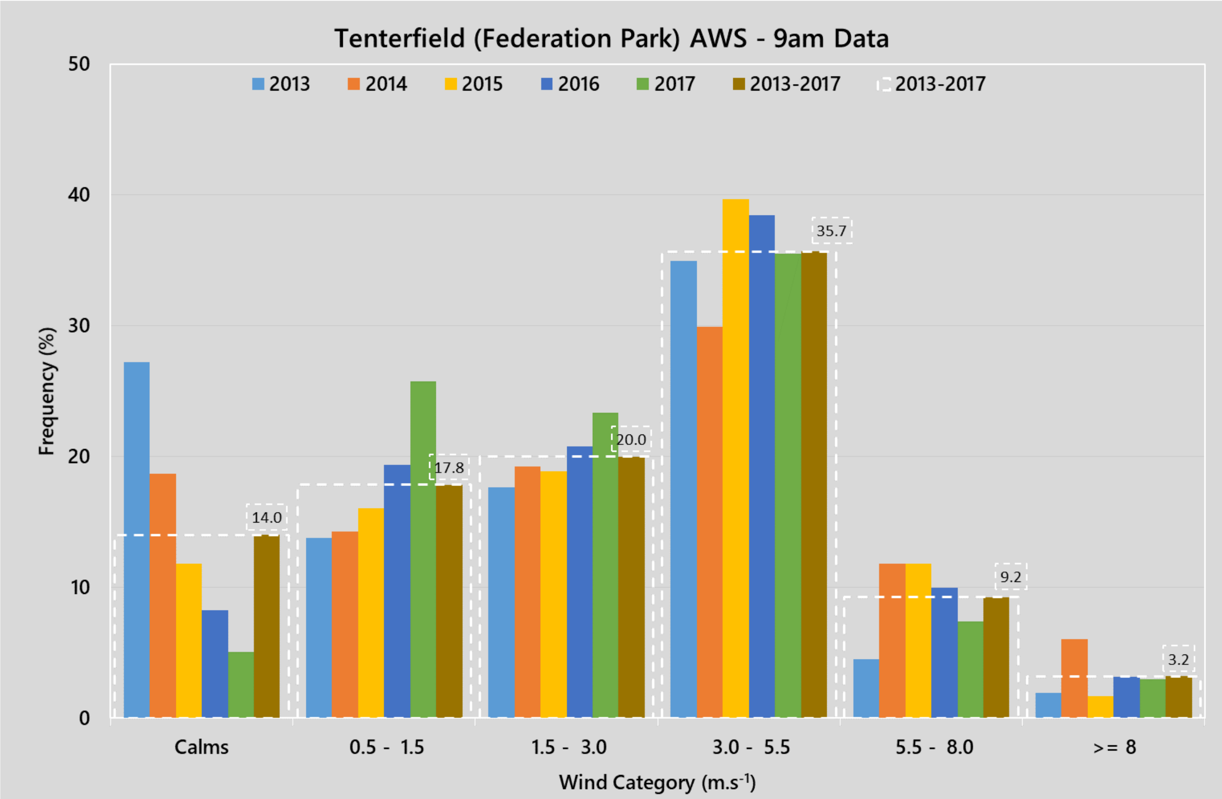


Figure 1-4 Annual wind speed distribution for 9 am – Tenterfield (Federation Park)



Meteorological Modelling

The BoM data adequately covers the issues of data quality assurance, however it is limited by its location compared to the Quarry site. To address these uncertainties, a multi-phased assessment of the meteorology data has been performed.

In absence of any measured onsite meteorological data, site representative meteorological data for the Quarry site was generated using the CALMET meteorological model in a format suitable for using in the CALPUFF dispersion model (refer **Section 5.1**).

CALMET is a meteorological model that develops wind and temperature fields on a three-dimensional gridded modelling domain. Associated two-dimensional fields such as mixing height, surface characteristics, and dispersion properties are also included in the file produced by CALMET. The interpolated wind field is then modified within the model to account for the influences of topography, as well as differential heating and surface roughness associated with different land uses across the modelling domain. These modifications are applied to the winds at each grid point to develop a final wind field and thus the final wind field reflects the influences of local topography and current land uses.

In this study, CALMET has been run in no-observations (no-obs) mode using gridded prognostic data generated by The Air Pollution Model (TAPM, v 4.0.5), developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

TAPM is a prognostic model which predicts wind speed and direction, temperature, pressure, water vapour, cloud, rainwater and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate site-specific hourly meteorological observations at user-defined levels within the atmosphere

The parameters used in TAPM and CALMET modelling are presented in **Table 1-1**.

Table 1-1
Meteorological parameters used for this study

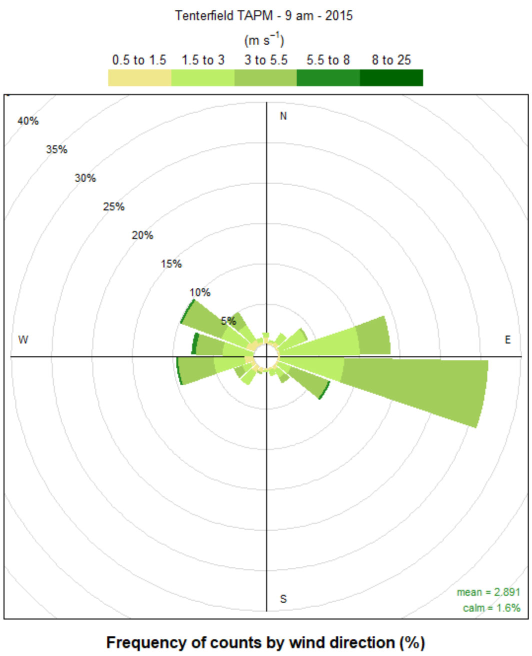
TAPM v 4.0.5	
Modelling period	1 January 2015 to 31 December 2015
Centre of analysis	406 656 mS, 6 791 636 mN (UTM Coordinates)
Number of grid points	25 x 25 x 25
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Terrain	AUSLIG 9 second DEM
Data assimilation	No assimilation
CALMET	
Modelling period	1 January 2015 to 31 December 2015
South-west corner of analysis	404 500 mS, 6 788 600 mE
Meteorological grid domain (resolution)	5 km x 5 km (0.1 km)
Vertical resolution (cell heights)	10 (0 m, 20 m, 40 m, 80 m, 160 m, 320 m, 640 m, 1200 m, 2000 m, 3000 m, 4000 m)
Data assimilation	No-obs approach using TAPM – 3D.DAT file

CALMET was run four times to reflect the changing topography of the Quarry Site between the existing scenario and Stage 1, 2 and 3 of proposed operations.

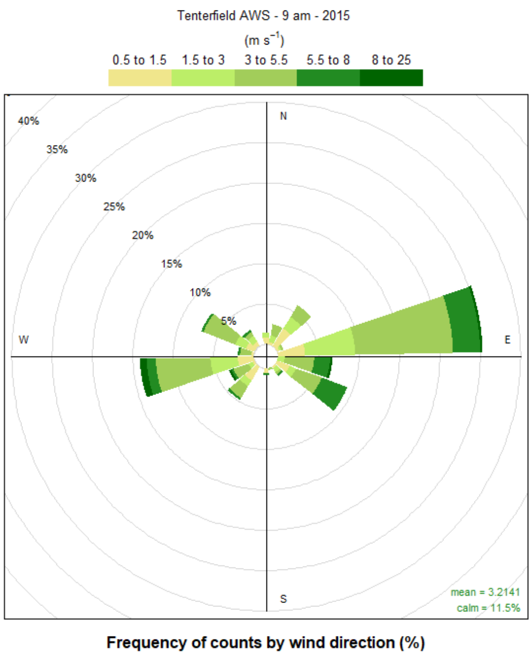
A comparison of the CALMET generated meteorological data associated with the existing scenario, and that observed at the Tenterfield (Federation Park) AWS is presented in **Figure 1-5**.

Figure 1-5 Modelled and observed meteorological data – Tenterfield (Federation Park) 9 am 2015

Tenterfield CALMET generated wind rose



Observations at Tenterfield AWS

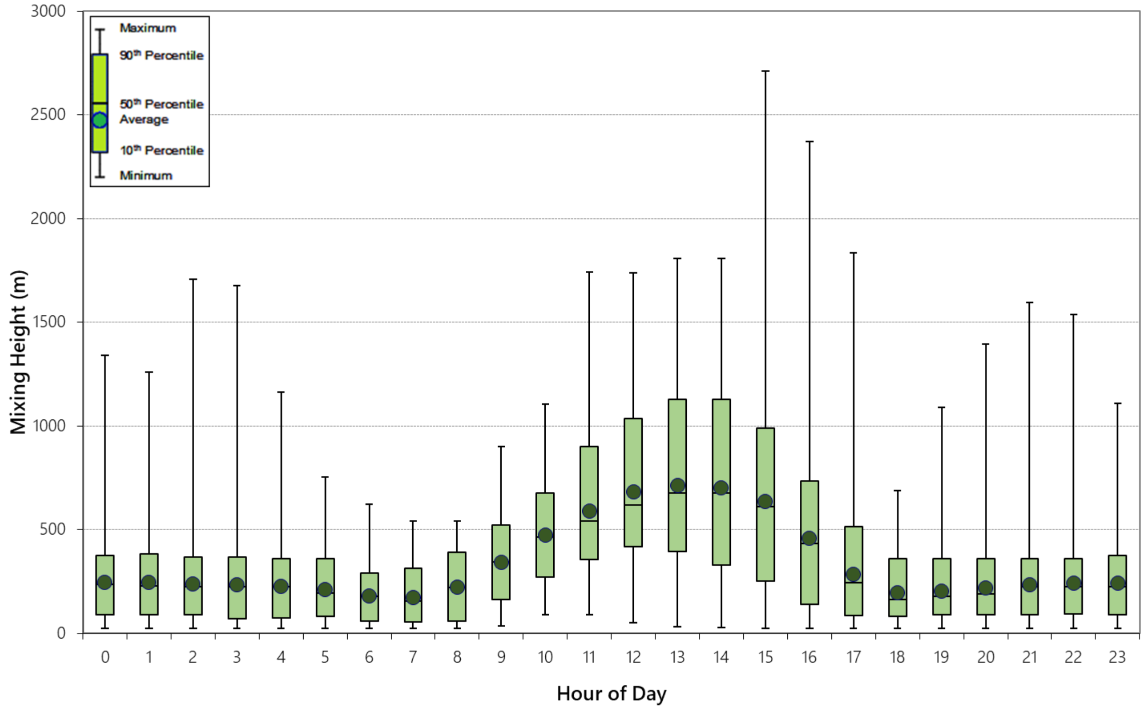


As generally required by the NSW EPA, the following provides a summary of the modelled meteorological dataset. Given the nature of the pollutant emission sources at the Quarry Site, detailed discussion of the humidity, evaporation, cloud cover, katabatic air drainage and air recirculation potential has not been provided. Details of the predictions of wind speed and direction, mixing height and temperature at the Quarry Site are provided below.

Diurnal variations in maximum and average mixing heights predicted by CALMET at the Quarry Site during 2015 are illustrated in **Figure 1-6**.

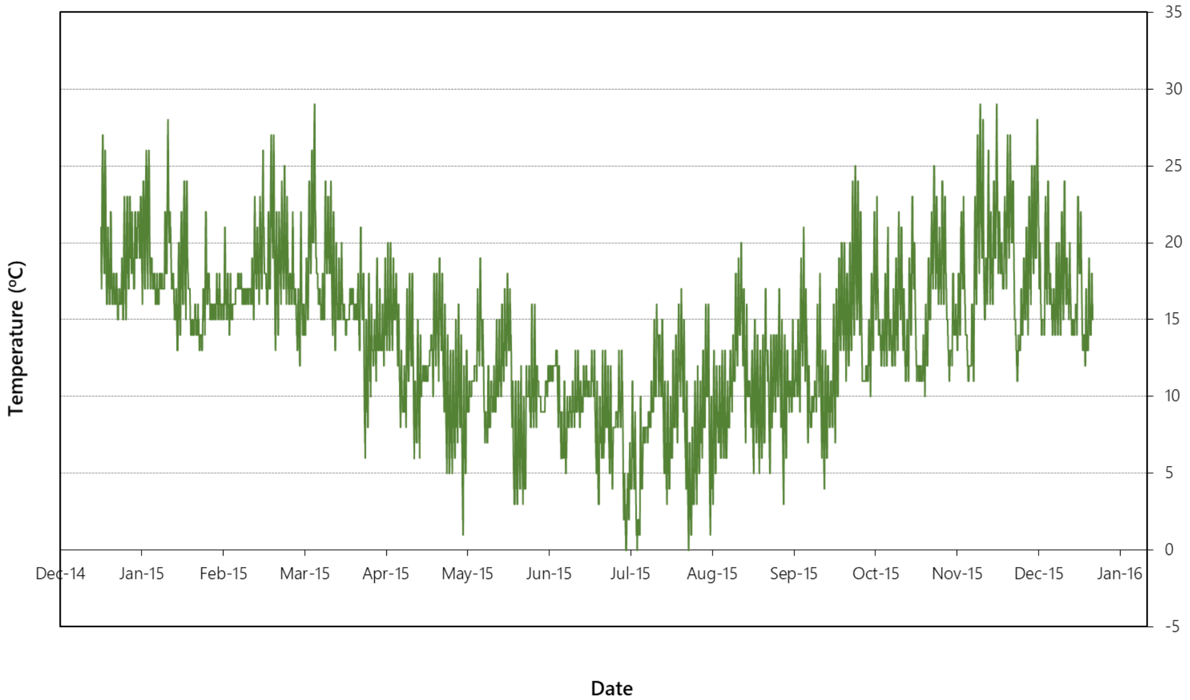
As expected, an increase in mixing height during the morning is apparent, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground-based temperature inversions and growth of the convective mixing layer.

Figure 1-6 Predicted mixing height – Quarry Site 2015



The modelled temperature variations predicted at the Proposal site during 2015 are presented in **Figure 1-7**.

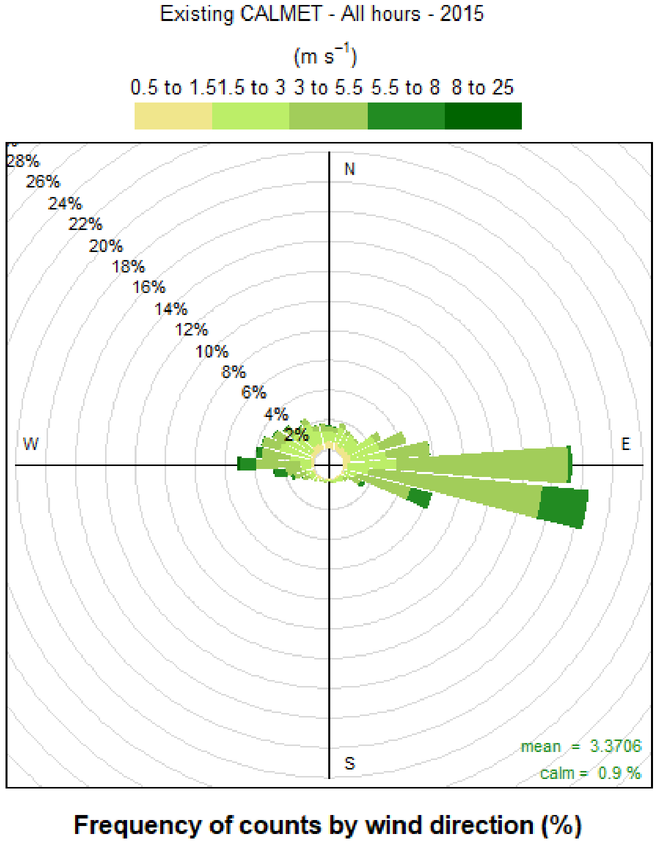
Figure 1-7 Predicted temperature –Quarry Site 2015



The maximum temperature of 29°C was predicted on the 20th March, and 26th November 2015 and the minimum temperature of 0°C was predicted on the 13th and 17th July and 5th August 2015.

The modelled wind speed and direction at the Quarry Site during 2015 are presented in **Figure 1-8**. These wind conditions are generally predicted to be similar in all operational scenarios at the point of extraction.

Figure 1-8 Predicted wind speed and direction –Quarry Site 2015



Annexure 2

Background Air Quality

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Air quality data is not monitored at the Quarry Site and therefore air quality data measured at a representative location has been adopted for the purposes of this assessment. Determination of data to be used as a location representative of the Quarry and during a representative year can be complicated by factors which include:

- The sources of air pollutant emissions around the Quarry Site and representative air quality monitoring station (AQMS); and,
- The variability of particulate matter concentrations (often impacted by natural climate variability).

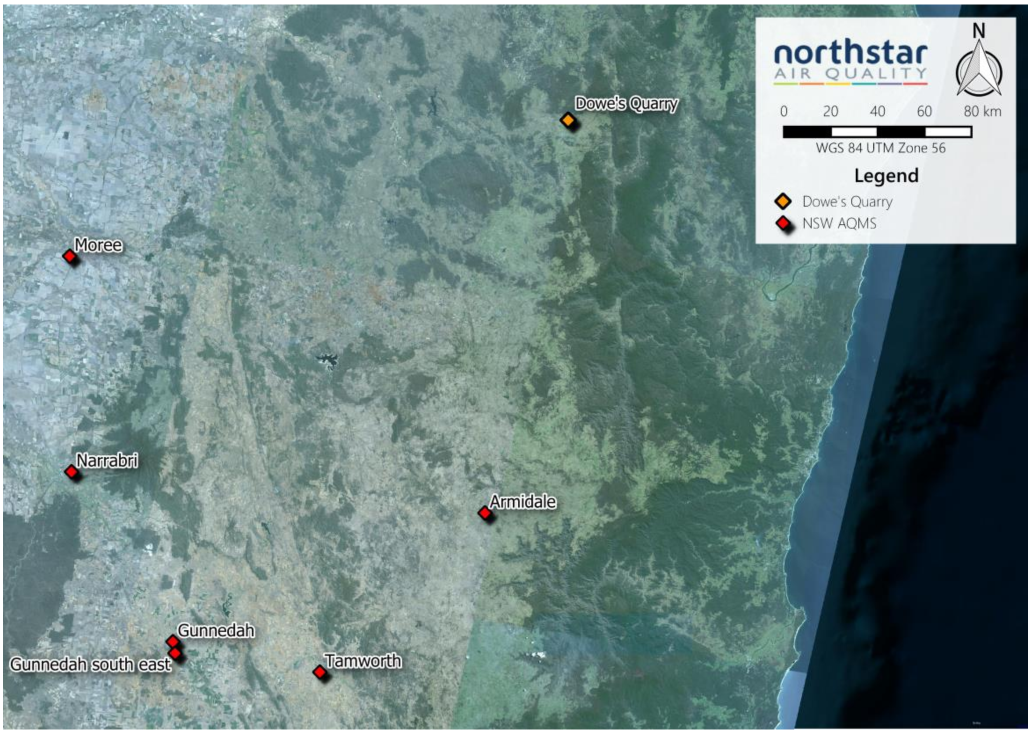
Air quality monitoring is performed by the NSW Department of Planning, Industry and Environment (DPI&E) at five AQMS in regional centres and as part of the Rural Air Quality Monitoring Network (RAQMN), within a 285 km radius of the Quarry Site. Details of the monitoring performed at these AQMS is presented in **Table 2-1** and **Figure 2-1**.

Table 2-1
Closest DPI&E AQMS to the Quarry

AQMS Location	Distance to Site (km)	Network[(1)]	Screening Parameters			
			2015 Data	Measurements		
				PM_{10}	$PM_{2.5}$	TSP
Armidale	171.3	RAQMN	×	×	×	✓
Moree	220.5	RAQMN	×	×	×	✓
Tamworth	258.2	AQMS	✓	✓	×	×
Narrabri	259.7	AQMS	✓	✓	×	×
Gunnedah	579.2	AQMS	✓	✓	×	×
Gunnedah South East	282.5	RAQMN	×	×	×	✓

Note: (1) RAQMN – Regional Air Quality Monitoring Network, Regional – Regional centre

Figure 2-1 Air quality monitoring stations surrounding the Quarry Site

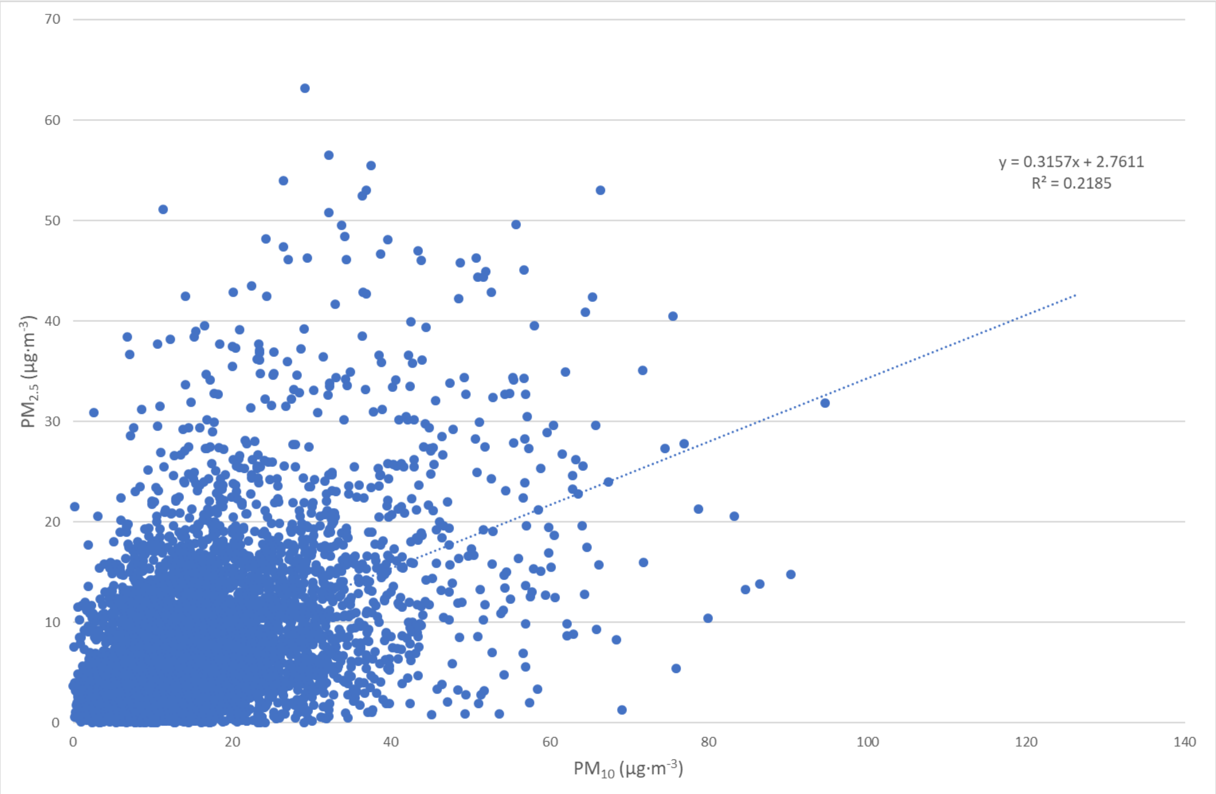


Source: Northstar Air Quality Pty Ltd

The closest identified AQMS to the Quarry Site with continuous data which is able to be adopted for use in this AQIA is located at Tamworth. It is noted that the AQMS located at Armidale and Moree, both of which are more proximate to the Quarry, do not measure PM_{10}, which is of critical importance to this AQIA.

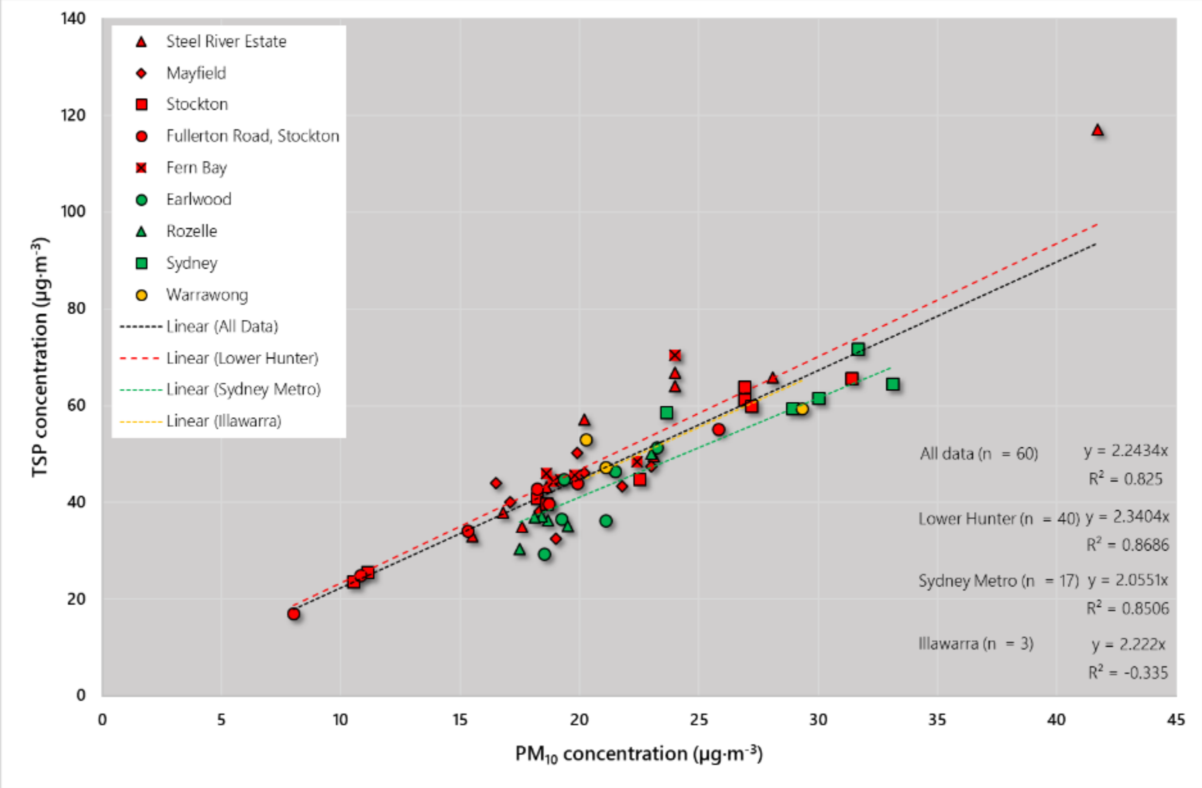
All identified monitoring stations did not measure $PM_{2.5}$ in 2015, and therefore a proxy measurement has been adopted/calculated. The proxy was calculated from the relationship between hourly PM_{10} and $PM_{2.5}$ data measured at Tamworth AQMS in 2016. An X-Y plot is presented in **Figure 2-2** to illustrate the relationship between the PM_{10} and $PM_{2.5}$ data as measured at Tamworth in 2016. The trendline equation ($PM_{2.5} = 0.3157 \times PM_{10} + 2.7611$) was used to calculate the proxy $PM_{2.5}$ using the PM_{10} data measured at Tamworth in 2015 data as input.

Figure 2-2 X-Y plot PM_{10} and $PM_{2.5}$ Tamworth 2016



It is noted that as part of the DPI&E Regional Air Quality Monitoring Network program there are AQMS that measure TSP, however access to that data is not available at the time of reporting. Based upon long-term historic monitoring data, an analysis of co-located measurements of TSP and PM_{10} in the Lower Hunter (1999 to 2011), Sydney Metropolitan (1999 to 2004) and Illawarra (2002 to 2004) regions is presented in **Figure 2-3**. The analysis concludes that, on the basis of the measurements collected in all regions between 1999 to 2011, the derivation of a broad TSP:PM_{10} ratio of 2.3404 : 1 (i.e. PM_{10} represents ~43% of TSP) from the Lower Hunter region is appropriate. In the absence of any more specific information, this ratio has been adopted within this AQIA, resulting in a background annual average TSP concentration of 33.0 µg·m^{-3} being adopted.

Figure 2-3 Co-located TSP and PM_{10} measurements, Lower Hunter, Sydney Metro and Illawarra



Summary statistics for TSP, PM_{10} and $PM_{2.5}$ are presented in **Table 2-2**.

Table 2-2
PM_{10} and $PM_{2.5}$ statistics 2015 – Tamworth

Page 1 of 2

Pollutant	TSP (µg·m^{-3})	PM_{10} (µg·m^{-3})	Proxy $PM_{2.5}$ (µg·m^{-3})
Averaging Period	**Annual**	**24-Hour**	**24-Hour**
Data Points (number)	361	361	361
Mean	33.0	14.1	7.2
Standard Deviation	-	6.1	1.9
Skew[1]	-	1.6	1.6
Kurtosis[2]	-	6.1	6.1
Minimum	-	3.6	3.9

Table 2-2 (Cont'd)
PM_{10} and $PM_{2.5}$ statistics 2015 – Tamworth

Page 2 of 2

Pollutant	TSP ($\mu g \cdot m^{-3}$)	PM_{10} ($\mu g \cdot m^{-3}$)	Proxy $PM_{2.5}$ ($\mu g \cdot m^{-3}$)
Percentiles ($\mu g \cdot m^{-3}$)			
1	-	4.7	4.2
5	-	6.4	4.8
10	-	7.3	5.1
25	-	10.2	6.0
50	-	12.9	6.8
75	-	17.0	8.1
90	-	22.1	9.7
95	-	24.5	10.5
97	-	26.3	11.1
98	-	28.8	11.9
99	-	30.8	12.5
Maximum	33.0	52.7	19.4
Data Capture (%)	98.9	98.9	98.9

Note: 1 - Skew represents an expression of the distribution of measured values around the derived mean. Positive skew represents a distribution tending towards values higher than the mean, and negative skew represents a distribution tending towards values lower than the mean. Skew is dimensionless.

2 - Kurtosis represents an expression of the value of measured values in relation to a normal distribution. Positive skew represents a more peaked distribution, and negative skew represents a distribution more flattened than a normal distribution. Kurtosis is dimensionless.

Graphs presenting the daily varying PM_{10} and proxy $PM_{2.5}$ data recorded at Tamworth in 2015 are presented in **Figure 2-4** and **Figure 2-5**, respectively.

Figure 2-4 PM_{10} measurements, Tamworth 2015

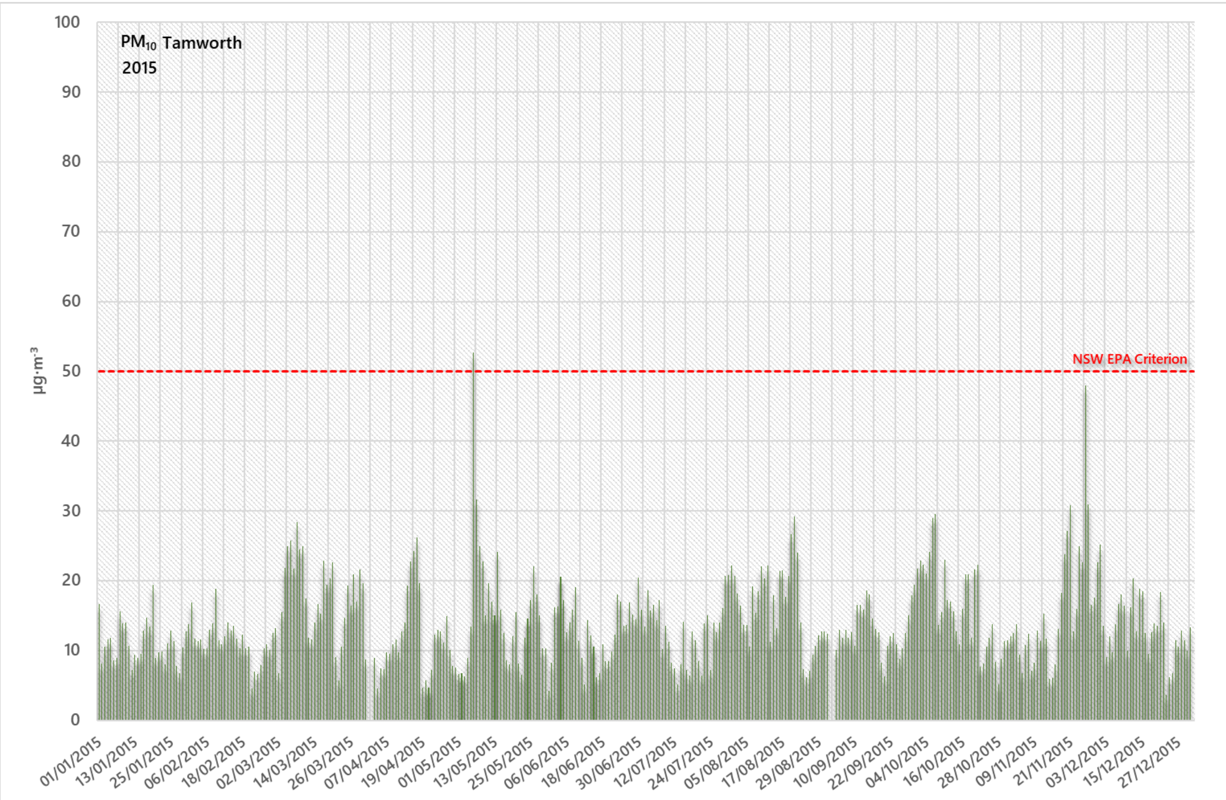
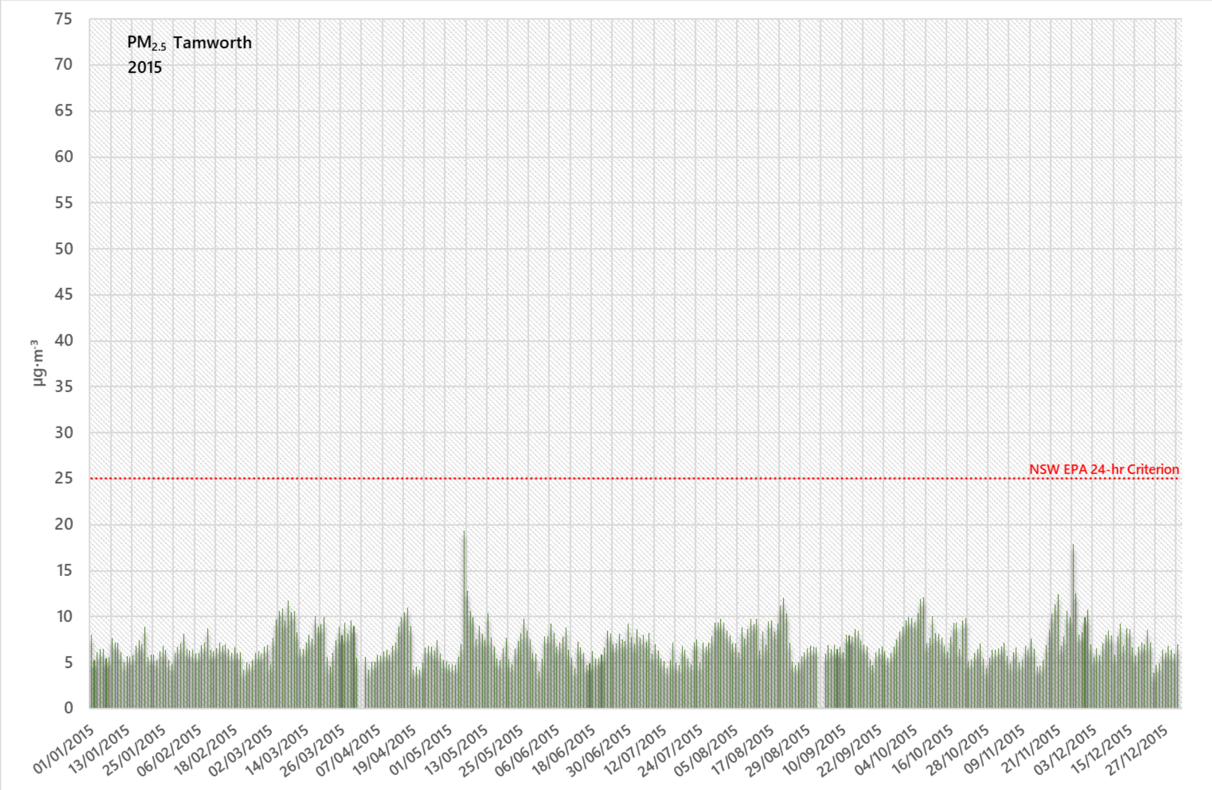


Figure 2-5 Proxy $PM_{2.5}$ measurements, Tamworth 2015



It is noted that the Approved Methods (NSW EPA, 2017) requires that background concentrations (as provided above) are added to dispersion model predictions to determine a 'cumulative' impact.

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Annexure 3

Emissions Estimation

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EMISSIONS ESTIMATION – EMISSION FACTORS

As outlined in Section 2.4, a number of operations to be performed as part of the Proposal have the potential to result in emissions of particulate matter. A detailed outline of the emission estimation techniques adopted to derive total emissions from the sources identified in Section 2.4 are presented below.

Emission factors published by the US EPA in the Compilation of Air Pollutant Emission Factors (AP-42) have been adopted to allow estimation of particulate matter emissions (TSP, PM_{10} and $PM_{2.5}$) from the Proposal operation. Several AP-42 sections have been consulted in the preparation of this assessment including:

- 11.9 Western Surface Coal Mining
- 11.19.2 Crushed Stone Processing and Pulverised Mineral Processing
- 13.2.2 Unpaved Roads
- 13.2.1 Paved Roads
- 13.2.4 Aggregate Handling and Storage Piles

Drilling and blasting

Emissions of particulate matter resulting from drilling and blasting have been estimated using the emission factor presented in Section 11.9 of AP-42 (Western Surface Coal Mining) (US EPA, 1998).

The emission factor in Table 11.9-2 has been adopted for blasting:

$$TSP\ (kg \cdot blast^{-1}) = 0.00022(A)^{1.5}$$

where:

A is the horizontal area (m^2) with blasting depth ≤ 12 m.

PM_{10} and $PM_{2.5}$ emission factors are derived using the scaling factors outlined in Table 11.9.2 of (US EPA, 1998), which are 0.52 for PM_{10} and 0.03 for $PM_{2.5}$ (applied to the TSP emission factor).

The emission factor in Table 11.9-4 has been adopted for drilling:

$$TSP\ (kg \cdot hole^{-1}) = 0.59$$

PM_{10} and $PM_{2.5}$ emission factors have been derived using the same scaling factors as for blasting as outlined above in the absence of drilling specific factors.

On average, up to 20 000 t of material is anticipated to be removed by each blast. Assuming a 12 m drill holed depth, a 3 m by 3 m hole pattern and a material density of 2.4 $t \cdot m^{-3}$, and up to 12 blasts each year (approximately one per month), the annual blasting area (m^2) in each of the modelled operational stages has been taken to be 8 333 m^2.

Blasting has also been assumed to occur during the assessment of maximum 24-hour impacts, and up to 50 000 t of material would be anticipated to be removed in a 'large' blast. Assuming the parameters outlined above, this would result in a blasting area of 1 736 m^2 per blast.

Loading and unloading, managing stockpiles

Emissions of particulate matter resulting from the loading of materials to trucks, and the unloading of materials at the raw feed, crusher hopper, overburden emplacement area and stockpiles, and the management of stockpiles at the processing plant have been estimated using the emission factor presented in Section 13.2.4 of AP-42 (Aggregate Handling and Storage Piles) (US EPA, 2006b).

The emission factor on page 13.2.4-4 has been adopted for the operations outlined above:

$$E\ (kg \cdot tonne^{-1}) = k(0.0016)\ \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

where:

E = emission factor

k = particle size multiplier (dimensionless)

U = mean wind speed ($m \cdot s^{-1}$)

M = material moisture content (%)

The particle size multiplier for TSP, PM_{10} and $PM_{2.5}$ are provided in (US EPA, 2006b) as 0.74, 0.35 and 0.2, respectively.

The value adopted for U (mean wind speed) has been calculated from the output of the modelled meteorological file which is discussed in detail in **Annexure 1**. This value has been calculated to be 3.4 $m \cdot s^{-1}$.

The value adopted for M (material moisture content) has been assumed to be 2 % for all materials handled at the Quarry Site. A review of several AQIA was performed which indicates that a range of values between 2 % and 5 % moisture content for materials handled at hard rock or aggregate quarries have been previously adopted:

- 2 % for soil as per page 17 of (GHD, 2016)
- 4 % for hard rock as per page 24 of (GHD, 2009)
- 3 % for rock and 5% for overburden as per page 25 of (Heggies, 2008)
- 2 % for aggregate as per page B-4 of (Pacific Environment Limited, 2017)
- 5 % for hard rock and 4% for product as per page 3-38 of (BMT WBM Pty Ltd, 2011)

In the case of the AQIA reviewed, no source data for those moisture content values are provided. For the purposes of this assessment, a value of 2 % has been adopted for all materials to be handled as part of Proposal operations. This is the lowest value of those reviewed and is conservative.

Processing

Emissions of particulate matter resulting from the processing of materials (crushing and screening) have been estimated using the emission factors presented in Section 11.19.2 of AP-42 (Crushed Stone Processing and Pulverised Mineral Processing) (US EPA, 2004).

For uncontrolled tertiary crushing (and uncontrolled primary and secondary crushing):

$$\text{TSP}\ (kg \cdot tonne^{-1}) = 0.0027$$

$$\text{PM}_{10}\ (kg \cdot tonne^{-1}) = 0.0012$$

$$\text{PM}_{2.5}\ (kg \cdot tonne^{-1}) = 0.00012$$

$PM_{2.5}$ emission factors are not available in AP42 although have been taken to be 10% of PM_{10} as per aggregate handling sources (MRI, 2006).

For uncontrolled screening:

$$\text{TSP}\ (kg \cdot tonne^{-1}) = 0.0125$$

$$\text{PM}_{10}\ (kg \cdot tonne^{-1}) = 0.0043$$

$$\text{PM}_{2.5}\ (kg \cdot tonne^{-1}) = 0.00043$$

$PM_{2.5}$ emission factors are not available in AP42 although taken to be 10 % of PM_{10} as per aggregate handling sources (MRI, 2006).

Transportation

Emissions of particulate matter resulting from the movement of materials on unpaved and paved roads have been estimated using the emission factors presented in Section 13.2.2 (Unpaved Roads) and 13.2.1 (Paved Roads) of AP-42, respectively (US EPA, 2006a), (US EPA, 2011).

The emission factor on page 13.2.2-4 of (US EPA, 2006a) has been adopted for the operations of vehicles on unpaved roads:

$$E\ (kg \cdot VKT^{-1}) = 0.2819\ \times k(s/12)^{a}(W\ \times\ 0.907185/3)^{b}$$

where:

E = emission factor (kg per vehicle kilometre travelled) multiplied by 0.2819 to convert from lb per vehicle mile travelled

k = particle size multiplier (dimensionless)

s = surface material silt content (%)

W = mean vehicle weight (tons) multiplied by 0.907185 to convert to metric tonnes

The particle size multipliers for TSP, PM_{10} and $PM_{2.5}$ (k) are provided in (US EPA, 2006a) as 4.9, 1.5 and 0.15, respectively. The silt content (s) of unpaved haul roads at the Quarry Site has been taken to be 8.3 % which equates to a haul road to/from pit at a stone quarrying and processing facility (Table 13.2.2-1 of (US EPA, 2006a)). This is considered to most appropriately reflect the proposed operations.

The mean weight (W) of vehicles has been calculated based on the use of '40 t' dump trucks, such as the CAT 771D (or similar) which has a payload of 41 t, tare weight of 34.7 t and a loaded weight of 75.7 t (ritchiespecs.com). The average vehicle weight has therefore been calculated to be 55.2 t (metric).

The emission factor on page 13.2.1-4 of (US EPA, 2011) has been adopted for the operations of vehicles on paved roads:

$$E\ (kg \cdot VKT^{-1}) = k(sL)^{0.91}(W\ \times\ 0.907185)^{1.02}$$

where:

E = emission factor (kg per vehicle kilometre travelled)

k = particle size multiplier (dimensionless)

sL = road surface silt loading ($g \cdot m^{-2}$)

W = average weight (tons) of vehicles travelling the road multiplied by 0.907185 to convert to metric tonnes

The particle size multipliers for TSP, PM_{10} and $PM_{2.5}$ (k) are provided in (US EPA, 2011) as 3.23, 0.62 and 0.15, respectively.

The road surface silt loading (sL) of the paved haul road between Mt Lindesay Rd and the unpaved section of access road has been taken to be 0.6 $g \cdot m^{-2}$. This value is considered to represent a potential worst-case. (US EPA, 2011) provides discussion regarding limited access roadways with the recommendation that a silt loading value of 0.015 $g \cdot m^{-2}$ be adopted. The value of 0.6 $g \cdot m^{-2}$ is therefore considered to be conservative. It is noted that this value is consistent with that adopted in the previous AQIA for the Quarry (ENVIRON, 2014).

The mean weight of vehicles (W) has been calculated based on the use of 50 t capacity B-Double vehicles, which would have a payload of 50 t, tare weight of 13.5 t and a loaded weight of 63.5 t. The average vehicle weight has therefore been calculated to be 38.5 t (metric).

Wind Erosion

Emissions of particulate matter resulting from the wind erosion of materials from the extraction area, overburden emplacement, product stockpiling area (including material stockpiles) have been estimated using the emission factor presented in Section 11.9 of AP-42 (Western Surface Coal Mining) (US EPA, 1998).

The emission factor in Table 11.9-4 of (US EPA, 1998) has been adopted for the action of wind erosion:

$$\text{TSP } (tonne \cdot ha^{-1} \cdot yr^{-1}) = 0.85$$

$$\text{PM}_{10} \ (tonne \cdot ha^{-1} \cdot yr^{-1}) = 0.425$$

$$\text{PM}_{2.5} \ (tonne \cdot ha^{-1} \cdot yr^{-1}) = 0.06375$$

To determine PM_{10} and $PM_{2.5}$ emissions, the particle size multipliers in Section 13.2.5 (Industrial Wind Erosion) of AP-42 have been applied to TSP emissions, specifically 0.5 for PM_{10} and 0.075 for $PM_{2.5}$ (US EPA, 2006c).

ACTIVITY DATA

Activity data for each modelled phase of the operations to be performed as part of the Proposal are presented in **Table 3-1** overleaf. Notes on the assumptions adopted in the calculation of those data are outlined below.

Note A: Quantity also reflects loading to trucks by excavator and unloading at final location

Note B: No overburden removal or transport assumed during peak daily activities

Note C: Assumed maximum fresh material transported from pit to processing plant during peak daily activities 1 400 t which equates to 35 truckloads, or approximately twice the daily average

Note D: Blasting assumed to occur during peak daily activities

Note E: Assumed 95% through jaw crusher

Note F: Maximum daily transport of material off site limited by approvals – maximum of 28 trucks per day

Note G: Processing in daily peak activities limited by capacity of equipment = 470 $t \cdot hr^{-1}$. Processing rate during daily peak activities assumed to be approximately 7 times greater than the average required.

Note H: Product stockpiles located in Product Storage Area. In pit stockpile areas covered by the area of the Extraction Area.

Note J: Area of overburden and fines emplacement included in area of 'extraction area'-relevant to Stage 2 and 3 only.

Length of transport routes in each Stage:

Existing

Overburden transport route – 0.25 km
Fresh rock transport route (unpaved) – 0.96 km
Fresh rock transport route (paved) – 0.77 km
Fines from Sunnyside to overburden transport route (unpaved) – 0.8 km
Fines from Sunnyside to overburden transport route (paved) – 0.77 km

Stage 1:

Overburden transport route – 0.64 km
Fresh rock to processing plant transport route – 0.36 km
Processing plant to Product Stockpiling Area transport route – 0.14 km
Product transport route from Product Stockpiling Area (unpaved) – 0.91 km
Product transport route (paved) – 0.77 km
Fines to overburden transport route – 0.28 km

Stage 2:

Overburden transport route – 0.53 km
Fresh rock to processing plant transport route – 0.25 km
Processing plant to Product Stockpiling Area transport route – 0.14 km
Product transport route from Product Stockpiling Area (unpaved) – 0.91 km
Product transport route (paved) – 0.77 km
Fines to overburden transport route – 0.53 km

Stage 3:

Overburden transport route – 0.39 km
Fresh rock to processing plant transport route – 0.13 km
Processing plant to Product Stockpiling Area transport route – 0.14 km
Product transport route from Product Stockpiling Area (unpaved) – 0.91 km
Product transport route (paved) – 0.77 km
Fines to overburden transport route – 0.26 km

Table 3-1
Adopted Activity Data

Page 1 of 2

Parameter	**Units**	**Existing**		**Stage 1**		**Stage 2**		**Stage 3**	
Period	**-**	**1 year**	**24 hour**	**1 year**	**24 hour**	**1 year**	**24 hour**	**1 year**	**24 hour**
Overburden removal[A,B]	tonnes	39 000	0	60 000	0	60 000	0	60 000	0
Overburden transport route	kilometres	476	0	1 875	0	1 553	0	1 142	
Fresh rock removal[A,C]	tonnes	150 000	1 120	230 000	1 400	230 000	1 400	230 000	1 400
Fresh rock transport route to in pit 'Processing Area'	kilometres			4 044	25	6 740	17	1 460	
Drilling	holes	936	77	926	77	926	77	926	77
Blasting[D]	m^2	8 333	1 736	8 333	1 736	8 333	1 736	8 333	1 736
Primary crushing (Jaw)[E,G]	tonnes			218 500	4 750	218 500	4 750	218 500	4 750
Secondary crushing (Cone)[G]	tonnes			230 000	5 000	230 000	5 000	230 000	5 000
Screening[G]	tonnes			230 000	5 000	230 000	5 000	230 000	5 000
Transport of product to Product Stockpiling Area	kilometres			1 573	34	1 573	34	1 573	34
Product transported off site	tonnes	150 000	1 120	230 000	1 400	230 000	1 400	230 000	1 400

Table 3-1 (Cont'd)
Adopted Activity Data

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Parameter	Units	Existing		Stage 1		Stage 2		Stage 3	
Period	**-**	**1 year**	**24 hour**	**1 year**	**24 hour**	**1 year**	**24 hour**	**1 year**	**24 hour**
Removal of fines[A]	tonnes			10 000	87	10 000	87	10 000	87
Fines brought to site	tonnes	10 000	87						
Transport of fines to overburden stockpile (paved)	kilometres	385	3.3						
Transport of fines to overburden stockpile (unpaved)	kilometres	350	3.0	137	1.2	137	1.2	137	1.2
Product transport route (unpaved on site)[F]	kilometres	7 033	52.5	8 372	51	8 372	51	8 372	51
Product transport route (paved)[F]	kilometres	5 775	43.1	7 084	43	7 084	43	7 084	43
Extraction area[J]	hectares	4.5	4.5	6.9	6.9	10.1	10.1	11.4	11.4
Overburden and fines stockpile	hectares	1.0	1.0	3.2	3.2	2.6	2.6	1.6	1.6
Product Storage Area stockpiles[H]	hectares			1.8	1.8	1.8	1.8	1.8	1.8

Emissions Controls

The Quarry operates an air Quality Management Plan (AQMP) (DMC, 2015) which outlines air quality control measures adopted by the Applicant at the Quarry Site. As per section 5 of the AQMP:

- The dust collection system on the drill rig is regularly serviced to ensure it remains effective.
- Blasting and secondary rock breakage is limited during periods of high winds or extremely dry weather, where it is practical to do so.
- Processing of all materials will be performed within the Extraction Area to provide a level of wind shielding to those activities.
- A bitumen seal will be applied to a 600 m section of the quarry access road to from its intersection with the Mount Lindesay Road.
- All other internal roads are surfaced with appropriate materials to limit dust lift-off and graded, where necessary.
- Road watering is undertaken on the remaining unsealed roads, if dust becomes a nuisance during periods of westerly winds.
- Appropriate care is taken to avoid spillage during loading.
- Load size is limited, as appropriate, to ensure materials do not extend above truck sidewalls.

- Each truck cover is fully extended on laden vehicles before each truck leaves the Quarry.
- All vehicles travelling on the quarry access road are limited to a speed no greater than 30km·hr^{-1}.
- All vehicles travelling on internal unsealed roads within the Quarry Site are limited to a speed no greater than 10km·hr^{-1}.
- DMcC's complaints management system would continue to be maintained to ensure that all complaints are dealt with through investigation and implementation of corrective treatments.

A number of the above measures have been implemented through a Driver's Code of Conduct.

Based on review of the above, emissions controls applied during each stage of operation are as follows:

- Dust collection on drill rig – 90 % control (NPI, 2012)
- Limited speed on site unpaved haul road – 44 % control (Countess Environmental , 2006)
- Water sprays on crushing – 77.7 % control (US EPA, 2004)
- Water sprays on screening- 91.2 % control (US EPA, 2004)
- Water sprays on transfer points – 50 % control (NPI, 2012)
- Pit retention for activities in pit – 50 % control for TSP, 5 % for PM_{10} and $PM_{2.5}$ (NPI, 2012)
- During peak daily operations, watering of all haul roads will also occur:
- Level 1 watering on unpaved haul roads – 50 % control (NPI, 2012)

Emissions Totals

Based on the above emission factors, activity rates and emission controls employed as part of the Proposal, the following tables outline the calculated emissions totals for each stage of operation and for annual average and peak daily activity rates:

Table 3-2 – Existing Annual Particulate Emissions (kg·annum^{-1})

Table 3-3 – Existing Peak Daily Particulate Emissions (kg·day^{-1})

Table 3-4 – Stage 1 Annual Particulate Emissions (kg·annum^{-1})

Table 3-5 – Stage 1 Peak Daily Particulate Emissions (kg·day^{-1})

Table 3-6 – Stage 2 Annual Particulate Emissions (kg·annum^{-1})

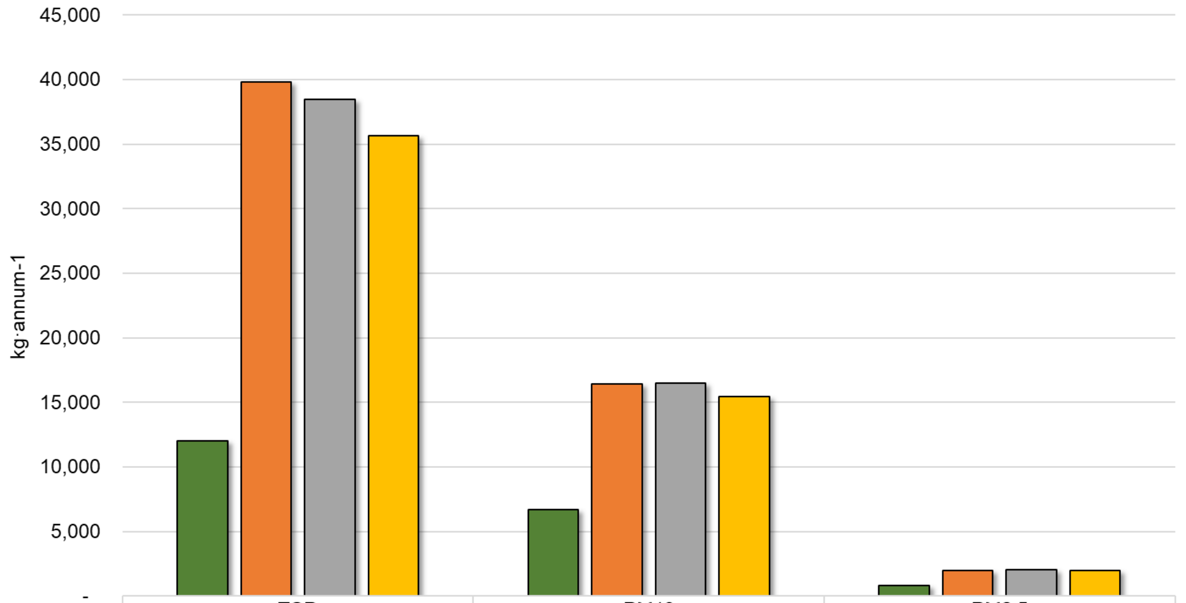
Table 3-7 – Stage 2 Peak Daily Particulate Emissions (kg·day^{-1})

Table 3-8 – Stage 3 Annual Particulate Emissions (kg·annum^{-1})

Table 3-9 – Stage 3 Peak Daily Particulate Emissions (kg·day^{-1})

Figure 3-1 and **Figure 3-2** also show these calculated emissions totals.

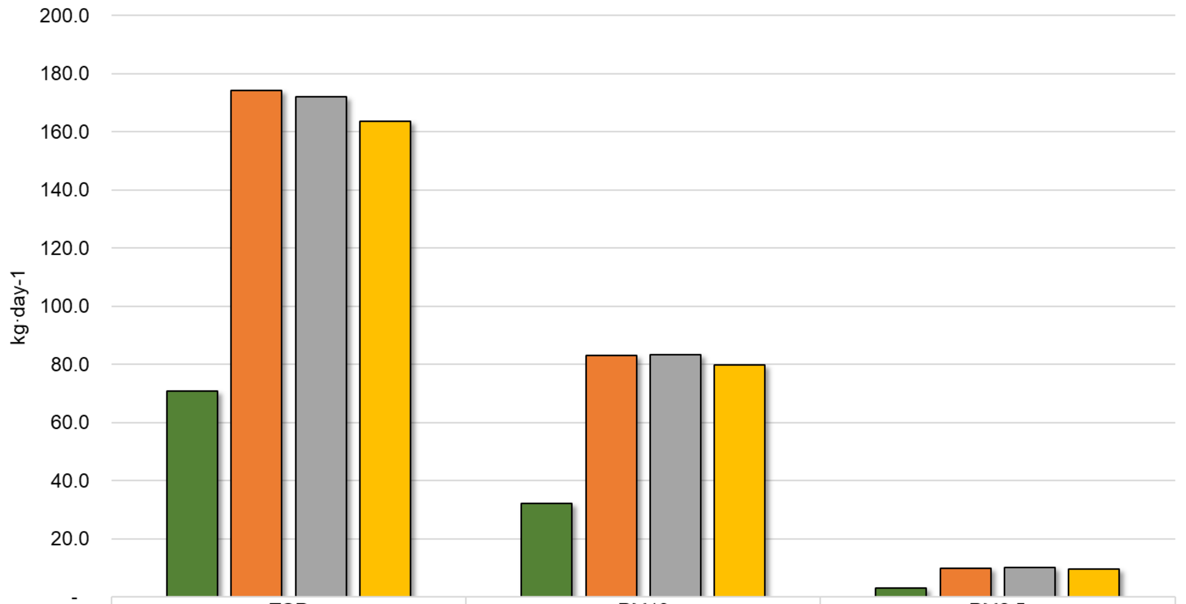
Figure 3-1 Annual Particulate Emission, Existing, Stage 1, Stage 2 and Stage 3



	TSP	PM10	PM2.5
Existing	12,014	6,676	801
Stage 1	39,815	16,408	1,987
Stage 2	38,488	16,460	2,044
Stage 3	35,657	15,440	1,947

Existing Stage 1 Stage 2 Stage 3

Figure 3-2 Peak Daily Particulate Emission, Existing, Stage 1, Stage 2 and Stage 3



	TSP	PM10	PM2.5
Existing	70.8	32.0	3.1
Stage 1	174.2	83.0	9.9
Stage 2	172.1	83.4	10.0
Stage 3	163.6	79.7	9.6

Existing Stage 1 Stage 2 Stage 3

Table 3-2
Existing – Annual Emissions Totals

Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions (kg·yr 1)		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Drilling of blast holes	AP-42 - Drilling (Overburden) - Table 11.9-4	0.59	0.3068	0.0177	kg/hole	926	holes	Dust collection on drill rig (90%) Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	27.3	27.0	1.6
Blasting of fresh rock	AP-42 - Blasting (Coal or Overburden) - Table 11.9-2	4.026048	2.093545	0.120781	kg/blast	12	blasts	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	24.2	23.9	1.4
Loading of road truck (rock)	AP-42 - Batch drop - Section 13.2.4.3	0.002085	0.000986	0.000149	kg/t	150000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	156.4	140.5	21.3
Loading of haul truck (overburden)	AP-42 - Batch drop - Section 13.2.4.3	0.002085	0.000986	0.000149	kg/t	39000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	40.7	36.5	5.5
Haul overburden to 'Overburden and Fines Stockpile'	AP-42 Unpaved roads - Section 13.2.2	4.135349	1.175944	0.117594	kg/VKT	476	VKT	Limited speed (44%)	1102.8	313.6	31.4
Unloading of overburden at 'Overburden and Fines Stockpile'	AP-42 - Batch drop - Section 13.2.4.3	0.002085	0.000986	0.000149	kg/t	39000	t		81.3	38.5	5.8
Hauling rock via unpaved road offsite	AP-42 Unpaved roads - Section 13.2.2	3.302336	0.939065	0.093907	kg/VKT	7033	VKT	Limited speed (44%)	6503.1	3513.5	351.4
Hauling of product from paved road to Mt Lindesay Rd	AP-42 Paved roads - Section 13.2.1	0.072923	0.013998	0.003387	kg/VKT	5775	VKT		421.1	80.8	19.6

Table 3-2 (Cont'd)
Existing – Annual Emissions Totals

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	Emission Factor								Controlled Emissions ($kg{\cdot}yr^{1}$)		
Description	**Source**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**Units**	**Activity Rate**	**Units**	**Controls**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
Transport of fines via paved road	AP-42 Paved roads - Section 13.2.1	0.072923	0.013998	0.003387	kg/VKT	385	VKT		14.0	5.1	1.2
Transport of fines to 'Overburden and Fines Stockpile' via unpaved road	AP-42 Unpaved roads - Section 13.2.2	3.302336	0.939065	0.093907	kg/VKT	350	VKT	Limited speed (44%)	647.3	184.1	18.4
Unloading of fines at 'Overburden and Fines Stockpile'	AP-42 - Batch drop - Section 13.2.4.3	0.002085	0.000986	0.000149	kg/t	10000	t		20.9	9.9	1.5
Wind erosion of 'Extraction Area'	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	5	ha	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	1912.5	1816.9	272.5
Wind erosion of 'Overburden and Fines Stockpile'	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	1	ha		850.0	425.0	63.8
								Total	**11801.4**	**6615.3**	**795.3**

Table 3-3
Existing – Peak Daily Emissions Totals

Page 1 of 2

Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions (kg·yr[1])		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Drilling of blast holes	AP-42 - Drilling (Overburden) - Table 11.9-4	0.59	0.3068	0.0177	kg/hole	77.0	holes	Dust collection on drill rig (90%) Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	2.3	2.2	0.1
Blasting of fresh rock	AP-42 - Blasting (Coal or Overburden) - Table 11.9-2	4.026048	2.093545	0.120781	kg/blast	1.0	blasts	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	8.0	7.9	0.5
Loading of road truck (rock)	AP-42 - Batch drop - Section 13.2.4.3	0.002085	0.000986	0.000149	kg/t	1120.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	1.2	1.0	0.2
Loading of haul truck (overburden)	AP-42 - Batch drop - Section 13.2.4.3	0.002085	0.000986	0.000149	kg/t	0.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	0.0	0.0	0.0
Haul overburden to 'Overburden and Fines Stockpile'	AP-42 Unpaved roads - Section 13.2.2	4.135349	1.175944	0.117594	kg/VKT	0.0	VKT	Limited speed (44%)	0.0	0.0	0.0
Unloading of overburden at 'Overburden and Fines Stockpile'	AP-42 - Batch drop - Section 13.2.4.3	0.002085	0.000986	0.000149	kg/t	0.0	t		0.0	0.0	0.0
Hauling rock via unpaved road offsite	AP-42 Unpaved roads - Section 13.2.2	3.302336	0.939065	0.093907	kg/VKT	52.5	VKT	Limited speed (44%)	48.6	13.8	1.4
Hauling of product from paved road to Mt Lindesay Rd	AP-42 Paved roads - Section 13.2.1	0.072923	0.013998	0.003387	kg/VKT	43.1	VKT		3.1	0.6	0.1

Table 3-3 (Cont'd)
Existing – Peak Daily Emissions Totals

Page 2 of 2

Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions ($kg{\cdot}yr^{1}$)		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Transport of fines via paved road	AP-42 Paved roads - Section 13.2.1	0.072923	0.013998	0.003387	kg/VKT	3.3	VKT		0.2	0.0	0.0
Transport of fines to 'Overburden and Fines Stockpile' via unpaved road	AP-42 Unpaved roads - Section 13.2.2	3.302336	0.939065	0.093907	kg/VKT	3.0	VKT	Limited speed (44%)	2.8	0.8	0.1
Unloading of fines at 'Overburden and Fines Stockpile'	AP-42 - Batch drop - Section 13.2.4.3	0.002085	0.000986	0.000149	kg/t	87.0	t		0.2	0.1	0.0
Wind erosion of 'Extraction Area'	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	4.5	ha	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	5.2	5.0	0.7
Wind erosion of 'Overburden and Fines Stockpile'	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	1.0	ha		2.3	1.2	0.2
								Total	**73.9**	**32.6**	**3.3**

Table 3-4
Stage 1 – Annual Emissions Totals

Page 1 of 4

Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions ($kg{\cdot}yr^{1}$)		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Drilling of blast holes	AP-42 - Drilling (Overburden) - Table 11.9-4	0.59	0.3068	0.0177	kg/hole	926	holes	Dust collection on drill rig (90%) Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	27.3	27.0	1.6
Blasting of fresh rock	AP-42 - Blasting (Coal or Overburden) - Table 11.9-2	4.026047947	2.093544932	0.120781438	kg/blast	12	blasts	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	24.2	23.9	1.4
Loading of haul truck (rock)	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	239.8	215.5	32.6
Loading of haul truck (overburden)	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	60000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	62.6	56.2	8.5
Hauling rock to in pit 'Processing Area'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	4043.956044	VKT	Limited speed (44%)	4682.5	2529.9	253.0
Haul overburden to 'Overburden and Fines Stockpile'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	1875.457875	VKT	Limited speed (44%)	4343.2	1235.0	123.5
Unloading of rock at in pit 'Processing Area'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	239.8	215.5	32.6

Table 3-4 (Cont'd)
Stage 1 – Annual Emissions Totals

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Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions ($kg{\cdot}yr^{1}$)		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Unloading of overburden at 'Overburden and Fines Stockpile'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	60000	l		125.1	59.2	9.0
Excavator loading Jaw Crusher at in pit 'Processing Area'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t	Pit retention (50% TSP, 5% $PM_{10'}$ $PM_{2.5}$)	239.8	215.5	32.6
Crushing of rock in Jaw Crusher	AP-42 - Primary crushing - Table 11.19.2.1	0.0027	0.0012	0.000216	kg/tonne	218500	tonnes	Pit retention (50% TSP, 5% $PM_{10'}$ $PM_{2.5}$) Controlled (77.7%)	65.8	55.5	10.0
Crushing of rock in Cone Crusher	AP-42 - Secondary crushing - Table 11.19.2.1	0.0027	0.0012	0.000216	kg/tonne	230000	tonnes	Pit retention (50% TSP, 5% $PM_{10'}$ $PM_{2.5}$) Controlled (77.7%)	69.2	58.5	10.5
Screening of rock	AP-42 - Screening - Table 11.19.2.1	0.0125	0.0043	0.000301	kg/tonne	230000	tonnes	Pit retention (50% TSP, 5% $PM_{10'}$ $PM_{2.5}$) Controlled (91.2%)	126.5	82.7	5.8
Loading material stockpiles from processing	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t	Pit retention (50% TSP, 5% $PM_{10'}$ $PM_{2.5}$)	119.9	107.7	16.3
Hauling product to material stockpiles out of pit	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	1572.649573	VKT	Limited speed (44%)	3641.9	1035.6	103.6

Table 3-4 (Cont'd)
Stage 1 – Annual Emissions Totals

Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions (kg·yr[1])		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Unloading product at stockpile area	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t		479.6	226.8	34.3
Hauling of product from Material stockpiles to paved road	AP-42 Unpaved roads - Section 13.2.2	3.51567239	0.999730511	0.099973051	kg/VKT	8372	VKT	Limited speed (44%)	16482.6	4687.1	468.7
Loading product to trucks	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t		479.6	226.8	34.3
Hauling of product from paved road to Mt Lindesay Rd	AP-42 Paved roads - Section 13.2.1	0.084040786	0.016131668	0.003902823	kg/VKT	7084	VKT		595.3	114.3	27.6
Loading of fines at in pit 'Processing Area' to haul truck	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	10000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	10.4	9.4	1.4
Transport of fines to 'Overburden and Fines Stockpile'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	136.7521368	VKT	Limited speed (44%)	316.7	90.1	9.0
Unloading of fines at 'Overburden and Fines Stockpile'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	10000	t		20.9	9.9	1.5
Wind erosion of Material Stockpiles (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0	ha		0.0	0.0	0.0

Table 3-4 (Cont'd)
Stage 1 – Annual Emissions Totals

Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions ($kg{\cdot}yr^{1}$)		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Wind erosion of 'Extraction Area'	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	6.9	ha	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	2932.5	2785.9	417.9
Wind erosion of 'Overburden and Fines Stockpile'	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	3.2	ha		2720.0	1360.0	204.0
Wind erosion of in pit 'Processing Area' (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0	ha		0.0	0.0	0.0
								Total	**38 045**	**15 427**	**1 839**

Table 3-5
Stage 1 – Peak Daily Emissions Totals

Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions ($kg{\cdot}yr^{-1}$)		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Drilling of blast holes	AP-42 - Drilling (Overburden) - Table 11.9-4	0.59	0.3068	0.0177	kg/hole	77.0	holes	Dust collection on drill rig (90%) Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	2.3	2.2	0.1
Blasting of fresh rock	AP-42 - Blasting (Coal or Overburden) - Table 11.9-2	4.026047947	2.093544932	0.120781438	kg/blast	1.0	blasts	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	8.0	7.9	0.5
Loading of haul truck (rock)	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	1400.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	1.5	1.3	0.2
Loading of haul truck (overburden)	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	0.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	0.0	0.0	0.0
Hauling rock to in pit 'Processing Area'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	24.6	VKT	Limited speed (44%)	14.3	7.7	0.8
Haul overburden to 'Overburden and Fines Stockpile'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	0.0	VKT	Limited speed (44%)	0.0	0.0	0.0
Unloading of rock at in pit 'Processing Area'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	1400.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	1.5	1.3	0.2
Unloading of overburden at 'Overburden and Fines Stockpile'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	0.0	t		0.0	0.0	0.0
Excavator loading Jaw Crusher at in pit 'Processing Area'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	5000.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	5.2	4.7	0.7
Crushing of rock in Jaw Crusher	AP-42 - Primary crushing - Table 11.19.2.1	0.0027	0.0012	0.000216	kg/tonne	4750.0	tonnes	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$) Controlled (77.7%)	1.4	1.2	0.2

Table 3-5 (Cont'd)
Stage 1 – Peak Daily Emissions Totals

Page 2 of 3

Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions (kg·yr^{-1})		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Crushing of rock in Cone Crusher	AP-42 - Secondary crushing - Table 11.19.2.1	0.0027	0.0012	0.000216	kg/tonne	5000.0	tonnes	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$) Controlled (77.7%)	1.5	1.3	0.2
Screening of rock	AP-42 - Screening - Table 11.19.2.1	0.0125	0.0043	0.000301	kg/tonne	5000.0	tonnes	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$) Controlled (91.2%)	2.8	1.8	0.1
Loading material stockpiles from processing	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	5000.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	2.6	2.3	0.4
Hauling product to material stockpiles out of pit	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	34.2	VKT	Limited speed (44%)	39.6	11.3	1.1
Unloading product at stockpile area	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	5000.0	t		10.4	4.9	0.7
Hauling of product from Material stockpiles to paved road	AP-42 Unpaved roads - Section 13.2.2	3.51567239	0.999730511	0.099973051	kg/VKT	51.0	VKT	Limited speed (44%)	50.2	14.3	1.4
Loading product to trucks	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	1400.0	t		2.9	1.4	0.2
Hauling of product from paved road to Mt Lindesay Rd	AP-42 Paved roads - Section 13.2.1	0.084040786	0.016131668	0.003902823	kg/VKT	43.1	VKT		3.6	0.7	0.2
Loading of fines at in pit 'Processing Area' to haul truck	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	87.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	0.1	0.1	0.0
Transport of fines to 'Overburden and Fines Stockpile'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	1.2	VKT	Limited speed (44%)	1.4	0.4	0.0
Unloading of fines at 'Overburden and Fines Stockpile'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	87.0	t		0.2	0.1	0.0

Table 3-5 (Cont'd)
Stage 1 – Peak Daily Emissions Totals

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Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions (kg·yr^{-1})		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Wind erosion of Material Stockpiles (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0.0	ha		0.0	0.0	0.0
Wind erosion of 'Extraction Area'	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	6.9	ha	Pit retention (50% TSIP, 5% PM_{10}, $PM_{2.5}$)	8.0	7.6	1.1
Wind erosion of 'Overburden and Fines Stockpile'	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	3.2	ha		7.5	3.7	0.6
Wind erosion of in pit 'Processing Area' (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0.0	ha		0.0	0.0	0.0
								Total	**164.8**	**76.2**	**8.8**

Table 3-6
Stage 2 – Annual Emissions Totals

	Emission Factor								Controlled Emissions ($kg \cdot yr^{-1}$)		
Description	**Source**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**Units**	**Activity Rate**	**Units**	**Controls**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
Drilling of blast holes	AP-42 - Drilling (Overburden) - Table 11.9-4	0.59	0.3068	0.0177	kg/hole	926	holes	Dust collection on drill rig (90%) Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	27.3	27.0	1.6
Blasting of fresh rock	AP-42 - Blasting (Coal or Overburden) - Table 11.9-2	4.026047947	2.093544932	0.120781438	kg/blast	12	blasts	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	24.2	23.9	1.4
Loading of haul truck (rock)	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	239.8	215.5	32.6
Loading of haul truck (overburden)	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	60000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	62.6	56.2	8.5
Hauling rock to in pit 'Processing Area'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	2808.302808	VKT	Limited speed (44%)	3251.7	1756.9	175.7
Haul overburden to 'Overburden and Fines Stockpile'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	1553.113553	VKT	Limited speed (44%)	3596.7	1022.8	102.3
Unloading of rock at in pit 'Processing Area'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	239.8	215.5	32.6
Unloading of overburden at 'Overburden and Fines Stockpile'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	60000	t		125.1	59.2	9.0
Excavator loading Jaw Crusher at in pit 'Processing Area'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	239.8	215.5	32.6
Crushing of rock in Jaw Crusher	AP-42 - Primary crushing - Table 11.19.2.1	0.0027	0.0012	0.000216	kg/tonne	218500	tonnes	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$) Controlled (77.7%)	65.8	55.5	10.0

Table 3-6 (Cont'd)
Stage 2 – Annual Emissions Totals

Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions ($kg{\cdot}yr^{-1}$)		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Crushing of rock in Cone Crusher	AP-42 - Secondary crushing - Table 11.19.2.1	0.0027	0.0012	0.000216	kg/tonne	230000	tonnes	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$) Controlled (77.7%)	69.2	58.5	10.5
Screening of rock	AP-42 - Screening - Table 11.19.2.1	0.0125	0.0043	0.000301	kg/tonne	230000	tonnes	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$) Controlled (91.2%)	126.5	82.7	5.8
Loading material stockpiles from processing	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	119.9	107.7	16.3
Loading of product to haul trucks	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t		239.8	215.5	32.6
Hauling product to material stockpiles out of pit	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	1572.649573	VKT	Limited speed (44%)	3641.9	1035.6	103.6
Hauling of product from Materials Stockpiles to paved road	AP-42 Unpaved roads - Section 13.2.2	3.51567239	0.999730511	0.099973051	kg/VKT	8372	VKT	Limited speed (44%)	16482.6	4687.1	468.7
Unloading product at stockpile area	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t		479.6	226.8	34.3
Loading product to trucks	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t		479.6	226.8	34.3
Hauling of product from paved road to Mt Lindesay Rd	AP-42 Paved roads - Section 13.2.1	0.084040786	0.016131668	0.003902823	kg/VKT	7084	VKT		595.3	114.3	27.6
Wind erosion of 'Overburden and Fines Emplacement' (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0	ha		0.0	0.0	0.0
Loading of fines at in pit 'Processing Area' to haul truck	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	10000	t		10.4	9.4	1.4

Table 3-6 (Cont'd)
Stage 2 – Annual Emissions Totals

Page 3 of 3

Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions ($kg \cdot yr^{-1}$)		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Transport of fines to 'Overburden and Fines Stockpile'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	136.7521368	VKT	Limited speed (44%)	316.7	90.1	9.0
Unloading of fines at 'Overburden and Fines Stockpile'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	10000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	20.9	9.9	1.5
Wind erosion of Material Stockpiles (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0	ha		0.0	0.0	0.0
Wind erosion of 'Extraction Area'	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	10.1	ha	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	4292.5	4077.9	611.7
Wind erosion of 'Overburden and Fines Stockpile'	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	2.6	ha		2210.0	1105.0	165.8
Wind erosion of in pit 'Processing Area' (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0	ha		0.0	0.0	0.0
Wind erosion of 'Overburden and Fines Emplacement' (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0	ha		0.0	0.0	0.0
Wind erosion of out of pit Material Stockpiles	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	1.8	ha		1530.0	765.0	114.8
								Total	**38 487**	**16 460**	**2 044**

Table 3-7
Stage 2 – Peak Daily Emissions Totals

Page 1 of 3

Description	Emission Factor					Activity Rate	Units	Controls	Controlled Emissions ($kg{\cdot}yr^{-1}$)		
	Source	TSP	PM_{10}	$PM_{2.5}$	Units				TSP	PM_{10}	$PM_{2.5}$
Drilling of blast holes	AP-42 - Drilling (Overburden) - Table 11.9-4	0.59	0.3068	0.0177	kg/hole	77.0	holes	Dust collection on drill rig (90%) Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	2.3	2.2	0.1
Blasting of fresh rock	AP-42 - Blasting (Coal or Overburden) - Table 11.9-2	4.026047947	2.093544932	0.120781438	kg/blast	1.0	blasts	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	8.0	7.9	0.5
Loading of haul truck (rock)	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	1400.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	1.5	1.3	0.2
Loading of haul truck (overburden)	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	0.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	0.0	0.0	0.0
Hauling rock to in pit 'Processing Area'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	17.1	VKT	Limited speed (44%)	9.9	5.3	0.5
Haul overburden to 'Overburden and Fines Stockpile'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	0.0	VKT	Limited speed (44%)	0.0	0.0	0.0
Unloading of rock at in pit 'Processing Area'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	1400.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	1.5	1.3	0.2
Unloading of overburden at 'Overburden and Fines Stockpile'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	0.0	t		0.0	0.0	0.0
Excavator loading Jaw Crusher at in pit 'Processing Area'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	5000.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	5.2	4.7	0.7
Crushing of rock in Jaw Crusher	AP-42 - Primary crushing - Table 11.19.2.1	0.0027	0.0012	0.000216	kg/tonne	4750.0	tonnes	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$) Controlled (77.7%)	1.4	1.2	0.2
Crushing of rock in Cone Crusher	AP-42 - Secondary crushing - Table 11.19.2.1	0.0027	0.0012	0.000216	kg/tonne	5000.0	tonnes	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$) Controlled (77.7%)	1.5	1.3	0.2

Table 3-7 (Cont'd)
Stage 2 – Peak Daily Emissions Totals

Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions (kg·yr^{-1})		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Screening of rock	AP-42 - Screening - Table 11.19.2.1	0.0125	0.0043	0.000301	kg/tonne	5000.0	tonnes	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$) Controlled (91.2%)	2.8	1.8	0.1
Loading material stockpiles from processing	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	5000.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	2.6	2.3	0.4
Loading of product to haul trucks	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	5000.0	t		5.2	4.7	0.7
Hauling product to material stockpiles out of pit	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	34.2	VKT	Limited speed (44%)	39.6	11.3	1.1
Hauling of product from Materials Stockpiles to paved road	AP-42 Unpaved roads - Section 13.2.2	3.51567239	0.999730511	0.099973051	kg/VKT	51.0	VKT	Limited speed (44%)	50.2	14.3	1.4
Unloading product at stockpile area	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	5000.0	t		10.4	4.9	0.7
Loading product to trucks	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	1400.0	t		2.9	1.4	0.2
Hauling of product from paved road to Mt Lindesay Rd	AP-42 Paved roads - Section 13.2.1	0.084040786	0.016131668	0.003902823	kg/VKT	43.1	VKT		3.6	0.7	0.2
Wind erosion of 'Overburden and Fines Emplacement' (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0.0	ha		0.0	0.0	0.0
Loading of fines at in pit 'Processing Area' to haul truck	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	87.0	t		0.1	0.1	0.0
Transport of fines to 'Overburden and Fines Stockpile'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	1.2	VKT	Limited speed (44%)	1.4	0.4	0.0
Unloading of fines at 'Overburden and Fines Stockpile'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	87.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	0.2	0.1	0.0

Table 3-7 (Cont'd)
Stage 2 – Peak Daily Emissions Totals

Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions (kg·yr^{-1})		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Wind erosion of Material Stockpiles (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0.0	ha		0.0	0.0	0.0
Wind erosion of 'Extraction Area'	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	10.1	ha	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	11.8	11.2	1.7
Wind erosion of 'Overburden and Fines Stockpile'	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	2.6	ha		6.1	3.0	0.5
Wind erosion of in pit 'Processing Area' (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0.0	ha		0.0	0.0	0.0
Wind erosion of 'Overburden and Fines Emplacement' (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0.0	ha		0.0	0.0	0.0
Wind erosion of out of pit Material Stockpiles	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	1.8	ha		4.2	2.1	0.3
								Total	**172.1**	**83.4**	**10.0**

Table 3-8
Stage 3 – Annual Emissions Totals

Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions ($kg \cdot yr^{-1}$)		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Drilling of blast holes	AP-42 - Drilling (Overburden) - Table 11.9-4	0.59	0.3068	0.0177	kg/hole	926	holes	Dust collection on drill rig (90%) Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	27.3	27.0	1.6
Blasting of fresh rock	AP-42 - Blasting (Coal or Overburden) - Table 11.9-2	4.026047947	2.093544932	0.120781438	kg/blast	12	blasts	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	24.2	23.9	1.4
Loading of haul truck (rock)	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	239.8	215.5	32.6
Loading of haul truck (overburden)	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	60000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	62.6	56.2	8.5
Hauling rock to in pit 'Processing Area'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	1460.317	VKT	Limited speed (44%)	1690.9	913.6	91.4
Haul overburden to 'Overburden and Fines Stockpile'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	1142.857	VKT	Limited speed (44%)	2646.6	752.6	75.3
Unloading of rock at in pit 'Processing Area'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	239.8	215.5	32.6
Unloading of overburden at 'Overburden and Fines Stockpile'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	60000	t		125.1	59.2	9.0
Excavator loading Jaw Crusher at in pit 'Processing Area'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	239.8	215.5	32.6
Crushing of rock in Jaw Crusher	AP-42 - Primary crushing - Table 11.19.2.1	0.0027	0.0012	0.000216	kg/tonne	218500	tonnes	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$) Controlled (77.7%)	65.8	55.5	10.0

Table 3-8 (Cont'd)
Stage 3 – Annual Emissions Totals

Page 2 of 3

Description	Emission Factor					Activity Rate	Units	Controls	Controlled Emissions ($kg{\cdot}yr^{-1}$)		
	Source	TSP	PM_{10}	$PM_{2.5}$	Units				TSP	PM_{10}	$PM_{2.5}$
Crushing of rock in Cone Crusher	AP-42 - Secondary crushing - Table 11.19.2.1	0.0027	0.0012	0.000216	kg/tonne	230000	tonnes	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$) Controlled (77.7%)	69.2	58.5	10.5
Screening of rock	AP-42 - Screening - Table 11.19.2.1	0.0125	0.0043	0.000301	kg/tonne	230000	tonnes	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$) Controlled (91.2%)	126.5	82.7	5.8
Loading material stockpiles from processing	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	119.9	107.7	16.3
Loading of product to haul trucks	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t		239.8	215.5	32.6
Hauling product to material stockpiles out of pit	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	1572.65	VKT	Limited speed (44%)	3641.9	1035.6	103.6
Hauling of product from Materials Stockpiles to paved road	AP-42 Unpaved roads - Section 13.2.2	3.51567239	0.999730511	0.099973051	kg/VKT	8372	VKT	Limited speed (44%)	16482.6	4687.1	468.7
Unloading product at stockpile area	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t		479.6	226.8	34.3
Loading product to trucks	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	230000	t		479.6	226.8	34.3
Hauling of product from paved road to Mt Lindesay Rd	AP-42 Paved roads - Section 13.2.1	0.084040786	0.016131668	0.003902823	kg/VKT	7084	VKT		595.3	114.3	27.6
Wind erosion of 'Overburden and Fines Emplacement' (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0	ha		0.0	0.0	0.0
Loading of fines at in pit 'Processing Area' to haul truck	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	10000	t		10.4	9.4	1.4

Table 3-8 (Cont'd)
Stage 3 – Annual Emissions Totals

Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions ($kg \cdot yr^{-1}$)		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Transport of fines to 'Overburden and Fines Stockpile'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	126.9841	VKT	Limited speed (44%)	294.1	83.6	8.4
Unloading of fines at 'Overburden and Fines Stockpile'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	10000	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	20.9	9.9	1.5
Wind erosion of Material Stockpiles (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0	ha		0.0	0.0	0.0
Wind erosion of 'Extraction Area'	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	11.4	ha	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	4845.0	4602.8	690.4
Wind erosion of 'Overburden and Fines Stockpile'	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	1.6	ha		1360.0	680.0	102.0
Wind erosion of in pit 'Processing Area' (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0	ha		0.0	0.0	0.0
Wind erosion of 'Overburden and Fines Emplacement' (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0	ha		0.0	0.0	0.0
Wind erosion of out of pit Material Stockpiles	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	1.8	ha		1530.0	765.0	114.8
								Total	**35 656.6**	**15 440.0**	**1 947.2**

Table 3-9
Stage 3 – Peak Daily Emissions Totals

Page 1 of 3

Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions (kg·yr^{-1})		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Drilling of blast holes	AP-42 - Drilling (Overburden) - Table 11.9-4	0.59	0.3068	0.0177	kg/hole	77.0	holes	Dust collection on drill rig (90%) Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	2.3	2.2	0.1
Blasting of fresh rock	AP-42 - Blasting (Coal or Overburden) - Table 11.9-2	4.026047947	2.093544932	0.120781438	kg/blast	1.0	blasts	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	8.0	7.9	0.5
Loading of haul truck (rock)	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	1400.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	1.5	1.3	0.2
Loading of haul truck (overburden)	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	0.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	0.0	0.0	0.0
Hauling rock to in pit 'Processing Area'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	8.9	VKT	Limited speed (44%)	5.1	2.8	0.3
Haul overburden to 'Overburden and Fines Stockpile'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	0.0	VKT	Limited speed (44%)	0.0	0.0	0.0
Unloading of rock at in pit 'Processing Area'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	1400.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	1.5	1.3	0.2
Unloading of overburden at 'Overburden and Fines Stockpile'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	0.0	t		0.0	0.0	0.0
Excavator loading Jaw Crusher at in pit 'Processing Area'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	5000.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	5.2	4.7	0.7
Crushing of rock in Jaw Crusher	AP-42 - Primary crushing - Table 11.19.2.1	0.0027	0.0012	0.000216	kg/tonne	4750.0	tonnes	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$) Controlled (77.7%)	1.4	1.2	0.2
Crushing of rock in Cone Crusher	AP-42 - Secondary crushing - Table 11.19.2.1	0.0027	0.0012	0.000216	kg/tonne	5000.0	tonnes	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$) Controlled (77.7%)	1.5	1.3	0.2
Screening of rock	AP-42 - Screening - Table 11.19.2.1	0.0125	0.0043	0.000301	kg/tonne	5000.0	tonnes	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$) Controlled (91.2%)	2.8	1.8	0.1

Table 3-9 (Cont'd)
Stage 3 – Peak Daily Emissions Totals

Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions (kg·yr^{-1})		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Loading material stockpiles from processing	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	5000.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	2.6	2.3	0.4
Loading of product to haul trucks	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	5000.0	t		5.2	4.7	0.7
Hauling product to material stockpiles out of pit	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	34.2	VKT	Limited speed (44%)	39.6	11.3	1.1
Hauling of product from Materials Stockpiles to paved road	AP-42 Unpaved roads - Section 13.2.2	3.51567239	0.999730511	0.099973051	kg/VKT	51.0	VKT	Limited speed (44%)	50.2	14.3	1.4
Unloading product at stockpile area	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	5000.0	t		10.4	4.9	0.7
Loading product to trucks	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	0.0	t		0.0	0.0	0.0
Hauling of product from paved road to Mt Lindesay Rd	AP-42 Paved roads - Section 13.2.1	0.084040786	0.016131668	0.003902823	kg/VKT	43.1	VKT		3.6	0.7	0.2
Wind erosion of 'Overburden and Fines Emplacement' (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0.0	ha		0.0	0.0	0.0
Loading of fines at in pit 'Processing Area' to haul truck	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	87.0	t		0.1	0.1	0.0
Transport of fines to 'Overburden and Fines Stockpile'	AP-42 Unpaved roads - Section 13.2.2	4.135348796	1.175944146	0.117594415	kg/VKT	1.1	VKT	Limited speed (44%)	1.3	0.4	0.0
Unloading of fines at 'Overburden and Fines Stockpile'	AP-42 - Batch drop - Section 13.2.4.3	0.00208509	0.000986191	0.000149338	kg/t	87.0	t	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	0.2	0.1	0.0

Table 3-9 (Cont'd)
Stage 3 – Peak Daily Emissions Totals

Description	Emission Factor				Units	Activity Rate	Units	Controls	Controlled Emissions (kg·yr^{-1})		
	Source	TSP	PM_{10}	$PM_{2.5}$					TSP	PM_{10}	$PM_{2.5}$
Wind erosion of Material Stockpiles (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0.0	ha		0.0	0.0	0.0
Wind erosion of 'Extraction Area'	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	11.4	ha	Pit retention (50% TSP, 5% PM_{10}, $PM_{2.5}$)	13.3	12.6	1.9
Wind erosion of 'Overburden and Fines Stockpile'	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	1.6	ha		3.7	1.9	0.3
Wind erosion of in pit 'Processing Area' (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0.0	ha		0.0	0.0	0.0
Wind erosion of 'Overburden and Fines Emplacement' (included in Extraction Area)	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	0.0	ha		0.0	0.0	0.0
Wind erosion of out of pit Material Stockpiles	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	850	425	63.75	kg/ha/yr	1.8	ha		4.2	2.1	0.3
								Total	**163.6**	**79.7**	**9.6**

Appendix 3

Human Health Risk Assessment
prepared by
Environmental Risk Sciences Pty Ltd

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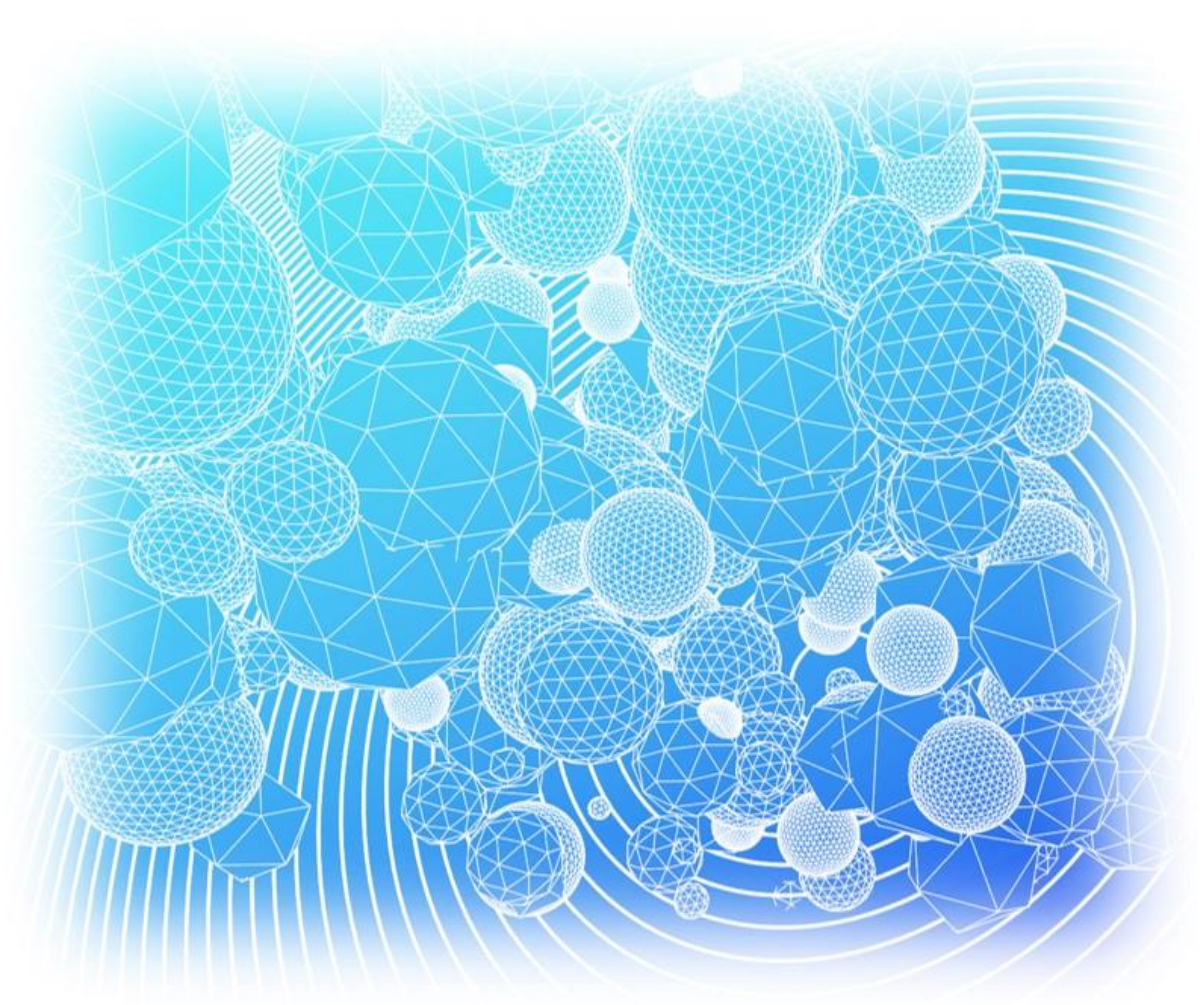


Human Health Risk Assessment for Respirable Crystalline Silica: Expansion of Dowe's Quarry

Prepared for: R. W. Corkery & Co. PTY Limited

4 March 2020

EnRiskS

Document History and Status

Report Reference	RWC/20/DOWR001
Revision	B – Final
Date	4 March 2020
Previous Revisions	A – Draft issued on 3 March 2020

Limitations

Environmental Risk Sciences Pty Ltd has prepared this report for the use of R. W. Corkery & Co. Pty Limited (RWC) in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report.

It is prepared in accordance with the scope of work and for the purpose outlined in the **Section 1** of this report.

The methodology adopted, and sources of information used are outlined in this report. Environmental Risk Sciences Pty Ltd has made no independent verification of this information beyond the agreed scope of works and assumes no responsibility for any inaccuracies or omissions. No indications were found that information contained in the reports provided for use in this assessment was false.

This report was prepared from December 2019 to March 2020 and is based on the information provided and reviewed at that time. Environmental Risk Sciences Pty Ltd disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Table of Contents

Glossary of Terms

ADI	Acceptable Daily Intake
ACGIH	American Conference of Governmental Industrial Hygienists.
AIOH	Australian Institute of Occupational Hygienists Inc
ANZECC	Australia and New Zealand Environment and Conservation Council
AQIA	Air Quality Impact Assessment
ATSDR	US Agency for Toxic Substances and Disease Registry
COPD	Chronic Obstructive Pulmonary Disease
EIS	Environmental Impact Statement
ESL	Effects Screening Levels
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IARC	International Agency for Research on Cancer
MDH	Minnesota Department of Health
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NIOSH	National Institute for Occupational Safety and Health
NOAEL	No Observable Adverse Effect Level
OEHHA	California EPA Office for Environmental Health Hazard Assessment
PEL	Permissible Exposure Limit
$PM_{2.5}$	Particulate matter below 2.5 µm in diameter
PM_{10}	Particulate matter below 10 microns in diameter
REL	Recommended Exposure Limit
ReV	Chronic Reference Value
RCS	Respirable Crystalline Silica
RfC	Reference Concentration
RfD	Reference Dose
TC	Tolerable Concentration
TCEQ	Texas Commission on Environmental Quality
TDI	Tolerable Daily Intake
TLV	Threshold Limit Value
TRV	Toxicity Reference Value
TSP	Total Suspended Particulates
TWA	Time-weighted Average
UR	Unit Risk
USEPA	United States Environmental Protection Agency,
WHO	World Health Organisation

Executive Summary

Introduction

Environmental Risk Sciences Pty Ltd (enRiskS) has been engaged by R. W. Corkery & Co. Pty Limited (RWC) to review available data and undertake a human health risk assessment (HHRA) in relation to the potential presence of respirable crystalline silica (RCS) in dust emitted during the continued operation and extension of Dowe's Quarry (the "Quarry"). Rural residential properties are located adjacent to the Quarry and some members of the community are concerned that dust containing RCS emitted from the Quarry may migrate onto the residential properties and be inhaled.

The Quarry is located on Rural Land owned by Mr. Rod Dowe and leased to Darryl McCarthy Constructions Pty Ltd (Darryl McCarthy Constructions). The Quarry is located approximately 8 km north-east of Tenterfield in NSW and has been operating at its current location since 1987. The current destination of raw materials extracted from the Quarry is the Sunnyside Crushing and Screening Plant (the "Sunnyside Plant"), located to the north-west of the Quarry and Tenterfield. Material extracted from the Quarry is processed and dispatched to their destination at the Sunnyside Plant.

Darryl McCarthy Constructions is seeking development consent for the continued operation and expansion of extraction activities within the Quarry. The proposed activities comprise:

- Ongoing extraction of quartzose material within the existing extraction area and an additional 4.4 hectares (ha) of area, producing up to 230,000 tonnes per annum (tpa) of stone products;
- Crushing and screening of extracted material at the Quarry using mobile processing equipment. All on-site materials processing (including crushing and screening) is proposed to be performed within the extraction area (the pit);
- Ongoing transportation of fragmented and crushed rock on the New England highway to the Sunnyside Plan and other destinations (including locally within Tenterfield);
- Ongoing transport of stone material directly to the destination, where further processing at the Sunnyside Plant is not required; and
- Transport of clay fines and crusher fines from the Sunnyside Plant to the Quarry for progressive emplacement within and adjacent to the extraction area.
- The Quarry will then be progressively rehabilitated for native vegetation conservation.

It is understood that the key changes to the operation of the Quarry outlined in the development application (DA) of relevance to this HHRA include the expansion of the extraction area and the crushing and screening of extracted material at the Quarry, instead of at the Sunnyside Plant as per current operations. As noted above, all crushing and screening activities will be undertaken within the quarry pit. It is understood that this is with the aim of reducing the potential for dispersion of dust emissions and create a barrier to noise propagation from the Quarry.

An Environmental Impact Statement (EIS; R. W. Corkery 2019) has been submitted to Tenterfield Council in support of the DA to continue and expand activities at the Quarry. The Air Quality Impact Assessment (AQIA) undertaken as part of the EIS provides some consideration that dust emitted from the Quarry may contain RCS. This report provides a more detailed assessment of the potential risks to human health posed by the potential presence of RCS in dust emitted from the Quarry, to residents utilising the existing residential properties adjacent to the Quarry.

Objectives

The objectives of the assessment presented in this report are:

- To undertake an evaluation of the potential risks to human health associated with RCS in dust that may be emitted from the quarry and may migrate onto residential properties adjacent to the Quarry; and
- Based on the HHRA, and if required, identify any additional data that may be necessary to assist in refining the assessment of risk or in considering additional risk management measures that may be needed.

This assessment has been undertaken to evaluate potential risks to human health at residential properties adjacent to the Quarry based on the data and information available up to the end of February 2020 and as described in **Section 2.1**. The HHRA has addressed human health risk issues relevant to RCS that may be present in dust sourced from the Quarry and the ongoing low-density rural/residential use of the existing properties adjacent to the Quarry

The assessment has not addressed any ecological/environmental risk issues, human health risk issues associated with other chemicals or human health risk issues at the Quarry or the Sunnyside Plant. No assessment has been undertaken of other non-site sourced contamination that may be present beneath off-site properties.

Approach

The assessment of potential risks to community health has been undertaken in accordance with enHealth guidance (enHealth 2012a).

This assessment has relied on the air quality impact assessment (AQIA) to estimate the potential concentration of fine particles, as $PM_{2.5}$, the community may be exposed to as a result of the proposed Quarry operations. Due to the nature of the materials being quarried, it has then been assumed that 100% of the $PM_{2.5}$ dust generated from the Quarry is RCS. X-ray diffraction (XRD) analysis of the raw material at the Quarry was undertaken by the QUT Central Analytical Research Facility in November 2019 and identified that the raw materials produced at the Quarry are 99.5% quartz (crystalline silica) with trace impurities.

The potential risks associated with community inhalation exposures to RCS has also been evaluated on the basis of current information in relation to the adverse health effects. The assessment has also considered the levels of exposure at which such health effects may be of concern in both occupational environments and in the community.

Conclusions

Based on the available data and the scope of this assessment, it has been concluded that health risks to residents in existing properties adjacent to the Quarry are low and acceptable.

Environmental Risk Sciences Pty Ltd has undertaken a human health risk assessment (HHRA) in relation to the potential presence of respirable crystalline silica (RCS) in dust emitted during the continued operation and extension of Dowe's Quarry (the "Quarry"). It is noted that limitations apply to the outcomes due to the focus of this assessment on RCS and the uncertainties identified and analysed in the report.

The HHRA has addressed human health risk issues relevant to RCS that may be present in dust sourced from the Quarry and the ongoing low-density rural/residential use of the existing properties adjacent to the Quarry.

No additional dust mitigation measures are recommended for operations assuming the proposed dust mitigation measures including the planned air monitoring program are implemented. It is recommended that $PM_{2.5}$ and PM_{10} samples captured for monitoring are subject to laboratory analysis of for silica concentration. This is recommended to confirm the concentrations of silica in these PM fractions, that adjacent receptors may be exposed to.

Standard dust mitigation measures including dust suppression through chemical and water means, the tarping of loads, inspection of truck tyres and street sweeping should also continue for the operation. The proposed extension to the seal on the Quarry Access Road to a total length of 800m is supported..

Section 1. Background

1.1 Introduction

Environmental Risk Sciences Pty Ltd (enRiskS) has been engaged by R. W. Corkery & Co. Pty Limited (RWC) to review available data and undertake a human health risk assessment (HHRA) in relation to the potential presence of respirable crystalline silica (RCS) in dust emitted during the continued operation and extension of Dowe's Quarry (the "Quarry"). Rural residential properties are located adjacent to the Quarry and some members of the community are concerned that dust containing RCS emitted from the Quarry may migrate onto and impact the residential properties and be inhaled.

The Quarry is located on Rural Land owned by Mr. Rod Dowe and leased to Darryl McCarthy Constructions Pty Ltd (Darryl McCarthy Constructions). The Quarry is located approximately 8 km north-east of Tenterfield in NSW and has been operating at its current location since 1987. The current destination of raw materials extracted from the Quarry is the Sunnyside Crushing and Screening Plant (the "Sunnyside Plant"), located to the north-west of the Quarry and Tenterfield. Material extracted from the Quarry is processed and dispatched to their destination at the Sunnyside Plant. **Figure 1.1** (RWC 2019) shows the location of the Quarry, the Sunnyside Plant and Tenterfield.

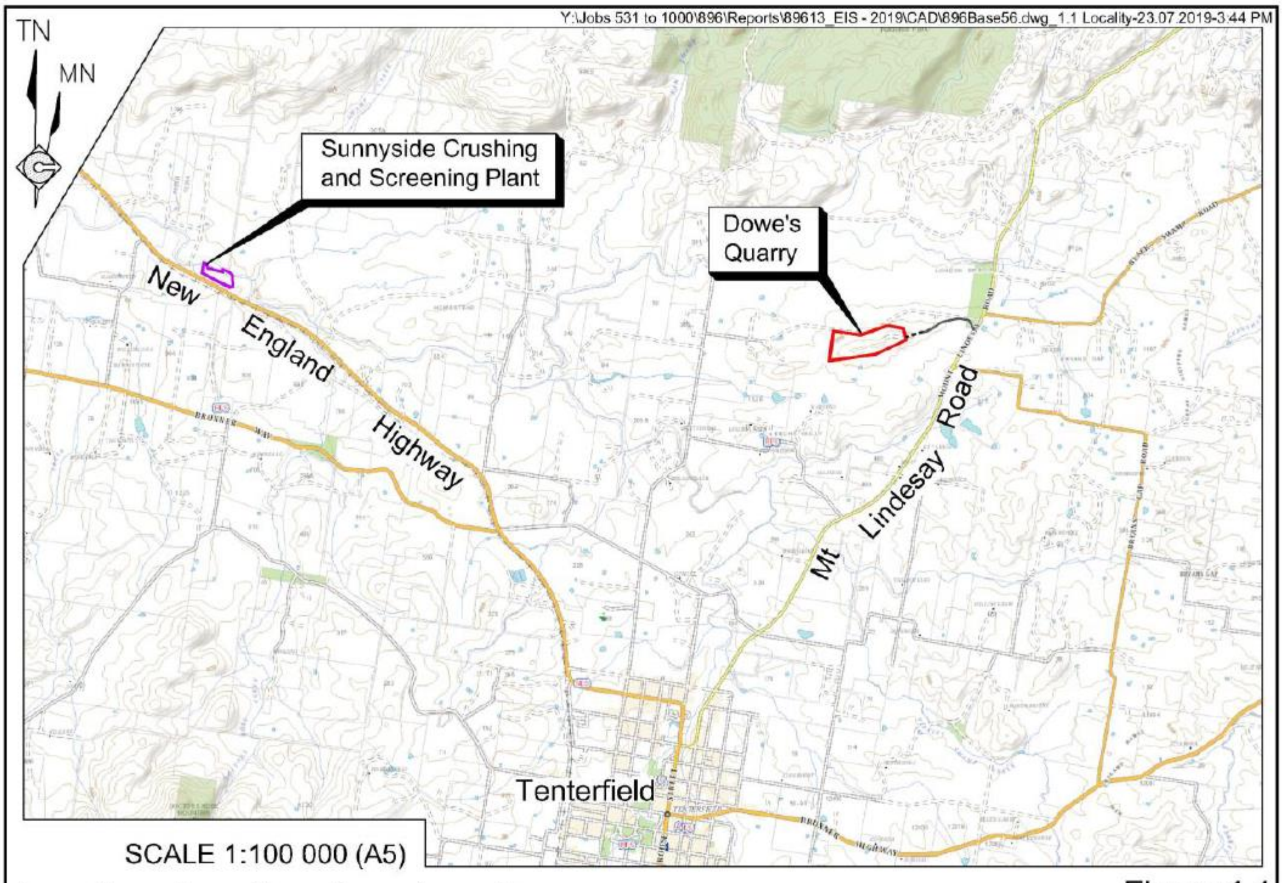


Figure 1.1
LOCALITY PLAN

Darryl McCarthy Constructions is seeking development consent for the continued operation and expansion of extraction activities within the Quarry. The proposed activities comprise:

- Ongoing extraction of quartzose material within the existing extraction area and an additional 4.4 hectares (ha) of area, producing up to 230,000 tonnes per annum (tpa) of stone products;
- Crushing and screening of extracted material at the Quarry using mobile processing equipment. All on-site materials processing (including crushing and screening) is proposed to be performed within the extraction area (the pit);
- Ongoing transportation of fragmented and crushed rock on the New England highway to the Sunnyside Plan and other destinations (including locally within Tenterfield);
- Ongoing transport of stone material directly to the destination, where further processing at the Sunnyside Plant is not required; and
- Transport of clay fines and crusher fines from the Sunnyside Plant to the Quarry for progressive emplacement within and adjacent to the extraction area.
- The Quarry will then be progressively rehabilitated for native vegetation conservation.

It is understood that the key changes to the operation of the Quarry outlined in the Development Application (DA) of relevance to this HHRA include the expansion of the extraction area and the crushing and screening of extracted material at the Quarry, instead of at the Sunnyside Plant as per current operations. As noted above, all crushing and screening activities will be undertaken within the quarry pit. It is understood that this has been designed with the aim of reducing the potential for dust emissions from the Quarry to impact on surrounding areas.

An Environmental Impact Statement (EIS; R. W. Corkery 2019) has been submitted to Tenterfield Council in support of the DA to continue and expand activities at the Quarry. The Air Quality Impact Assessment (AQIA) undertaken as part of the EIS provides some consideration that that dust emitted from the Quarry may contain RCS.

This report provides a more detailed assessment of the potential risks to human health posed by the potential presence of RCS in dust emitted from the Quarry, to residents at existing residential properties adjacent to the Quarry.

1.2 Objectives

The objectives of the assessment presented in this report are:

- To undertake an evaluation of the potential risks to human health associated with RCS in dust that may be emitted from the quarry and may migrate onto residential properties adjacent to the Quarry; and
- Based on the HHRA, and if required, identify any additional data that may be necessary to assist in refining the assessment of risk or in considering additional risk management measures that may be needed.

This assessment has been undertaken to evaluate potential risks to human health at residential properties adjacent to the Quarry based on the data and information available up to the end of February 2020 and as described in **Section 2.1**. The HHRA has addressed human health risk issues relevant to RCS that may be present in dust sourced from the Quarry and the ongoing low-density rural/residential use of the existing properties adjacent to the Quarry

The assessment has not addressed any ecological/environmental risk issues, human health risk issues associated with other chemicals or any occupational health and safety issues at the Quarry or the Sunnyside Plant. No assessment has been undertaken of other non-site sourced contamination that may be present beneath off-site properties.

1.3 Methodology

In general, the approach taken for the assessment of human health and environmental risks is in accordance with guidelines/protocols endorsed by Australian regulators, including:

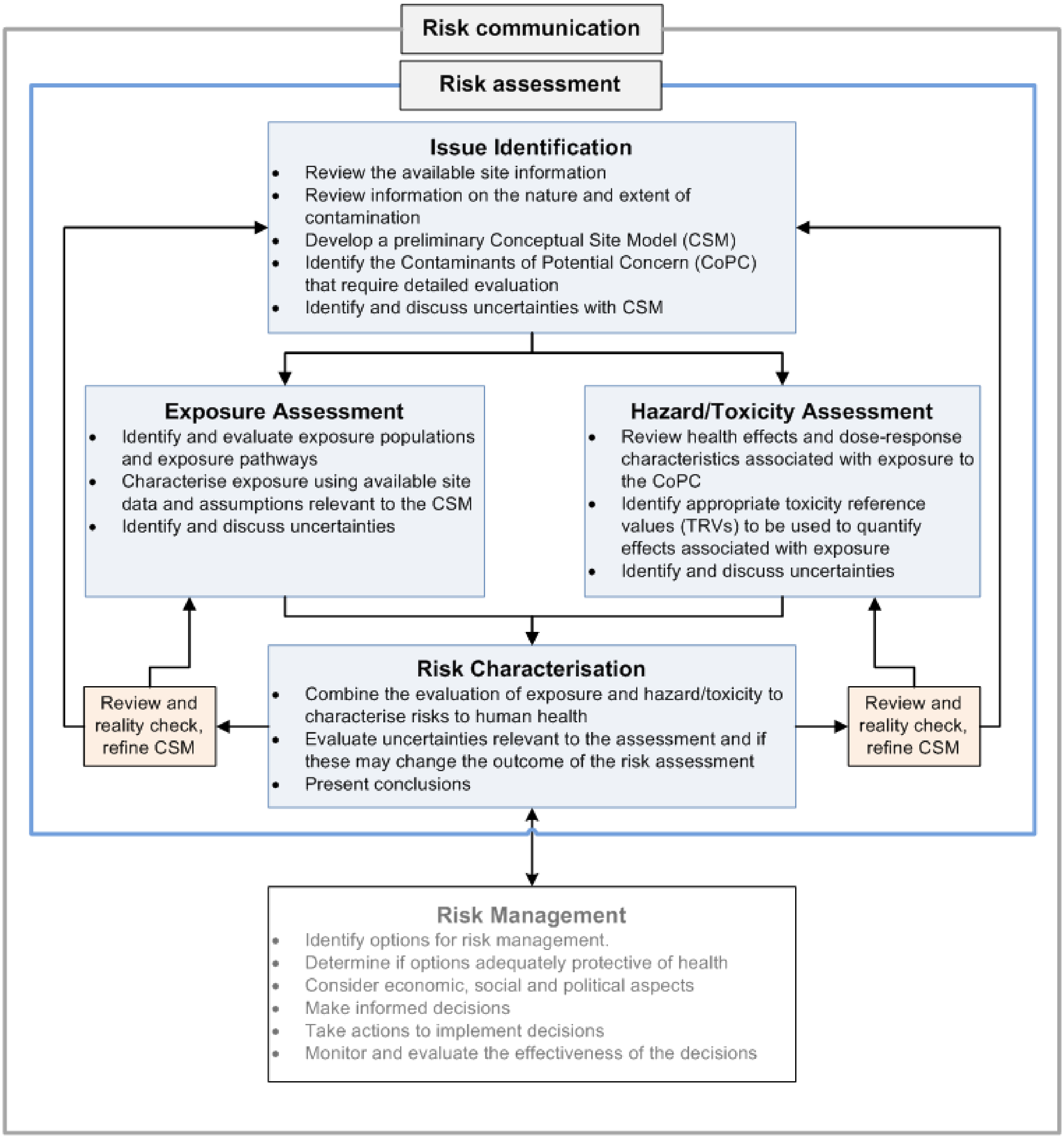
- enHealth Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards (enHealth 2012a);
- enHealth Australian Exposure Factor Guide (enHealth 2012b);
- National Environmental Protection Measure – Assessment of Site Contamination (ASC NEPM) including Schedule B1 Guideline on Investigation Levels of Soil and Groundwater (NEPC 1999 amended 2013a) and Schedule B4 Guideline on Health Risk Assessment Methodology (NEPC 1999 amended 2013b).

In addition, protocols and guidelines developed by international agencies such as the United States Environmental Protection Agency (USEPA) and the World Health Organisation (WHO) have been used (and referenced) to provide supplementary guidance where required. International guidance has not been adopted where it is inconsistent with the Australian regulatory or policy setting.

The overall approach adopted in this assessment is as follows:

- Issue identification comprising summary of relevant information and available data (**Section 2**);
- Review of the human toxicity of RCS, including the identification of appropriate screening level guidelines for the assessment of potential effects associated with exposures to RCS (**Section 3**) and;
- Assessment of human health risks based on the above. The assessment of risk will present conclusions in relation to risk with consideration of the uncertainties identified in the assessment and any requirements to undertake risk management measures (**Section 4**).

The overall approach for the HHRA is outlined in the following (modified from enHealth 2012):



Section 2. Issue identification

2.1 General

This section provides a summary of the information relevant to the assessment and characterisation of the potential for RCS impacts in dust that may be emitted from the Quarry. This assessment is based on a review of the following information:

- RWC (2019), Environmental Impact Statement for the Expansion of the Dowe's Quarry, via Tenterfield, Report to Daryl McCarthy Constructions Pty Ltd, R. W. Corkery & Co Pty Limited, October 2019 specifically (of relevance to this HHRA):
  - Cover and Contents
  - Executive Summary
  - 1 - Introduction
  - 2 - Proposal Description
  - Appendix 6 – Air Quality Impact Assessment (AQIA)
- Northstar (2020), Dowe's Quarry, Air Quality Assessment, Northstar Air Quality, January 2020. This is an updated Draft of the AQIA included in the EIS that was provide to enRiskS by RWC on 6 February 2020;
- Group Submission, DA Application #2019.101 Designated development – Dowes Quarry, 12 November 2019 (the "Group Submission");
- Objection letter to Tenterfield Shire Council Re. Dowe's Quarry DA No. 2019.101, letter from B. and J. Morrow to the Chief Executive – Tenterfield Shire Council, 9 November 2019 (the "Morrow Submission"); and
- Additional information provided by RWC (as referenced).

Unless otherwise indicated, the information used to compile this section of the HHRA has been sourced from RWC (2019).

2.2 Description of the Quarry

RWC (2019) and Northstar (2020) indicate that the Quarry is situated on a small ridge to the south of Washpool Creek. The area to the north of the Quarry is relatively flat land that comprises patches of remnant vegetation and areas cleared for cropping and light grazing. A small valley is present to the south of the Quarry, created by a further ridge aligned generally parallel to the Quarry. The proposal would modify the existing topography through in part removal of the ridge to the east and west of the existing extraction area and development of the overburden and fines emplacement area.

The Quarry comprises an extraction area, processing area, bund, overburden and fines stockpile, overburden and fines emplacement area, sediment dams and an access road. The total area of the Quarry if 26.8 ha, with the disturbance area comprising a maximum of 16.4 ha. The layout of the Quarry is shown on **Figure 2.1**.

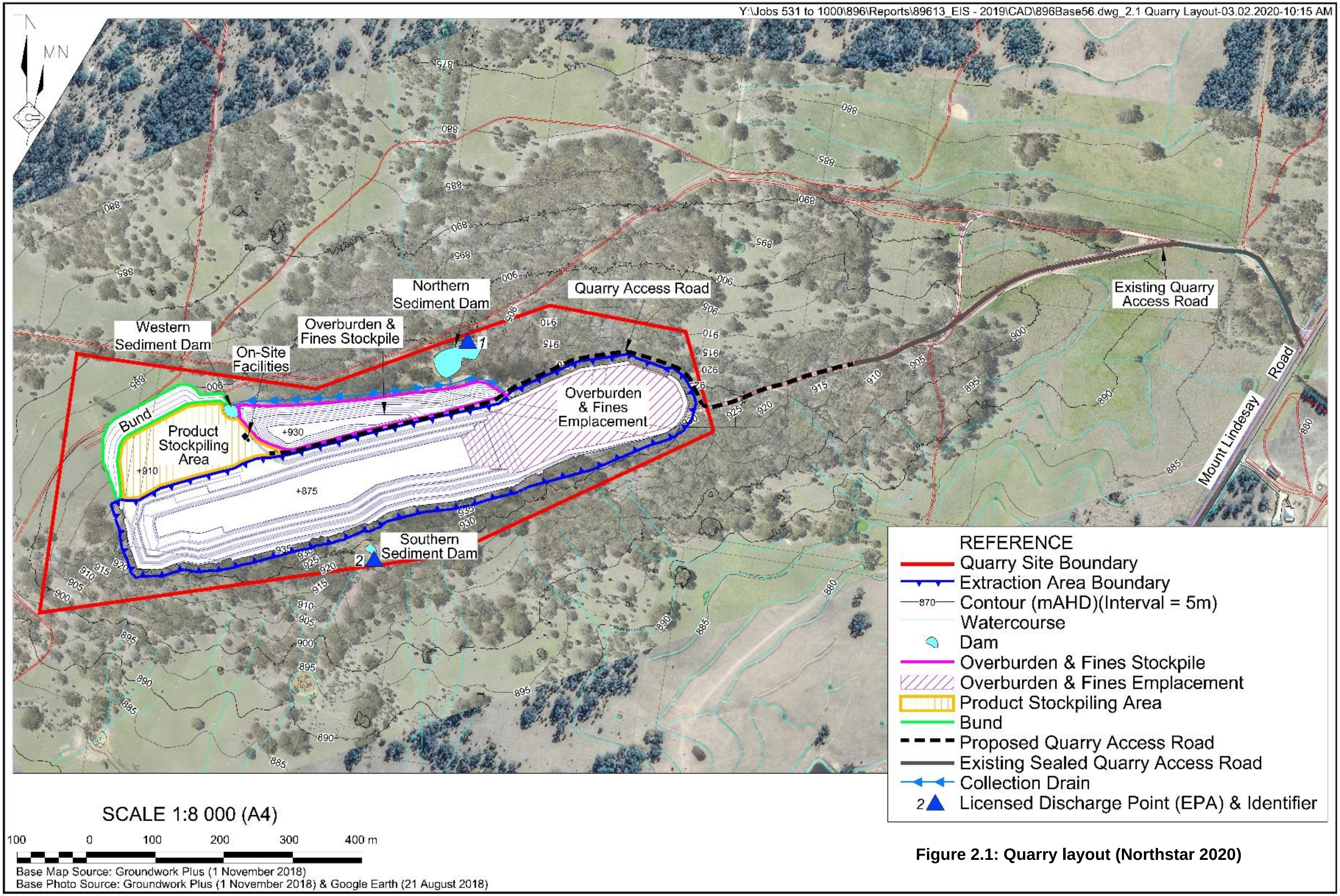


Figure 2.1: Quarry layout (Northstar 2020)

Rainfall is infrequent with few rain days each month resulting in rainfall greater than 1 mm. The mean annual rainfall is 848.5 mm with rainfall distributed unevenly throughout the year. Based on data from CSIRO for the last 5 years, the prevailing wind direction is to the east and west (likely to be the result of the topography of the Quarry).

The principal product currently produced at the Quarry is graded fractured quartoze rock blend with all fragments typically less than 400 mm. This product is produced by blasting and fragmenting oversize rock with a hydraulic hammer. RWC have indicated that analysis of the material proposed to be quarried indicates the material comprises 99.5% silica.

As indicated in **Section 1.1** (RWC, 2019 and Northstar, 2020), the key changes to the operation of the Quarry of relevance to this HHRA include the expansion of the extraction area and the production of a range of smaller products (5 to 24 mm) using a mobile crushing and screening plant. The crushing and screening of extracted material will also be undertaken at the Quarry, instead of at the Sunnyside Plant (as per current operations).

To facilitate this, the extraction area at the Quarry is proposed to be expanded to 11.4 ha across 3 stages. Extraction operations will be undertaken in a similar manner to existing operations i.e. using conventional drill and blast methods. Blasts would typically occur no more than once per month however the DA proposed blasting of no more than once per week excluding events required in the event of a misfire. The production rate will not exceed 230,000 tonnes per annum, which has been selected based on the inferred resource area, anticipated demand and allows for peaks in some years.

Excavated material will either be loaded directly onto highway trucks for transportation to the Sunnyside Plant, or hauled to the processing area at the Quarry for crushing using a mobile crushing plant. The rushing/screening rate at the Quarry will be up to 470 tonnes per hour. All crushing and screening works will be undertaken within the Quarry holes in the extraction area. Crushing equipment proposed to be used at the Quarry comprises a Jaw Crusher, Cone Crusher and Mobile Screen.

Following processing, products will be temporarily stored as stockpiles (5,000 to 10,000 tonnes) in a product stockpiling area, located immediately to the north-west of the extraction area. A bund would be constructed to the north and west of the product stockpiling area with the intent of mitigating any noise and visual impacts generated by operations. An overburden and fines stockpiling area will be located immediately north of the extraction area. As extraction operations continue, this material will be progressively backfilled within the generated voids to ground surface level. Two sediment dams will collect surface water runoff from the overburden and fines stockpile as well as other disturbed areas.

Dust emission to air that may occur during operation of the Quarry comprise:

- Clearing of vegetation;
- Emissions from product production and handling including those generated during blasting;
- Wheel generated emissions from product transportation product; and
- Wind erosion of exposed surfaces including stockpiled product.

2.3 Proposed dust management measures

The following mitigation measures are proposed at the Quarry to minimise any impacts from dust, as detailed in the air quality management plan (AQMP) for the Quarry:

- Use of a water truck;
- Regular servicing of the dust collection system on the drill rig;
- Misting water sprays on the mobile crushing and screening plant
- Rock boxes and dust covers on conveyor belts;
- Blasting and secondary rock breakage to be limited during periods of high wind or extremely dry weather (where practicable);
- All unsealed internal roads to be surfaced to minimise dust lift-off;
- Road watering on unsealed roads if dust becomes a nuisance during periods of westerly winds;
- All plant and equipment are washed down before any maintenance;
- Housekeeping on site including washing down only, with no blowing or sweeping;
- Use of appropriate care to avoid spillage during loading;
- Covering of trucks prior to leaving the Quarry;
- A speed limit of 30 km/hour on the Quarry access road, with a 10 km/hour limit on the unsealed internal roads;
- Maintenance staff wear personal protective equipment (PPE) including personally fitted masks (P2 type);
- All employees are inducted, and training is provided, which includes the minimisation of dust; and
- Continuation of the existing complaints system.

Darryl McCarthy Constructions has advised that the following dust management measures are currently implemented at the Sunnyside Plant during crushing activities:

- Use of a water truck;
- The crusher has in built dust sprays with a polo citrus addition that turns water into atomised water bubbles to maximise water particle size and maximise dust control;
- Use of airconditioned cabs;
- Maintenance staff wear personal protective equipment (PPE) including gloves and masks
- Plant is washed down prior to maintenance; and
- Crushing is not undertaken if winds exceed 30 kilometres per hour at the on-site weather station.

It has been indicated that the same management measures would be implemented during future crushing activities at the Quarry.

Darryl McCarthy Constructions has also committed to implementing continuous particulate matter monitoring at the Quarry at two locations (east and west of the Quarry). It is also expected that dust deposition monitoring would be undertaken at three locations, and a State-of-the-art Weather Station (Weathermation Live) will be installed so that operations can be proactively managed with wind speed and direction informing decisions for ongoing blasting / processing

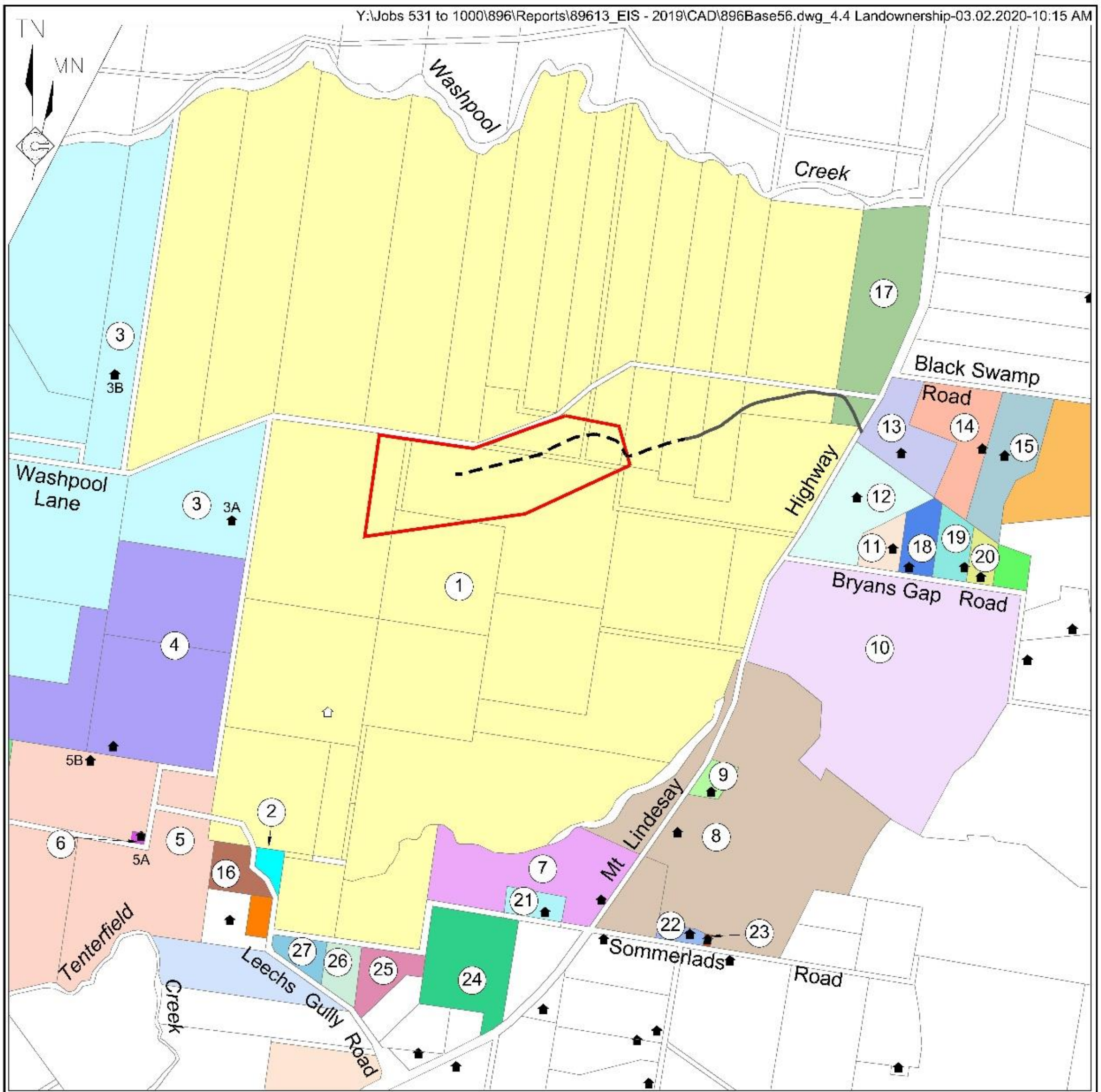
It is noted that operations at the Quarry would be undertaken in accordance with a Dust Control Plan, implemented under the Quarry Safety Management System.

2.4 Receptors and exposure pathways

The land surrounding the Quarry is agricultural with some residential properties.

Residents (adults and children) in residential properties adjacent to the Quarry are the receptors or population of concern for this HHRA. The relevant exposure pathway is the inhalation of dust sourced from the Quarry that may contain RCS.

The location and distances of the surrounding residences to the closest point of the existing and proposed extraction areas are shown on **Figure 2.2**. Residences are located to the east, west and south. There are no residences located to the north between the Quarry and Bald Rock National Park (approximately 2.5 km north of the Quarry).



REFERENCE
- Quarry Site Boundary
- Cadastral Boundary
- Proposed Quarry Access Road
- Existing Sealed Quarry Access Road
- Residence (Project Related)
- Residence (Non-Project Related)
- Landowner Reference (See Table)

Ref	Landowner	Ref	Landowner
1	RSH & MO Dowe	15	AJ & BW Lawrence
2	JP Jacquet, MJ Bielski	16	PJ Della & TM Curry
3A,3B	RF & LL Tumbridge	17	The State of New South Wales
4	RL Caldwell	18	MN & DN Larsen
5A,5B	GL & JM Smith	19	GB & DK Phillips
6	DB Weir, GR Smith, WF Marsden	20	CA Jackson, D Bunic
7	JM Dowe	21	DM & AJ Mullins
8	RB & CA Sewell	22	JP & SL Doyle
9	MJ & NJ Lewis, RB & CA Sewell	23	LD Merchant
10	KR & LA Willcocks	24	Harewood Investments Pty Limited
11	KH Baxman & CC Haynes	25	D Puglisi
12	BL & JA Morrow	26	BJ & RL Tom
13	RM Ibbett, S Ibbett	27	BJ Tom & Brad Tom Investments Pty Ltd
14	GM O'Reilly, MP Watt		

SCALE 1:25 000 (A4)

250 0 250 500 750 1000 1250 m

Cadastral Source: LPI (2014)
Landowner Source: Department of Lands Online Search - April 2019

Figure 2.2: Location of adjacent residences (Northstar 2020)

Figure 2.2 shows that the closest non-mine owned residential properties to the Quarry are as follows (property owners are listed in parenthesis):

- East:
  - Property 10 (KR & LA Wilcocks)
  - Property 12 (BL & JA Morrow)
  - Property 13 (RM & S Ibbett)
- West:
  - Property 3A (RF & LL Tumbridge)

Based on this information, the quarrying activities will be moved to the west of the current location, which means activities will be closer to the properties to the west and further away from the properties to the east. Property 10 is currently unoccupied and is located the furthest away to the east. Properties 12 and 13 are located 1,300 to 1,470 m respectively to the east of the boundary of the proposed Quarry activities. This is an additional 150 m to the east for Property 12 and an additional 160 m to the east for Property 13 as compared to the distance to the boundary of the current Quarry activities. Property 3A is located 540 m from the boundary of the proposed Quarry activities. This is 510 m closer as compared to the current Quarry extent. Residences 10, 12 and 13 are located along the transport routes currently used to transport raw materials to the Sunnyside Plant. This is important as the Morrow Submission (Property 12) raises concerns in relation to dust emitted from truck tyres during the transportation of quarry materials.

The EIS was required to include an assessment of the likely air quality impacts of the development, with a particular focus on dust impacts on nearby private residences. This was provided in the form of the AQIA (Northstar 2020) which predicted concentrations of 4 types of particles in air at the adjacent residences, that were assumed to be sourced from the Quarry. Predicted concentrations were compared to guideline values endorsed by the NSW Government as applicable to the residential properties. The results of the AQIA are important to this HHRA as RCS may be transported in dust emitted from the Quarry to nearby residents. Hence, where dust emitted from the Quarry contains RCS, the predicted concentrations of particles in dust at the residential properties can be used to estimate potential health risks to residents from RCS. A general introduction to the 4 types of particles assessed in the AQIA is provided in **Section 2.5**. The methodology and results of the AQIA are summarised in **Section 2.6**.

2.5 Introduction to particles

As discussed above, the AQIA assessed 4 types of particles: $PM_{2.5}$, PM_{10}, total suspended particulates (TSP) and deposited dust. TSP refers to all particulates with an equivalent aerodynamic particle[1] size below 50 microns in diameter[2]. It is a fairly gross indicator of the presence of dust with a wide range of sizes:

- Larger particles (termed 'inspirable', comprise particles around 10 microns and larger) are more of a nuisance as they will deposit out of the air (measured as deposited dust) close to

[1] The term equivalent aerodynamic particle is used to reference the particle to a particle of spherical shape and particle of density one gram per cubic metre.

[2] The size, diameter, of dust particles is measured in micrometers (microns).

the source and, if inhaled, are mostly trapped in the upper respiratory system[3] and do not reach the lungs; and
- Finer particles (smaller than 10 microns, termed 'respirable') are transported further from the source and are of more concern with respect to human health as these particles can penetrate into the lungs (see discussion below).

Hence, not all of the dust characterised as TSP is relevant for this HHRA, and TSP has not been further evaluated in this assessment. Deposited dust has not been considered further in the HHRA for the same reason.

Instead, this HHRA has focused on particulates of a size that are respirable. These particulates comprise the following (as illustrated in **Figure 2.3**):

- PM_{10} - particulate matter below 10 microns in diameter, µm;
- $PM_{2.5}$ - particulate matter below 2.5 µm in diameter;
- PM_1 - particulate matter below one µm in diameter, often termed very fine particles; and
- Ultrafines - particulate matter below 0.1 µm in diameter.

These particles are small and have the potential to penetrate beyond the body's natural clearance mechanisms of cilia and mucous in the nose and upper respiratory system, with smaller particles able to further penetrate into the lower respiratory tract[4] and lungs.

It is noted that the term 'respirable' is often used by various different groups and regulatory authorities (that include Safe Work Australia (Safe Work Australia 2013)) to refer to various ranges of particulate fractions that are smaller than 10 µm in diameter. This includes the above, as well as other groups such as PM_4 (particulate matter below 4 µm in diameter) and PM_7 (particulate matter below 7 µm in diameter). These other groupings of respirable particulates are not commonly measured in air, and hence many of the assessments utilise $PM_{2.5}$ or PM_{10} as surrogates for PM_4 and PM_7.

[3] The upper respiratory tract comprises the mouth, nose, throat and trachea. Larger particles are mostly trapped by the cilia and mucosa and swept to the back of the throat and swallowed.

[4] The lower respiratory tract comprises the smaller bronchioles and alveoli, the area of the lungs where gaseous exchange takes place. The alveoli have a very large surface area and absorption of gases occurs rapidly with subsequent transport to the blood and the rest of the body. Small particles can reach these areas, be dissolved by fluids and absorbed.

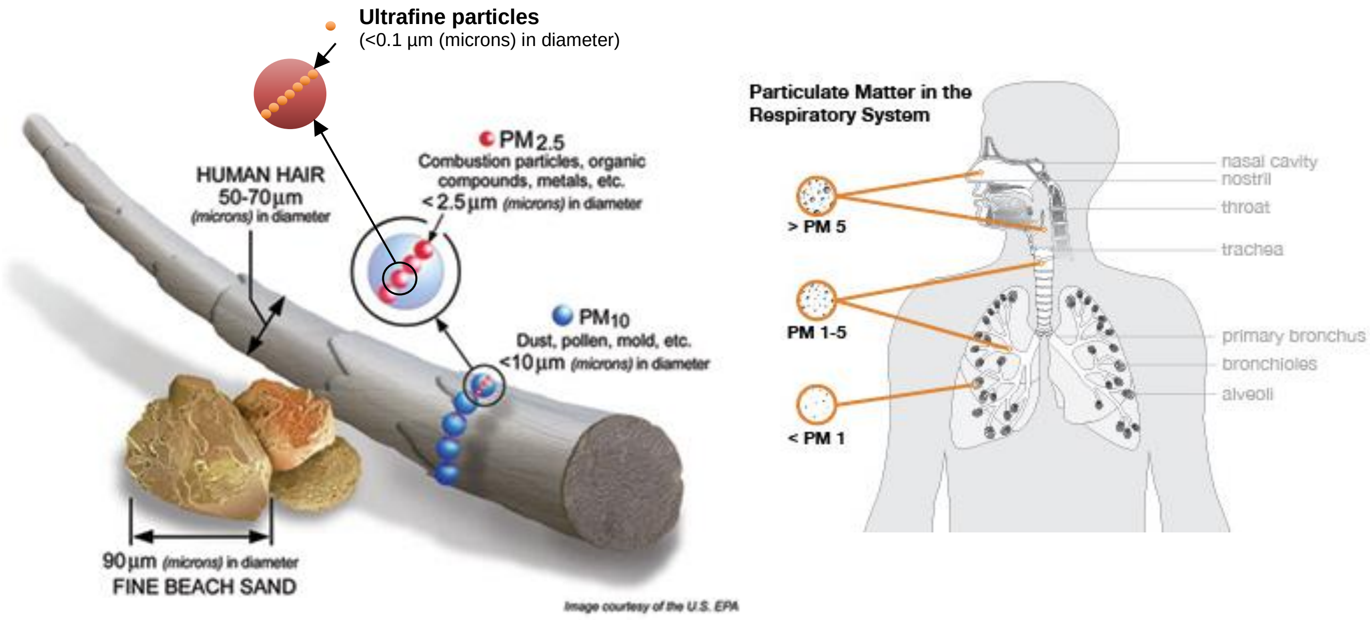


Figure 2.3: Illustrative representation of particle sizes and penetration into the lungs

In relation to measuring and assessing particulate matter, the following should be noted:

- The measurement of particulate matter in air most commonly reports PM_{10}. This is the concentration of particulate matter that less than or equal to 10 µm in diameter (and includes the smaller fractions of $PM_{2.5}$ and very fine particles). The measurement techniques for PM_{10} are well established and provide stable, robust, verifiable data that is consistently reported across all regains and countries; and
- The measurement of $PM_{2.5}$ is becoming more common. This is the concentration of particulate matter that less than or equal to 2.5 µm in diameter (and includes the smaller fractions of very fine particles and ultrafines). The measurement techniques used for $PM_{2.5}$ are less well-established resulting in data that varies depending on the type of equipment used and how it is set-up and maintained. Data on this fraction is, however, of most relevance to the assessment of health impacts; and
- The measurement of very fine particles and ultrafine particles is difficult (using equipment that is less robust/stable and provides variable data) and has not been undertaken in most air environments. In addition, there are no health based guidelines established for these fine fractions of particles. Hence the assessment of these fractions is not undertaken where specific sources of particles is being considered.

Figure 2.3 shows that $PM_{2.5}$ and smaller is the particle size that may reach the lower parts of the respiratory tract (the smaller bronchioles and alveoli). This is the area of the lungs where gaseous exchange takes place and the area that may be impacted by RCS (refer to **Section 4**). $PM_{2.5}$

includes a significant contribution from PM_1 (hence these fractions are included in the assessment of $PM_{2.5}$) Hence the further assessment of exposure to fine particulate matter has focused on particulates reported/evaluated as $PM_{2.5}$, with the consideration of PM_{10} for completeness.

2.6 Summary of the air quality impact assessment (AQIA)

Northstar (2020) indicates that the AQIA has been undertaken in accordance with guidelines/protocols endorsed by Australian regulators including the National Environment Protection (Ambient Air Quality) Measure (Ambient Air Quality NEPM) (NEPC 2016) and NSW EPA Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (NSW EPA 2016). These documents provide air quality standards and goals for particulate matter (i.e. dust), including smaller size particulate matter as PM_{10} and $PM_{2.5}$, that may be inhaled by humans.

As noted above, the AQIA considered the following sources of dust emissions during operation of the Quarry, based on the proposed expansion of activities:

- Clearing of vegetation;
- Extraction, processing and storage of product including emissions from blasting;
- Wheel generated emissions from transporting product; and
- Wind erosion of exposed surfaces.

The modelling considered an activity rate of 230,000 tonnes per annum or 5,000 tonnes per day, which is noted to be significantly greater than those which are likely to be experienced as part of ongoing Quarry operations. Hence, the AQIA is stated to be conservative and likely to provide an overestimate of dust emissions that may occur. Potential impacts during construction were considered to be appropriately covered off by activities during ongoing operation and were not assessed separately.

The AQIA considered potential impacts to 25 privately owned residential properties surrounding the site including the 3 closest currently inhabited residences listed in **Section 2.4** (properties 3A, 12 and 13). It is however noted that the distances to properties 12 and 13 (located to the east) assumed in the AQIA was based on the distance to the Quarry boundary which is 900 m and 1,000 m respectively. This is 300 to 500 m closer than the distance from the part of the Quarry where activities are undertaken. This is a conservative assumption in the AQIA.

The dominant wind direction was assumed to be to the east and west (towards the above residences), and dispersion modelling (using the approved CALPUFF software) was undertaken. Two additional models (TAPM and CALMET) was used to predict the meteorological (weather) parameters required for CALPUFF. These models consider the local topography. The use of these models was required as no weather data was available for the Quarry. The closest location with weather data to the Quarry was the monitoring station in the nearby town of Tenterfield however only daily data (at 9 am) is recorded at this location which is not generally considered appropriate for modelling (hourly data is needed). The nearest full meteorological station with hourly data is >82 km away (which is too far away and not in an appropriate area – specifically the topography was very different).

The CALPUFF model was used to predict the concentrations of different types of particles, comprising $PM_{2.5}$, PM_{10}, TSP and deposited dust, at each nearby residential property. The predicted concentrations were compared to the adopted air quality guidelines.

Data on background particulate concentrations was obtained from the Rural Air Quality Monitoring Network, where the data from the closest station was adopted. The closest station that provided PM_{10} data was Tamworth, located 258 km from the Quarry. Two stations are located closer to the Quarry (Armidale and Moree) however neither of these stations measure PM_{10}. It is also noted that the closest station (Armidale) is 171 km from the Quarry. No station within 300 km reported $PM_{2.5}$ concentrations, hence, $PM_{2.5}$ concentrations were inferred from PM_{10} concentrations (noting that $PM_{2.5}$ is a subset of PM_{10}). The data from 2015 was adopted for the AQIA. The AQIA assessment indicates that data from 2015 best represents the general trend across the 5-year study period (2013 to 2017). The level of RCS in background $PM_{2.5}$ or PM_{10} is not known as it is not measured, however it is expected to be low. Further discussion on background levels of RCS is presented in **Section 3.4**.

Cumulative impacts from other operations within the area that have the potential to generate RCS were assessed to be negligible as the closest industry with the potential to impact on air quality was the Sunnyside Plant, located 7.5 km to the west of the Quarry.

The concentrations of $PM_{2.5}$ and PM_{10} predicted by the AQIA are summarised in **Table 2.1**. The results in the "incremental impact" column are the estimated concentrations at the residential properties as specifically sourced from Quarry activities. The results in the "cumulative concentration" column are the sum of the incidental impact and background concentrations. As noted above, RCS was assessed as unlikely to be present in background particulate matter.

As outlined in **Section 2.5**, $PM_{2.5}$ concentrations are most relevant to this HHRA, hence, concentrations of these particles have been presented. PM_{10} concentrations have also been presented for completeness. Northstar (2020) indicates that the maximum modelled incremental concentrations are associated with a worst-case scenario where all material crushing occurs at the Quarry at the highest anticipated rate.

Table 2.1: Predicted concentrations of $PM_{2.5}$ and PM_{10} (Northstar 2020)

Residential property	Maximum predicted concentration (µg/m^3)					
	$PM_{2.5}$			PM_{10}		
	Incremental impact (from the Quarry)	Background	Cumulative concentration	Incremental impact (from the Quarry)	Background	Cumulative concentration
Maximum annual average[1]						
Property 3A	0.2	7.2	7.4	1.3	14.1	15.4
Property 12	0.1	7.2	7.3	0.5	14.1	14.6
Property 13	0.1	7.2	7.3	0.4	14.1	14.5
Other properties (maximum)	0.1	7.2	7.3	0.5	14.1	14.6
Adopted guideline value [N]	--	--	**8**	--	--	**25**
Maximum 24-hour Average Incremental Concentration[1]						
Property 3A	2.9	--	--	19.9	--	--
Property 12	0.9	--	--	5.4	--	--
Property 13	0.8	--	--	7.5	--	--
Other properties (maximum)	0.7	--	--	7.0	--	--
Adopted Guideline Value [N]	--	--	**25**	--	--	**50**
Maximum Cumulative 24-hour Average, Property 3A[2]						
Existing Operations: Day with Maximum Background	0.2	19.4	19.6	1.2	52.7	53.9
Existing Operations: Day with Maximum Incremental Impact	0.6	9.2	9.9	4.8	20.5	25.3
Stage 1: Day with Maximum Background	0.4	19.4	19.8	2.4	52.7	55.1
Stage 1: Day with Maximum Incremental Impact	1.7	9.2	10.9	12.1	20.5	32.6
Stage 2: Day with Maximum Background	0.5	19.4	19.9	3.3	52.7	56.0
Stage 2: Day with Maximum Incremental Impact	2.2	9.2	11.4	15.6	20.5	36.1
Stage 3: Day with Maximum Background	0.6	19.4	20.0	3.8	52.7	56.5
Stage 3: Day with Maximum Incremental Impact	2.9	9.2	12.2	19.9	20.5	40.4
Adopted Guideline Value [N]	--	--	**25**	--	--	**50**

Notes for Table 2.1:

1 = Modelling was undertaken for 3 stages of activities. The maximum predicted value from any stage has been presented in the table.

2 = The AQIA provides detailed results for property 3A as this property was predicted to have the highest impacts. The results from days when the incremental impact was predicted to be above 0.1 µg/m^3 have been presented in the table.

N = Air guidelines adopted from the Air Quality NEPM (NEPC 2016) and NSW guidance (NSW EPA 2016)

Review of **Table 2.1** indicates an exceedance of the adopted 24-hour average guideline for PM_{10}, which occurred for modelling based on all 3 stages of Quarry expansion on 6 May 2015. Northstar (2020) notes that this exceedance is caused by the background air quality and not the incremental impacts from the Quarry. As noted above, background particulate matter is not expected to contain significant levels silica. For other days, the maximum incremental concentrations do not occur with sufficiently high background conditions to result in an exceedance of the air quality guidelines.

Many of the days where elevated levels are reported are likely to relate to bushfire smoke or dust storms (from drought conditions) where the dust generated relates to surface soil.

There were no exceedances of the adopted guidelines at any property for $PM_{2.5}$.

The guidelines adopted by Northstar (2020) as presented in **Table 2.1** are relevant for the assessment of $PM_{2.5}$ generally, and not for the assessment of RCS. Further information in relation to the human toxicity of RCS is provided in **Section 3**. Review of potential health risks from RCS in dust that may be generated from the Quarry and migrate to the adjacent residences is provided in **Section 4**.

This assessment has assumed that 100% of the predicted $PM_{2.5}$ concentration in RCS, which is appropriate based on the measured silica content in the material to be quarried (99.5%).

2.7 Summary

This HHRA provides an assessment of potential health risks associated with the potential presence of RCS in dust emitted during the continued operation and extension of the Quarry. The Quarry is located approximately 8 km north-east of Tenterfield in NSW and has been operating at its current location since 1987. The operator of the Quarry is seeking development consent for the continued operation and expansion of extraction activities within the Quarry, including the expansion of the extraction area and the crushing and screening of extracted material at the Quarry, instead of at the Sunnyside Plant (as per current operations). All crushing and screening activities will be undertaken within the Quarry pit. It is understood that this is with the aim of reducing the potential for dust emissions from the Quarry.

Dust emission to air that may occur during operation of the Quarry comprise:

- Clearing of vegetation;
- Emissions from product production and handling including those generated during blasting;
- Wheel generated emissions from product transportation product; and
- Wind erosion of exposed surfaces including stockpiled product.

The modelling undertaken has incorporated dust mitigation measures proposed to be implemented, and are detailed in the AQMP for the Quarry.

The land surrounding the Quarry is agricultural with some residential properties. The closest non-mine owned residential properties to the Quarry are:

- East: Property 10, Property 12 and Property 13; and
- West: Property 3A

Property 10 is currently unoccupied and is further away from the Quarry than the other properties.

An Air Quality Impact Assessment (Northstar 2020), which provides predicted concentrations of 4 types of particles in air at the residences adjacent to the quarry, that were assumed to be sourced from the Quarry, is available for review. Predicted concentrations of TSP, deposited dust, PM_{10} and $PM_{2.5}$ were generated through a modelling exercise that is noted to be conservative based on expected Quarry operations. The AQIA then compared predicted concentrations of particulates in air to guideline values endorsed by the NSW Government as applicable to the residential properties. No exceedances of the guidelines were noted as a result of activities at the Quarry.

This HHRA has focused on particulates of a size that are respirable, as relevant to the assessment of potential health effects from RCS. These particulates comprise the PM_{10} and $PM_{2.5}$ size fractions. $PM_{2.5}$ and smaller is the particle size that may reach the lower parts of the respiratory tract (the smaller bronchioles and alveoli). This is the area of the lungs where gaseous exchange takes place and the area that may be impacted by RCS. Hence the further assessment of exposure to fine particulate matter has focused on particulates reported/evaluated as $PM_{2.5}$, with the consideration of PM_{10} for completeness.

The maximum predicted incremental impact concentrations of PM_{10} and $PM_{2.5}$ generated by the AQIA are summarised in **Table 2.2**. These are the concentrations of particulates considered further in this HHRA, which has assumed that 100% of the predicted $PM_{2.5}$ concentration is RCS. It is noted that the annual average concentration is an average of all the 24-hour averages, and so considers any peaks in concentrations that may occur daily, over a year.

Table 2.2: Summary of $PM_{2.5}$ and PM_{10} Concentrations (µg/m^3) (Northstar 2020)

Value	Maximum Predicted Concentration	
	$PM_{2.5}$	PM_{10}
Maximum annual average	0.2	1.3
Maximum 24-hour	2.9	19.9

Section 3. Toxicity assessment

3.1 General

The quantitative assessment of potential risks to human health for any chemical requires the consideration of the health end-points and where carcinogenicity is identified; the mechanism of action needs to be understood.

For chemicals that are not carcinogenic, a threshold exists below which there are no adverse effects (for all relevant end-points). The threshold typically adopted in risk calculations (a tolerable daily intake [TDI] or tolerable concentration [TC]) is based on the lowest no observed adverse effect level (NOAEL), typically from animal or human (e.g. occupational) studies, and the application of a number of safety or uncertainty factors. Intakes/exposures lower than the TDI / TC is considered safe, or not associated with an adverse health risk (NHMRC 1999).

Where the chemical has the potential for carcinogenic effects the mechanism of action needs to be understood as this defines the way that the dose-response is assessed. Carcinogenic effects are associated with multi-step and multi-mechanism processes that may include genetic damage, altering gene expression and stimulating proliferation of transformed cells. Some carcinogens have the potential to result in genetic (DNA) damage (gene mutation, gene amplification, chromosomal rearrangement) and are termed genotoxic carcinogens. For these carcinogens it is assumed that any exposure may result in one mutation or one DNA damage event that is considered sufficient to initiate the process for the development of cancer sometime during a lifetime (NHMRC 1999). Hence no safe-dose or threshold is assumed, and assessment of exposure is based on a linear non-threshold approach using slope factors or unit risk values.

For other (non-genotoxic) carcinogens, while some form of genetic damage (or altered cell growth) is still necessary for cancer to develop, it is not the primary mode of action for these chemicals. For these chemicals, carcinogenic effects are associated with indirect mechanisms (that do not directly interact with genetic material) where a threshold is believed to exist.

Dose-response values (threshold or non-threshold) that are considered relevant to the characterisation of potential health effects associated with exposure to the CoPCs identified have been selected from credible peer-reviewed sources as outlined in enHealth (enHealth 2012a) and NEPM (NEPC 1999 amended 2013b).

3.2 Respirable crystalline silica

3.2.1 General

The US Agency for Toxic Substances and Disease Registry (ATSDR) released an updated Toxicological Profile for Silica in September 2019 (ATSDR 2019). This toxicity profile is based on the information presented in the ATSDR document, with support from other references where indicated.

Silica in the form of quartz is one of the most commonly occurring minerals on the Earth's surface, with over 95% of the earth's crust made of minerals containing silica. There are 2 forms of silica –

crystalline silica and amorphous silica. Amorphous silica lacks a crystalline structure. Two common forms of crystalline silica are quartz and cristobalite.

Silica from quartz is an odourless, white, black, purple or green solid and is generally considered to be insoluble in water and unreactive in the environment. RCS in dust is also considered stable. Amorphous silica is more soluble than crystalline silica, hence, the primary source of dissolve silica in water is amorphous silica. Any silica that does not dissolve settles as sediment.

Silica is naturally released into the environment through the weathering of rocks, volcanic activity and biogenic sources. Hence, background exposures may occur through air, indoor dust, food, water, soil and various consumer products. Crystalline silica has a wide variety of commercial and industrial uses including:

- To produce high-temperature or refractory silica brick, foundry moulds and cores for metal casings;
- To manufacture glass and pure silicon for computer chips;
- As a filler in asphalt, plastics, rubber and paint;
- As an abrasive (e.g. for blasting);
- In sand and gravel used for building roads and in concrete;
- In the water-sand mix used by the oil and gas industry to fracture rock;
- In bricks, mortar, plaster, calk, roofing granules and stone building materials (including benchtops);
- In art clay, glazes and gemstones in jewellery;
- In personal care products such as cleansers and talcum powder and cosmetics; and
- In pet litter and furniture foam.

3.2.2 Exposure, absorption and health effects

The exposure route of concern for RCS is inhalation. Exposure to RCS is known to occur in industrial and occupational settings, with RCS recognised as an important occupational inhalation hazard.

The mechanisms that contribute to the absorption of inhaled particles are the physical transformation of particles deposited in the lung (including any surface modification or fragmentation), the dissolution of particles and interactions of particles with macrophages. Macrophages are cells in the immune system that recognise, eat and destroy target cells. The activity of macrophages is the dominant mechanism by which RCS is absorbed from the pulmonary region (referred to as “the lungs” in this review).

After being inhaled, RCS is cleared from the lungs via lymph drainage, macrophage phagocytosis and migration, and upward mucociliary flow. However, the presence of RCS in the pulmonary region also triggers cytotoxicity (toxicity to cells in the lungs) and apoptosis (cell death) leading to impaired clearance of the inhaled RCS. Dissolution does not play a strong role in RCS clearance due to the low solubility of silica. Absorbed RCS is not metabolised but may be transported to the lymph nodes following inhalation and may be excreted in the urine. Hence, inhaled RCS is not easily removed from the lungs.

Health effects associated with inhaled RCS reported in the scientific literature are strictly associated with occupational exposures to particles that are of respirable size (i.e. <10 µm) in silica industries. These effects include acute as well as chronic health effects.

Acute silica exposure causes respiratory tract inflammation. It also stimulates a significant increase in alveolar macrophages, leading to elevated levels of reactive oxygen species (ROS), which plays an important part in inflammation and the production of antioxidant compounds.

When poorly soluble particles, such as RCS, are inhaled they are deposited in the lungs, where long term inflammation results in disease such as silicosis and fibrosis. The prolonged inflammation results in the formation of fibrotic scar tissue and degradation of the muco-ciliary escalator (lung clearance mechanism). The improper repair of damaged lung tissue is essential for the development of chronic disease.

Health effects associated with occupational exposures include silicosis, lung cancer, renal toxicity and autoimmune diseases. The health effects that are generally of greatest concern to humans are silicosis and lung cancer

Silicosis is a progressive and irreversible fibrotic lung disease that has been recognised since Roman and Greek times and is not caused by any substance other than RCS (including amorphous silica). A fibrotic lung disease is a disease where excess fibrous connective tissue is formed in an organ. This type of effect is also referred to as scarring when in response to an injury. Silicosis is caused by inhaling RCS, where the RCS is then deposited on the lungs. There is no known cure for silicosis. There are several types of silicosis:

- **Acute silicosis** is caused by intense exposure to fine RCS dust, such as those generated during blasting or tunnelling. With this disease, the alveolar (the tiny air sacks in the lungs which absorb oxygen) fill with a protein rich fluid containing damaged cells. Inflammation of the lung also occurs. Symptoms include laboured breathing, dry cough, decreased pulmonary function, fever and fatigue followed by cyanosis and respiratory failure;
- **Simple silicosis** is the most common type of silicosis and results from long periods (10 to >20 years) of continuous exposures to relatively low levels of RCS dust (i.e. low levels are those considered to be those above occupational exposure limits, but less than 10 times the occupational exposure limit, refer to **Table 3.1**). Primary function and general health is typically not compromised in the early stages, however, intensity of cough and mucous discharge increases as the disease progresses. Decreases in lung function are often observed (including non-reversible air flow obstruction);
- **Progressive massive fibrosis (PMF)** is a progression of simple silicosis where nodular lung lesions (injuries) grow and come together to form masses of connective tissue that ultimately destroys the lung structures including the blood vessels. This leads to restricted lung volume and poor gas exchange; and
- **Accelerated silicosis** is a progressive form of simple silicosis that develops 5 to 10 years after exposure and is typically associated with moderate exposures (as opposed to simple silicosis which is associated with lower level exposures). Symptoms are similar to those of simple silicosis.

Decreased lung function can also be observed in the absence of silicosis and may be caused by exposures to RCS. This is known as chronic obstructive pulmonary disease (COPD). COPC is characterised by limitation in airflow caused by chronic bronchitis, emphysema, asthma or peripheral airways disease (ATSDR 2019; NIOSH 2002). Cigarette smoking is the main cause of COPD however occupational exposures to dust and community air pollution can also contribute and there are limited studies that link RCS and COPD. No studies have investigated a potential link between RCS and asthma and RCS is not known to cause asthma occupationally.

The most important factor for the development of silicosis is cumulative exposure to RCS. Time from first exposure to onset of symptoms can vary from a few weeks (for acute silicosis) to 20 years or more (for simple silicosis). Disease severity may also slowly increase following cessation of exposure, where RCS is retained in the lungs.

Several studies have looked at whether exposure to RCS causes lung cancer and compared to other occupational lung carcinogens, the reported association is low. However, an increase risk to lung cancer in RCS workers has been reported, with risks dependant on cumulative (successive and ongoing) exposures over times. The available evidence indicates that RCS is genotoxic with the ability to cause mutagenicity and DNA damage.

The major biological processes thought to cause silicosis and lung cancer are shown in **Figure 3.1**, and there appears to be some evidence that silicosis is more prevalent in situations where the silica inhaled is freshly fractured (where the silica particles may generate free radicals).

Exposure to RCS can also cause adverse renal and autoimmune outcomes. However, these effects are not as well studied as silicosis and lung cancer and associations are not evident in all studies. It is considered that renal toxicity occurs at higher exposure levels than silicosis.

Data on health effects following oral exposures to RCS is also limited. However, the available studies do not identify adverse effects in animals following exposures via this route (no data is available for humans). Similarly, adverse effects in humans and animals are expected following dermal exposures.

No information is available in relation to the susceptibility of children to RCS as silicosis is generally considered to be an occupational disease that typically appears after prolonged exposures. The same adverse effects would be expected to appear in children where exposures were similar to adult workers. Individuals with underlying lung and health conditions such as asthma and emphysema may be more susceptible to adverse respiratory effects from inhaled RCS. The risk of silicosis in workers who smoke cigarettes is also higher than in workers who do not smoke.

The presence of silica in the urine indicates that exposure has occurred. However, the presence of silica in the urine does not provide any specific information in relation to exposure levels and/or the potential for adverse health effects.

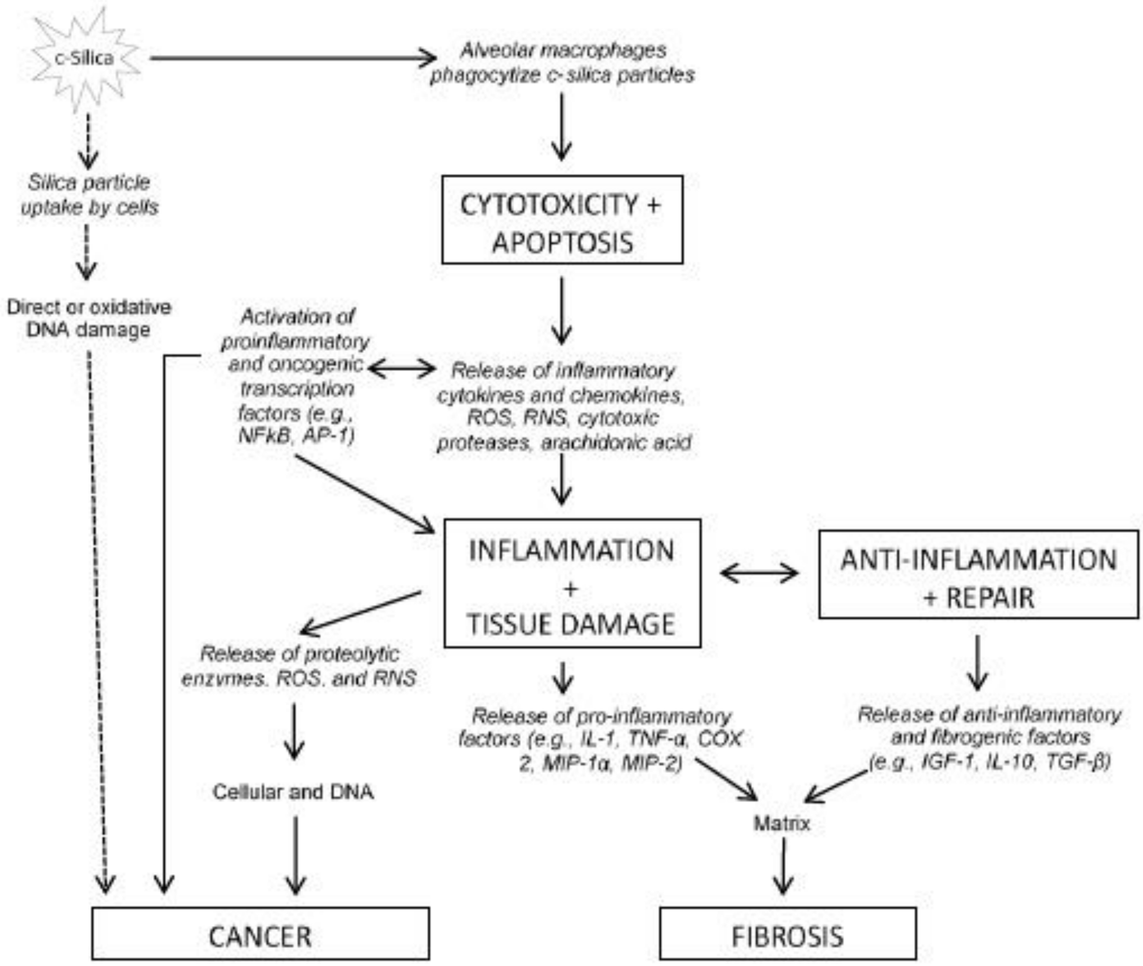


Figure 3.1: Biological pathways for the formation of silicosis and lung cancer (ATSDR 2019)

3.2.3 Classification

Inhaled crystalline silica dust in the form of quartz or cristobalite, is classified as Group 1 (carcinogenic to humans) by the International Agency for Research on Cancer (IARC) (IARC 2012).

The IARC classification is based on data from human workers in 5 main industrial settings comprising ceramics, diatomaceous earth facilities, ore mining, quarries, and sand and gravel operations. Of these settings, the data from diatomaceous earth facilities, quarries, and sand and gravel facilities was concluded to be least likely to be confounded (i.e. influenced by factors other than the presence of RCS). Most studies from these 3 industries reported associations between RCS exposure and lung cancer risk. Cancers other than lung cancer have not been as thoroughly researched. RCS has been demonstrated to be a lung carcinogen in experimental rats but not in mice and hamsters. It is noted that rats are generally considered more likely to get lung tumours than mice and hamsters. The mechanisms for carcinogenicity is likely to be inflammation. As noted above, RCS is thought to be genotoxic.

TCEQ (2009) notes that the carcinogenic potential of silica is controversial with statistically significant associations observed in some studies but not other studies. This may be due to the specific type of crystalline silica inhaled or on other external factors that affect biological activity and distribution (for example quartz is known to be variable where toxicity may be dependent on the surface characteristics and age of the particles, as well as other factors including confounding). There is epidemiological evidence that the risk of developing lung cancer is higher in workers with silicosis than those without silicosis, however it is not known if silicosis is necessary for the development of lung cancer.

TCEQ (2009) also emphasises that the identification of RCS as carcinogenic relates only to occupational exposures. This is because no epidemiological studies were available to IARC on environmental exposures at the time of the assessment.

The classification of RCS as an occupational carcinogen is supported by ACGIH (2010) which indicates that the consensus amount US and international agencies is that there is a positive association between silica exposures and lung cancer. Most agencies consider that silica does not directly act to initiate cancer, however, do agree that workers that have pulmonary fibrosis (following exposure to silica) are at risk of developing lung cancer (but does not prove that the fibrosis leads directly to lung cancer). However, ACGIG considers that a reduction in worker exposures such that risks from silicosis are eliminated will likely protect against the formation of lung cancer.

Silica is not currently identified by USEPA or TCEQ (TCEQ 2009) as having a mutagenic mode of action and data is not adequate to determine the mechanisms or key steps that are critical for lung cancer development, and hence the potential for increased susceptibility in children due to early life exposure.

3.2.4 Quantitative toxicity reference values

Toxicity reference values (TRVs) are quantitative values that are derived by key health authorities to be protective of the health effects that have been identified for a chemical. This involves an understanding of the different types of health effects that have been identified. It is often the case that different health effects occur at different levels of exposure. The detailed reviews that are undertaken by health authorities identify what the most sensitive health effect is and what would be the lowest, or most protective, quantitative value. This is the TRV, and it is established to be protective of all health effects.

For RCS, the information summarised above (and presented in the references noted) has been considered by a number of different health authorities. **Table 3.1** summarises the non-threshold and threshold chronic toxicity reference values (TRVs) that are available for RCS from Level 1 Australian and international sources. Two types of toxicity values are listed in this table:

- **Occupational air guidelines:** these guidelines are applicable to individuals who are exposed to chemicals in the workplace through use or handling, that does not present an unacceptable risk to worker health or cause undue discomfort. These guidelines relate exposures by healthy workers in the workplace, during work hours. The guidelines are higher than ambient or community air guidelines and may be at levels that are mildly irritating; and

- **Community air guidelines:** these guidelines represent the concentration of a chemical in air that, based on the current science, does not present an unacceptable risk to public or community health. These guidelines are based on a range of different studies conducted in animals and humans (from occupational studies or studies in large populations – epidemiological studies), with the application of an uncertainty factors to make sure that the guideline is relevant to the community who may have a range of sensitivities. The uncertainty factors may also take into account any limitations there are with the available studies.

The community air guidelines are the guidelines that are relevant for the assessment of potential health risks to residents that may be exposed to RCS in dust sourced from the Quarry. The occupational air guidelines have been provided for reference, as many of the health effects identified are of most significance for occupational exposures.

Table 3.1: Summary of relevant TRVs for RCS

Source	Value	Basis/Comments
Occupational Air Guidelines		
Australian		
Work Safe Victoria[5]	50 µg/m^3	Time-weighted Average (TWA) for Quartz (respirable dust) and an 8-hour workday during a 40 hour workweek. WorkSafe Victoria recommends that employees are not exposed to levels above 0.02 mg/m^3 as a precautionary measure.
Safe Work Australia HCIS (Safe Work Australia) (Safe Work Australia 2019)	50 µg/m^3	TWA for an 8-hour workday during a 40 hour workweek. This TWA has been recently revised down (in December 2019) from 100 µg/m^3. The Draft document supporting the derivation of the revised TWA indicates that there is no clear or observable adverse effect concentration (NOAEC) in humans, however concentrations below 25 µg/m^3 are considered to be protective of the lungs by ACGIH and multiple data sources identify adverse effects in the lungs at 50 µg/m^3 and lung cancer at 65 µg/m^3. Concentrations of 20 µg/m^3 are considered protective against both silicosis and lung cancer, with lung cancer considered a secondary effect to silicosis.
AIOH (AIOH 2009)	50 to 100 µg/m^3	The Australian Institute of Occupational Hygienists Inc (AIOH) supports the previous Safe Work Australia TWA of 0.1 mg/m^3 however indicates that control strategies and health surveillance should be implemented where there is a likelihood of 50% of the TWA being exceeded (i.e. concentrations >0.05 mg/m^3).
International		
WHO (WHO 2000)	None	No threshold or tolerable concentration identified. Recommends that occupational exposures to respirable quartz dust be reduced to the extent practicable.
NIOSH (NIOSH 2002)	50 µg/m^3 (respirable fraction)	Recommended Exposure Limit (REL) for RCS and a 10-hour workday during a 40-hour workweek. A no observable adverse effect level (NOAEL) was unable to be determined. The REL recognises that the sampling and analytical methods used to evaluate occupational exposures to RCS are not accurate enough to quantify exposures at concentrations below the REL. The REL is aimed at reducing the risk of developing silicosis, lung cancer and other adverse health effects. Substitution of less hazardous materials is also recommended where feasible. NIOSH defines the "respirable" fraction as "*the portion of airborne crystalline silica that is capable of entering the gas-exchange regions of the lungs if inhaled; by convention, a particle-size-selective fraction of the total airborne dust; includes particles with aerodynamic diameters less than approximately 10 µm and has a 50% deposition efficiency for particles with an aerodynamic diameter of approximately 4 µm.*" This definition is generally consistent with that used by Safe Work Australia (Safe Work Australia 2013).

[5] https://www.worksafe.vic.gov.au/dust-containing-crystalline-silica-construction-work

Source	Value	Basis/Comments
ACGIH (ACGIH 2010)	25 µg/m^3 (respirable particulate matter)	Threshold Limit Value (TLV) for α-quartz and cristobalite and the protection against both silicosis and lung cancer. RCS classified as A2 – suspected human carcinogen. The TLV is based on the following: <u>α-quartz</u> Based on no change in longevity of lung function in workers exposed to 50 µg/m^3, an increase in risk from silicosis in workers at 60 µg/m^3, and an increase in risk from lung cancer in workers at 65 µg/m^3. The TLV is based on the association of inflammation and fibrosis with lung cancer following silica exposures. The uncertainties associated with the epidemiological studies are noted and the industrial hygienist is advised to use every means available to keep exposures below the TLV. <u>Cristobalite</u> TVL for α-quartz recommended as the available human studies indicate a similar toxicity.
Cal/OSHA	50 µg/m^3 (respirable fraction)	Permissible Exposure Limit (PEL) enforced in workplaces under the jurisdiction of the California Division of Occupational Safety and Health.[6] The PEL applies to the respirable fraction as defined by NIOSH.
OSHA	--	PEL not considered in HHRA as the PELs are noted by OSHA to be outdated and inadequate for ensuring protection of worker health.[7]
Community Air Guidelines		
Australian		
EPA Victoria (2007)	3 µg/m^3 ($PM_{2.5}$ fraction)	Annual average assessment criteria for mining and extractive industries for RCS. This is the total concentration of background plus emissions arising from activities at a site. The assessment criteria are used to evaluate the impact of any residual emissions following appropriate controls. The REL from the California EPA Office for Environmental Health Hazard Assessment (OEHHA) has been adopted (refer below).
International		
TCEQ (TCEQ 2009)	Non-cancer: = 2 µg/m^3 (PM_4 fraction) Cancer: 0.27 µg/m^3 (PM_4 fraction)	Effects Screening Levels (ESLs) for quartz, cristobalite, tripoli and tridymite. <u>Non-cancer effects:</u> Chronic Reference Value (ReV) based on epidemiological data from 2 studies. The key study involved South African gold miners (Hnizdo and Sluie-Cremer 1993; 2,235 individuals following 24 years exposure mainly to RCS as quartz). The supporting study involved Californian diatomaceous earth workers (Hughes et. al. 1998; 2,342 individuals exposed for at least 1 year to cristobalite). Bench-mark dose modelling was undertaken at the 1% response rate for both studies. The adopted point of departure was in the range 4 to 6 µg/m^3. The adopted uncertainty factor (UF) was 3 to account for susceptibility in the general population (including children and the elderly). An UF of 3 was assessed to be adequate as a $BMCL_{01}$ could be derived and the cohort examined was large and therefore assessed to cover sensitive sub-populations. However, the study only included male workers. The derived ReV was 2 µg/m^3, based on the rounding of results from both studies. A chronic non-cancer ESL of 0.6 µg/m^3 was also derived based on a Hazard Quotient (HQ) of 0.3 (this is not relevant to Australia where the applicable HQ is 1).

[6] https://www.dir.ca.gov/title8/5155table_ac1.html#_blank
[7] https://www.osha.gov/dsg/annotated-pels/

Source	Value	Basis/Comments
		Cancer: Unit Risk (UR) of $3.6x10^{-5}$ $(\mu g/m^3)^{-1}$ derived based on lung cancer mortality in silica-exposed workers (as pooled by Steenland etc. al. 2001; 65,980 workers from a range of industries) and RCS of ≤4 µm in diameter. The derived chronic ESL (cancer) was 0.00027 mg/m^3 at a target risk level of $1x10^5$.
Minnesota Department of Health (MDH 2013)	3 µg/m^3 (PM fraction not stated)	Non-cancer effects: Chronic Health Based Value (HBV) based on the same key epidemiological study evaluated by TCEQ (2009) (Hnizdo and Sluie-Cremer 1993), with a point of departure of 0.0098 mg/m^3 and an UF of 3. The main difference in the TCEQ and MDH assessments was the assumed %RCS in dust inhaled by the workers (30% by MDH versus 54% by TCEQ; a difference of around 2-fold). Cancer: No cancer HBV was calculated. MDH concluded that if exposure to silica is maintained at levels below the Chronic HBV the likelihood of increased risk of developing lung cancer is minimal.
California OEHHA (OEHHA 2005)	3 µg/m^3 (PM_4 fraction)	Non-cancer effects: Inhalation Reference Exposure Level (REL) based on the same key epidemiological study evaluated by TCEQ (2009) (Hnizdo and Sluie-Cremer 1993), with a point of departure of 9.8 µg/m^3 and an UF of 3. The assumed silica content in dust was 30%. Data from the Hughes et. al. (1998) study and 3 additional supporting studies (Chinese tin miners, Chen et. al., 2001; Dakota gold miners, Steenland and Brown 1995; South African gold miners, Churchyard etc. al. 2004) was also considered. Derived RELs were in the range 3 to 6 µg/m^3. The REL applies to the respirable fraction as defined occupationally by ACGIH (2004)/ISO (1995) which has a 50% cut-off point at the 4 µm particle aerodynamic diameter. Cancer: OEHHA notes that RELs are not derived based on cancer endpoints and there are no approved cancer potency factors for silica.
Vermont Agency of Natural Resources (2018)[8]	0.12 µg/m^3 (PM fraction not stated)	Hazardous ambient air standard (annual average) for crystalline silica as listed in the 2018 Air Pollution Control Regulations. No information available in relation to the derivation of the air standard (information was requested on 7 February 2020, but no information had been provided at the time of this HHRA). This guideline has not been considered further in the HHRA as no information is available in relation to how the guideline has been derived.

[8] https://dec.vermont.gov/sites/dec/files/aqc/laws-regs/documents/AQCD%20Regulations%20ADOPTED_Dec132018.pdf

As noted above, the community air guidelines presented in **Table 3.1** are the guidelines that are relevant for the assessment of potential health risks to off-site residents that may be exposed to RCS in dust sourced from the Quarry. The community air guidelines are lower than the occupational guidelines by around 10 to 30 times.

International community air guidelines for RCS are similar (2 to 3 $\mu g/m^3$) and are all based on data from occupational studies on protection against silicosis . The guideline of 3 $\mu g/m^3$ was first derived by OEHHA (2005), was confirmed by the most recent review undertaken by MDH (2013) and adopted by EPA Victoria (2007). Hence, this guideline has been adopted in this HHRA. This means that exposures to RCS concentrations of less than 3 $\mu g/m^3$ are considered safe, or not associated with adverse health risks from RCS. A slightly lower guideline of 2 $\mu g/m^3$ has been derived by TCEQ (2009) but is noted to be based on the same key studies and is not significantly different to 3 $\mu g/m^3$.

The OEHHA (2005) guideline specifically considered the protection of sensitive members of the population, especially children (as silica particles may penetrate further into the airways) and women (who may be more sensitive than men to the development of silicosis). For this reason, an UF of 3 (and not 1) was used for interspecies variation in the development of the air guideline, as the key studies primarily investigated effects in male workers. MDH (2013) notes that the derived guideline also considers general population exposures and is based on a benchmark concentration low_{01} ($BMCL_{01}$; a value similar to a NOAEL) which is the 95% lower bound estimate of the concentration at which 1% of the population will develop silicosis.

Except for TCEQ (2009), national and international guidelines for cancer effects have not been derived, as silicosis was determined to be the most sensitive effect. i.e. cancer was deemed unlikely to occur at concentrations of RCS below the guideline for silicosis. The rationale for the inclusion of the cancer guideline by TCEQ (2009) appears to be based on the TCEQ policy position in relation to the lack of a clearly identified mode of action for silica toxicity, including the potential uncertainties in the epidemiology studies. In their response to comments on the Draft document outlining the derivation of the guidelines, TCEQ indicate that:[9]

- "*There is not a consensus among the scientific community on whether the carcinogenic mode of action for silica is non-linear or linear or whether silicosis is necessary for the development of lung cancer*".

The opinion of TCEQ (2009) is not supported by the more recent MDH (2013) review who indicate the following:

- *Silica has been classified as a known human carcinogen…because of an observed increase in lung cancers in occupationally exposed workers. There is, however, a large body of evidence that indicates that lung cancer attributed to silica occurs only after repeated insult leads to silicosis. While some controversy remains, MDH has determined that if exposure to silica is maintained at levels below those that result in silicosis the likelihood of increased*

[9] https://www.tceq.texas.gov/assets/public/implementation/tox/dsd/final/october09/comments/responses_silica.pdf

risk of developing lung cancer is minimal. MDH will continue to monitor this issue and reconsider this decision as new information becomes available.

In the absence of a definitive mode of action, TCEQ guidance indicates that where chronic adverse effects are determined to be associated with a linear dose-response relationship in the low-dose region, which is typically for chronic exposures to carcinogens, a cancer evaluation should be undertaken. This determination is based on data or science policy default assumptions (TCEQ 2006).

Irrespective of the above, IARC is clear that the determination that RCS is carcinogenic relates only to occupational exposures. For this reason, the TCEQ (2009) cancer guideline has not been adopted in this HHRA, however has been considered further in the uncertainty analysis (refer to **Section 4.3**).

In relation to the OEHHA (2005) community air guideline (REL), the background document notes that there is an absence of comprehensive data on the ability of different particle sizes to induce silicosis, hence, it is not possible to adjust the guideline for different size particle distributions (e.g. as might be measured at a particular site). Further, while silicosis is generally assumed to be induced by the fraction that reaches the alveoli (with the majority of particles around 4 µm), there is no data to confirm a lack of adverse effects for coarser particles of 4 to 10 µm. The guideline therefore applies to particles that are defined as "occupationally respirable". Given this:

- $PM_{2.5}$ and PM_{10} concentrations ≤3 µg/m^3 would not be expected to be associated with adverse health effects;
- PM_{10} concentrations >3 µg/m^3 require further investigation and/or risk management; and
- $PM_{2.5}$ >3 µg/m^3 < PM_{10} concentrations may require further investigation, including a more precise determination of the respirable fraction.

It is noted that Victoria (EPA Victoria 2007) has adopted the OEHHA (2005) guideline for RCS as $PM_{2.5}$. This has also been adopted in this assessment, as modelling of particulates has focused on $PM_{2.5}$ and PM_{10}.

3.3 Environmental silicosis

As noted above, RCS is recognised as an important occupational inhalation hazard. However, information in relation to the potential for silicosis in the general population is less available.

ATSDR (2019) indicates that the primary route of exposure to RCS in the non-occupational population is through to be via the inhalation of RCS during the use of commercial products containing quartz. People who live near quarries, sand or gravel operations or hydraulic fracturing operations may be exposed to RCS in dust. However, to date adverse health effects associated with inhaled RCS have been strictly associated with occupational exposures to particles that are of respirable size (i.e. <10 µm). Adverse effects of RCS have not been reported for incidental exposure to low levels of RCS in the environment (e.g. in beach sand) or from exposures that exceed the respirable size fraction.

A USEPA report into ambient levels of RCS indicates that environmental silicosis is not a well-defined term (USEPA 1996). Although some studies have reported silicosis in the absence of occupational exposures, most studies reporting pulmonary aliments following ambient dust exposures are from underdeveloped arid regions of the world, and in general, the studies lack control patients and/or specific silica dust exposure measurements. These studies often do not clearly differentiate between occupational and environmental exposures. OEHHA (2005) confirms that several international studies have reported environmental silicosis, which is where the silicosis occurs in the absence of an industry usually associated with the disease. However, in the instances reviewed, the exposures were high and therefore considered to be the same as occupational exposures, or to express this another way, higher than exposures by most of the population.

The main example provided by OEHHA (2005) (and by other reviews in the scientific literature) is the instances of pneumoconiosis in Ladakh, India. Pneumoconiosis is a group of diseases of the lung caused by the inhalation of dust, which include silicosis. The Ladakh area is high in the western Himalayas where there are no mines or industries. In around 450 randomly selected inhabitants across three villages (Saboo, Shey and Chushot), the prevalence of pneumoconiosis was 2.0% (3/150) in Saboo, 20.1% (31/149) in Shey and 45.3% (68/150) in Chushot. The prevalence of pneumoconiosis was observed to correspond with the severity of dust storms and the presence or absence of chimneys in kitchens. Without chimneys (Chushot), dust concentrations in kitchens averaged 7,500 $\mu g/m^3$ during cooking periods. The free silica content of the dust storms was 60-70%. The authors suggested that the pneumoconiosis was due to exposure to free silica from dust storms and to soot from cooking with domestic fuels (with effects potentially affected by the interaction of silica and soot). Similar findings have been reported following studies with Bedouin women who undertake work including spinning wool, cooking and cleaning tents, in individuals involved in occupations with high exposures to silica dust such as farmers or woodworkers (USEPA 1996) and in other Himalayan villages that are exposed to frequent dust storms (Bhagia 2012). These situations could also be considered equivalent to exposures adjacent to industries in developing countries such as India and South Africa (refer to **Table 3.2**) where monitoring and/or risk mitigation measures are not routinely implemented.

There is evidence of silicosis among domesticated grazing animals (horses, camels and water buffalo). This indicates the potential for environmental silicosis however the specific relevance of these findings to humans is not clear. It is also noted that the utilised diagnostic techniques (e.g. chest X-rays) may have overlooked low levels of environmental silicosis in the general population, particularly in dusty/arid regions (USEPA 1996).

As noted above, some key limitations of the studies in the scientific literature relating to environmental silicosis is data on concentrations for RCS in air that the study population was exposed to, as well as the presence of confounding exposures (in particular particles from cooking and heating with no controls). However, data is available from 2 air monitoring studies undertaken in the USA and UK where RCS concentrations were reported. This data is summarised below.

Air monitoring for RCS was undertaken in Wisconsin USA between 2012 to 2014 in response to community concern in relation to ambient RCS concentrations adjacent to frac sand production facilities (Richards & Brozell 2015). Multi-year sampling programs were undertaken adjacent to 4 facilities, of which 3 were frac sand mines and 1 was a frac sand processing plant. Sampling locations were around 600 to 1,300 m from the facilities and considered the prevailing wind direction/s. A total of 2,128 24-hour average sample values were available, across the 8 sampling locations at the 4 facilities.

The RCS concentration in the PM_4 fraction was measured, with 88% of samples reporting RCS below the limit of reporting of 0.31 µg/m^3. Geometric means of 0.22 to 0.41 µg/m^3 were reported for the analysed yearly datasets, depending on the data analysis approach adopted. 99% concentrations were in the range 0.31 to 1.44 µg/m^3. The difference between upwind and downwind sampling locations was small at all 4 facilities, with no detectable change on 78% of days. Maximum background RCS concentrations were in the range 0.56 to 2.10 µg/m^3 (averages in the order of 0.02 to 0.3 µg/m^3). The study concluded that the measured RCS concentrations adjacent to the facilities is within the background range.

Air monitoring was undertaken at and in the vicinity of 7 construction sites in the UK to estimate inadvertent exposures to RCS as a result of the activities (Stacey, Thorpe & Roberts 2011). In total, 48 samples were collected from construction sites with 11 air samples collected from adjacent areas occupied by the community. The sites assessed included demolition, block cutting, road building and general construction activities. The sampling reported evidence of RCS transport from the construction sites to the adjacent public areas, with similar crystalline components reported in both types of samples. RCS concentrations were generally reported to be low for all sites with the exception of several samples from block cutting and demolition activities which reported maximum RCS concentrations of 11.9 µg/m^3. RCS concentrations in urban area air in the range 0.08 to 0.44 µg/m^3.

Information is also available from 3 sites in Australia (including 2 sites in Queensland) where monitoring for RCS has been undertaken in the vicinity of quarrying or tunnelling sites in response to community concern. These studies are discussed below.

Darlington Range, Queensland

Information is available from air sampling undertaken by the Queensland Government Department of Science, Information Technology and Innovation, to investigate air quality in the residential suburbs bordering the 6 large hard rock quarries in Ormeau and Yatala in South-East Queensland (DSITI 2017). At Yatala, monitoring was undertaken at a private residence approximately 1.6 km north of the nearest quarry and 150 m from the road used by trucks to transport quarry products. At Ormeau, monitoring was undertaken at a private residence approximately 500 m east of the nearest quarry. Weekly sampling for $PM_{2.5}$ samples for crystalline silica analysis was undertaken at both sites between September 2015 and November 2016.

The 7-day crystalline silica concentration reported in the $PM_{2.5}$ fraction was compared to the OEHHA (2005) Reference Exposure Level (REL; refer to **Table 4.1**) of 3 µg/m^3. Maximum 7-day crystalline silica concentrations at both sites were reported to be low, with concentrations of 0.07 µg/m^3 reported at Ormeau and concentrations of 0.13 µg/m^3 reported at Yatala. The average 7-day concentration was 0.03 to 0.04 µg/m^3, with crystalline silica above the limit of reporting only measured in 8 to 14% of samples. On this basis, it was concluded that dust emissions from local quarries contain very low concentrations of RCS that are not expected to result in adverse health impacts. This is noted in the report to be like another site investigated by the Department at Mount Cotton.

Continuous monitoring was also undertaken for $PM_{2.5}$ and PM_{10}, with the following average concentrations reported (PM_{10} samples were not analysed for crystalline silica):

- Yatala: $PM_{2.5}$ of 4.5 to 5µg/m^3 and PM_{10} of 12 µg/m^3; and
- Ormeau: $PM_{2.5}$ of 4.3 to 5 µg/m^3 and PM_{10} of 18.3 µg/m^3.

Brisbane, Queensland

Monitoring for RCS was undertaken by the Queensland Government Air Quality Sciences Unit of the Department of Environment and Resource Management to investigate potential health effects from the inhalation of silica dust from the Airport Link/Northern Busway construction works at Lutwyche, Brisbane, Queensland (DERM undated). The monitoring was undertaken in response to community concerns in relation to dust emanating from the construction works. The report indicates that RCS is a potential component of airborne dust from the construction works due to the need to tunnel through granite, quartz and sandstone.

The monitoring measured concentrations of crystalline silica in the PM_{10} and $PM_{2.5}$ fractions at 2 sites in Lutwyche, including at a private residence adjacent to the southern end of the construction works and a church to the east of the works area. Monitoring was undertaken over a 7-day period on 16 occasions between April and August 2011. The average overall 7-day crystalline silica concentration was 0.57 to 1.43 µg/m^3 in the PM_{10} fraction and 0.57 to 1.21 µg/m^3 in the $PM_{2.5}$ fraction, with the following concentration range reported:

- 7-day PM_{10} fraction site 1: 0.22 to 1 µg/m^3;
- 7-day $P_{2.5}$ fraction site 1: 0.21 to 0.97 µg/m^3;
- 7-day PM_{10} fraction site 2: 0.5 to 3.72 µg/m^3; and
- 7-day $PM_{2.5}$ fraction site 2: 0.21 to 2.17 µg/m^3.

The difference in concentrations at site 1 and site was concluded to be due to wind, which favoured the migration of dust towards site 2. Measurements at site 2 were concluded likely to be representative of worst-case weather conditions. Significant effects due to rainfall were not noted.

Consistent with the DSITI (2017) assessment, RCS concentrations reported in dust were compared to the OEHHA (2005) REL of 3 µg/m^3. This guideline was adopted as there are no Queensland community air guidelines for RCS, however the report notes that the OEHHA guideline has been adopted by Victoria. The guideline was compared to the report $PM_{2.5}$ and PM_{10} concentrations as sampling equipment is not available to measure RCS concentrations of 3 µg/m^3 or less. Given the similarity of reported $PM_{2.5}$ and PM_{10} concentrations at both sites, and that overall average concentrations of both size fractions were below the adopted guideline, it was concluded that adverse health effects within the community from RCS from the works were unlikely.

Hunter Valley, NSW

An air quality study undertaken at 2 locations in the Hunter Valley airshed in NSW in the vicinity of operating open-cut coal mines (Morrison & Nelson 2011). This study reported RCS concentrations of 0.5 to 1.8 µg/m^3 for the PM_4 fraction and 0.2 to 1.4 µg/m^3 for the $PM_{2.5}$ fraction. Given that these concentrations were below the OEHHA (2005) guideline of 3 µg/m^3 it was concluded that adjacent populations were not at risk of silica induced disease.

3.4 Background intakes

ATSDR (2019) indicates that silica containing airborne dust is present in the environment as a result of the widespread natural occurrence and use of silica-containing products and materials. Local meteorological conditions can cause elevated concentrations of silica in dust, most notably in areas around recent volcanic eruptions and deserts (desert dust consists of fine particles, <10 µm, with a higher percentage of quartz). Monitoring has indicated that remote continental air contains a background dust concentration of 0.04 mg/m^3, of which ≥10% (i.e. ≥0.004 mg/m^3) may be crystalline silica. TCEQ (2009) indicates that the average ambient RCS is 1.9 µg/m^3, with a range of 0.3 to 5 µg/m^3. This is slightly lower than other estimates for the USA which indicate average quartz levels in metropolitan areas of 1.1 to 8 µg/m^3 (average of 3.2 µg/m^3) (Bhagia 2012).

ATSDR (2019) provides a summary of studies that have measured ambient RCS concentrations in urban environments, including those adjacent to silica industries. The available data is summarised in **Table 3.2**.

Table 3.2: Summary of measured RCS or quartz concentrations in urban environments[1]

Location	Concentration (µg/m^3)	Comments
Background Locations		
USA	0.9 to 8	24-hour ambient concentration of RCS sourced from 2.5 to 5 µm quartz in urban areas, as measured at 22 sites in several different states.
California, USA (WDNR 2010)	1.2 to 3.5	Silica concentration in PM_{10} fraction from 12 samples collected in urban areas.
	0 to 1.4	Silica concentration in PM_{10} fraction from 16 samples collected in rural areas.
	0 to 1.2	Silica concentration in PM_{10} fraction from 18 samples collected in remote background areas.
California, USA (Bhagia 2012)	1.1 to 1.3	Based on reported PM_{10} concentrations of 18.2 and 18.9 µg/m^3 with a 6-7% silica content.
Rome, Italy	0.25 to 2.9	As total PM_{10} with a mean diameter range of 0.3 to 10.5 µm where >87% of particles had a diameter of <2.5 µm. Silica concentrations in dust thought to be from the Sahara Desert as carried to Mediterranean Europe via the Southern Winds.
Tokyo, Japan	≤34	Concentration of quartz in air samples (no information on silica concentration or potential sources).
Locations Adjacent to Silica Industries		
California, USA	26 to 97	Airborne quartz concentration up to 750 m downwind a sand and gravel facility. PM_{10} concentrations were in the range 26 to 1,026 µg/m^3.
	4 to 16	Background (upwind) quartz readings.
California, USA	<0.3 to 2.8	RCS (as PM_4) concentrations up and downwind of a quarry and processing plant. The 8-hour working shift PM_{10} RCS concentration was 1 to 19 µg/m^3. This study was sponsored by the US National Stone, Sand & Gravel Association with samples collected down wind of 4 crushing plants processing high-quartz-context rock.
Minnesota, USA	<1 to 7	RCS (as PM_4) concentrations in ambient air near industrial sand mining, processing and transport sites.
Minnesota, USA (Richards & Brozell 2015)	0.4 to 1.3	Maximum RCS concentrations adjacent to 2 frac sand operations.
Gansu Province, China	≤5,720	Dust, comprising fine particles of <5µm, from sandy areas during the windy season. Dust concentration was 8,350 to 22,000 µg/m^3 of which 15 to 26% was free silica.
India	41 to 57	PM_{10} quartz concentration near an industrial slate pencil site.
	3.5	PM_{10} quartz concentration at a control site for the industrial slate pencil site (5 km away)

Location	Concentration (µg/m^3)	Comments
India	31 to 67	Based on average ambient air $PM_{2.5}$ at two villages near stone crushing sites and a silica content of up to 24%.
	120 to 156	Based on average ambient air PM_4 at two villages near stone crushing sites and a silica content of up to 24%.
	110 to 185	Based on average ambient air PM_{10} at two villages near stone crushing sites and a silica content of up to 24%.
	1,082 to 1,956	Based on ambient air PM_4 at stone crushing site and a silica content of up to 24%.
India (Bhagia 2012)	15.3	Average concentrations of crystalline silica (quartz) at 4 sites in the vicinity of agate industry. Control locations reported a concentration of 3 µg/m^3.
South Africa (Andraos, Utembe & Gulumian 2018)	17.4 to 34.9	PM_4 via personal monitoring approximately 0.2 to 7 km away from a tailing storage facility (8 sampling locations).

Notes:

1 = Ref. ATSDR (2019) unless otherwise noted.

Review of the above data indicates that where there are specific industries that generated RCS, and these are unmanaged (in terms of dust), levels of RCS in air adjacent to these facilities is significantly elevated (reference data for China and India). Levels adjacent to such industries are lower where dust generation is better managed (such as a number of sites in the US).

Where there are no specific RCS industries present background levels are lower. The average ambient RCS value of 1.9 µg/m^3 from TCEQ (2009) is considered a reasonable average that reflects an annual average exposure. This value is higher than the background levels reported in the Darlington Range in Queensland and similar to average values reported in Brisbane and the Hunter Valley (refer to **Section 3.3**), noting that all these sites are near RCS generating industries. Hence adopting a background of 1.9 µg/m^3, which is assumed to be as $PM_{2.5}$, in this assessment is expected to be conservative.

Section 4. Assessment of health risks

4.1 General

This section presents a screening level assessment of potential health risks relevant to residents in properties adjacent to the Quarry who may inhale dust containing RCS.

4.2 Screening level assessment of health risks

The assessment of potential risks to residents has been undertaken via a screening level assessment. This has involved comparison of the predicted level of RCS in the air within the community with the health-based guideline identified in **Section 3**.

The health based guideline adopted for this assessment is 3 µg/m^3 of RCS (OEHHA 2005) (EPA Victoria 2007). This guideline relates to an annual average concentration of RCS as $PM_{2.5}$ in air, where the community may be exposed. This guideline relates to total exposures to RCS.

In relation to exposures that may occur within the community, the following has been considered:

- Existing or background exposures to RCS – no data is available for the area near the Quarry, hence expected background level of RCS in air as discussed in **Section 3.4**, of 1.9 µg/m^3 has been adopted in this assessment. It is assumed that this background relates to RCS as $PM_{2.5}$.
- Impacts from the proposed Quarry operations – this has been modelled for the project, with the maximum incremental increase in annual average $PM_{2.5}$ predicted to be 0.2 µg/m^3 (refer to **Table 2.1**). It is assumed that 100% of the $PM_{2.5}$ is RCS.
- Total maximum annual average RCS exposures as $PM_{2.5}$ are therefore 2.1 µg/m^3, noting that the Quarry is contributing only 9.5% of the cumulative exposure, with the remainder being assumed natural background exposure.
- This is less than the adopted guideline of 3 µg/m^3.

On this basis, there are no health risk issues of concern in relation to community exposures to RCS in dust that may be sourced from the Quarry.

4.3 Uncertainties

4.3.1 General

This HHRA comprises a screening level assessment where it has been assumed that predicted concentrations of $PM_{2.5}$ in air at residential properties adjacent to the Quarry comprise 100% silica. The predicted $PM_{2.5}$ concentrations have been sourced from the AQIA (Northstar 2020) which has been undertaken in accordance with National and State requirements and has undergone review by NSW EPA. The predicted $PM_{2.5}$ concentrations are based on a modelling exercise, where there is some uncertainty, however it is noted that incremental annual average $PM_{2.5}$ concentrations are at least 15 times below the adopted screening level guideline. As discussed in **Section 3**, this screening level guideline has been derived using a conservative process and is protective of all members of the community including sensitive individuals and children. The adopted screening level guideline is also supported by other international reviews.

However, as there are uncertainties throughout all stages of any risk assessment, it is important to consider how these uncertainties impact on the assessment presented. This uncertainty analysis has considered:

- The slightly lower screening guideline derived by TCEQ (2009) for the protection of silicosis;
- The TCEQ (2009) screening level guideline for the protection of lung cancer;
- The predicted maximum 24-hour average $PM_{2.5}$ concentrations;
- The predicted PM_{10} concentrations; and
- The assumed silica content in dust.

Further discussion is provided below.

4.3.2 TCEQ (2009) TRVs

TCEQ (2009) has derived a slightly lower screening level guideline, 2 µg/m^3 versus the 3 µg/m^3 adopted in the HHRA. This guideline is based on the same key toxicity studies but a different assumed silica content in dust that workers in the original study (e.g. the South African gold miners) were exposed to. From the differing views of the international organisations, it appears that the silica content that these workers were exposed to was not well documented/explained. Hence the assumptions adopted by TCEQ (2009) were more conservative.

For the assessment of potential risk, TCEQ provided a guideline relevant to the protection of silicosis of 2 µg/m^3. This guideline relates to a threshold assessment of total exposure to RCS. The maximum predicted concentrations of RCS in the community (including background) is essentially equal to this guideline. Where only the impact form the Quarry is considered the maximum incremental exposure 0.2 µg/m^3 is 10 times below this guideline.

For the assessment of lung cancer effects, TCEQ (2009) adopted a non-threshold approach (which is different from other health agencies). This calculation relates to an incremental lifetime cancer risk and can only be compared with the incremental change in RCS predicted as a result of the project. The maximum increased in RCS predicted in the community from Quarry operations is 0.2 µg/m^3, which is below the incremental guideline of 0.29 µg/m^3 established by TCEQ.

On the basis of the above review, consideration of the TRVs established by TCEQ (2009) does not change the outcome of the assessment presented in this report – that there are no risk issues of concern in relation to community exposure to RCS derived from the proposed Quarry operations.

In addition, the following can also be noted:

- A predicted incremental annual average $PM_{2.5}$ concentration of 0.1 µg/m^3, which is 20 times below the guideline for silicosis and 2 to 3 times below the guideline for lung cancer, were predicted at all adjacent residential properties except Property 3A (refer to **Table 2.1**);
- As noted above, IARC is clear that the determination that RCS is carcinogenic relates only to occupational exposures. Hence, the comparison of $PM_{2.5}$ concentrations with the screening level guideline derived by TCEQ (2009) for protection against cancer is conservative and expected to overestimate these risks in the community; and
- The AQIA indicates that the assessment undertaken is designed to be protective of worst-case activities at the Quarry.

4.3.3 Maximum 24-hour average $PM_{2.5}$ concentrations

The AQIA also predicts a maximum incremental 24-hour average $PM_{2.5}$ concentration of 2.9 µg/m^3 at the adjacent residences (specifically Property 3A). The screening level guideline adopted in the HHRA is for chronic (long-term) exposures, not for short-term peaks such as a 24-hour average.

The daily peaks in the concentrations are all considered in the calculation of an annual average concentration. Hence, it is not appropriate to compare the chronic screening level guideline adopted in the HHRA with the maximum 24-hour average concentration.

TCEQ (2009) derived a screening level guideline for acute exposures (a ReV) of 47 µg/m^3. Maximum incremental 24-hour average $PM_{2.5}$ concentrations at Property 3A are 16 times below this acute guideline. In addition all cumulative concentrations of $PM_{2.5}$ (assuming 100% of all $PM_{2.5}$ is RCS, which is not the case for background $PM_{2.5}$) are below this guideline.

It is also noted that maximum 24-hour average $PM_{2.5}$ concentrations are well below the workplace exposure guidelines (which range from 25 to 100 µg/m^3; with a quoted safe level in the order of 20 µg/m^3) (ACGIH 2010). The workplace exposures guidelines are not relevant to acute exposures, they cover longer duration exposures for 8 hours per day over a 40-hour workweek.

On this basis, there are no acute (short-term) health risk issues of concern for the off-site community in relation to concentrations of RCS in dust that may be sourced from the Quarry.

4.3.4 PM_{10} concentrations

In this uncertainty analysis, PM_{10} concentrations have also been reviewed against the adopted screening level guideline given the recommendations of OEHHA (2005) which indicates that where $PM_{2.5}$ < 3 µg/m^3 but PM_{10} > 3 µg/m^3 concentrations may require further investigation, including a more precise determination of the respirable fraction (including the silica concentration in this fraction). As noted above, Victoria (and subsequently other states including NSW and Queensland) has adopted the OEHHA (2005) guideline for RCS as $PM_{2.5}$, and do not compare PM_{10} concentrations to the guideline. Hence, the approach adopted is conservative. There is no information on background levels of RCS as PM_{10}, hence it is not possible to consider total exposures.

The maximum modelled incremental increase in annual average PM_{10} associated with Quarry activities presented in the AQIA was 1.3 µg/m^3. If this was assumed to be 100% RCS, then this is below the adopted guideline of 3 µg/m^3.

This assumes that all the PM_{10} can be inhaled and would penetrate deep into the lungs, which is conservative, as only particles smaller than PM_5 are sufficiently small to penetrate deep enough into the lungs to be of concern. $PM_{2.5}$ comprises a proportion of PM_{10}.

A maximum incremental 24-hour average PM_{10} concentration of 19.9 µg/m^3 was reported by the AQIA for Property 3A. As discussed above, comparison of this concentration to the adopted screening level guideline for long-term (chronic) health effects is not appropriate, even assuming that all the PM_{10} is respirable. Maximum 24-hour average concentrations are however noted to be below the TCEQ (2009) acute guideline by around 2 times, which is an appropriate comparison, and below workplace exposure guidelines (ACGIH 2010).

On the basis of the above, consideration of the potential impact of the modelled concentrations of PM_{10}, and assuming these are 100% RCS, does not change the outcome of the assessment presented in this report – that there are no risk issues of concern in relation to community exposure to RCS derived from the proposed Quarry operations.

4.3.5 Assumed silica content in dust

One difference in the way the community air guidelines have been derived for RCS by international agencies is the assumed concentration of silica in dust that the workers in the key studies evaluated were exposed to. For example, for the same key study identified by 2 agencies, the proportion of silica in dust that workers were exposed to was assumed to be 30% by MDH (2013) and 54% by TCEQ (2009). The actual silica content in the dust the workers were exposed to is not known as it was not measured in the workplace.

This HHRA has assumed that the silica content in dust generated from the Quarry is 100%.

Unfortunately, a straightforward adjustment of air guidelines is problematic due to the different modelling methodologies adopted by the agencies and because the silica content that the workers in the study were initially exposed to is unclear. However, if a guideline of 3 µg/m^3 is derived for a silica content of 30% and a guideline of 2 µg/m^3 is derived for a silica content of 54%, a guideline for a silica content of 100% could be 2 to 3 times lower than the available guidelines. This may mean a guideline of around 0.7 to 1.5 µg/m^3. Predicted concentrations of $PM_{2.5}$ in air derived from the quarry where 100% RCS is assumed (maximum of 0.2 µg/m^3) are still below these alternative guidelines.

Section 5. Conclusions

Based on the available data and the scope of this assessment, it has been concluded that health risks to residents in existing properties adjacent to the Quarry are low and acceptable.

Environmental Risk Sciences Pty Ltd has undertaken a human health risk assessment (HHRA) in relation to the potential presence of respirable crystalline silica (RCS) in dust emitted during the continued operation and extension of Dowe's Quarry. It is noted that limitations apply to the outcomes due to the focus of this assessment on RCS and the uncertainties identified and analysed in the report.

The HHRA has addressed human health risk issues relevant to RCS that may be present in dust sourced from the Quarry and the ongoing low-density rural/residential use of the existing properties adjacent to the Quarry.

No additional dust mitigation measures are recommended for operations assuming the proposed dust mitigation measures including the planned air monitoring program are implemented. It is recommended that PM2.5 and PM10 samples captured for monitoring are subject to laboratory analysis for silica concentration. This is recommended to confirm the concentrations of silica in these PM fractions, that adjacent receptors may be exposed to.

Standard dust mitigation measures including dust suppression through chemical and water means, the tarping of loads, inspection of truck tyres and street sweeping should also continue for the operation. The proposed extension to the seal on the Quarry Access Road to a total length of 800m is supported.

Section 6. References

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Appendix 4

Noise and Vibration Impact Assessment

prepared by

Spectrum Acoustics Pty Limited

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Dowe's Quarry

Noise and Vibration Impact Assessment

Prepared by

SPECTRUM ACOUSTICS
NOISE AND VIBRATION CONSULTANTS

March 2020

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March 2020

SPECTRUM ACOUSTICS
NOISE AND VIBRATION CONSULTANTS

CONTENTS

TABLES

COMMONLY USED ACRONYMS

AHD	Australian Height Datum
ANZEC	Australian and New Zealand Environment and Council
ANZECC	Australian and New Zealand Environment and Conservation Council
DEC	Department of Environment and Conservation
DECC	Department of Environment and Climate Change
DECCW	Department of Environment, Climate Change and Water
DPE	Department of Planning and Environment
DRG	Division of Resources and Geoscience
EIS	*Environmental Impact Statement*
ENM	Environmental Noise Model
EPA	Environment Protection Authority
OEH	Office of Environment and Heritage
MIC	Maximum Instantaneous Charge
MS	Morning Shoulder
NPI	*NSW Noise Policy for Industry*
OP	overpressure levels
PNTLs	project noise trigger levels
PPV	peak particle vibration
PVS	Peak Vector Sum
RBL	Rating Background Levels
RH	relative humidity
RMS	Roads and Maritime Services
RNP	*NSW Road Noise Policy*
RTA	Renzo Tonin Associates
SEARs	Secretary's Environmental Assessment Requirements
SPL	Sound Pressure Level
VLAMP	*Voluntary Land Acquisition and Mitigation Policy*

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EXECUTIVE SUMMARY

A noise impact assessment has been conducted for the proposed continued operation and extension of the Dowe's Quarry ("the Proposal") including transportation of raw materials to the Sunnyside Crushing and Screening Plant. The site of the existing Dowe's Quarry and proposed quarry extension ("the Quarry Site") is approximately 1.1km west of Mt Lindesay Road approximately 8km northeast of Tenterfield.

Operation of the quarry and road transportation of materials would only occur during daytime hours.

Documents referred to in conducting the assessment include:

- NSW Noise Policy for Industry (NPI), EPA, 2017;
- NSW Road Noise Policy (RNP), OEH, 2011; and
- "Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration – September 1990" (ANZECC).

The NSW Noise Policy for Industry (NPI) default minimum daytime background noise level of 35 dB(A) was adopted to establish a noise emission criterion of 40 dB(A),$L_{eq(15minute)}$ for activities on site.

An assessment of available meteorological data found that winds of speeds up to 3 m/s occurred for less than 15% of the time during any season, implying that winds are not an assessable feature with regards to noise impact assessment.

Noise modelling was conducted to produce point calculations for two operational scenarios to individual residential receivers. Results are presented in tabular form.

Predicted operational noise levels were less than the noise trigger levels at all assessed receivers, for both operational scenarios.

Blast overpressure and ground vibrations levels below the criteria have been predicted at all receivers.

Road traffic noise levels below the criteria have been predicted at all receivers.

In summary, the assessment has found that the Proposal would be able to operate in compliance with the appropriate noise criteria for operational and road traffic noise emissions.

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1. INTRODUCTION

1.1 OBJECTIVES OF THE PROPOSAL

Darry McCarthy Construction Pty. Ltd. ("the Applicant") proposes to extend operations at Dowe's Quarry which produces a range of ivory coloured stone products. The site of the existing Dowe's Quarry and proposed quarry extension ("the Quarry Site") is approximately 1.1km west of the Mt Lindesay Road approximately 8km northeast of Tenterfield, within the Tenterfield Local Government Area (see **Figure 1**).

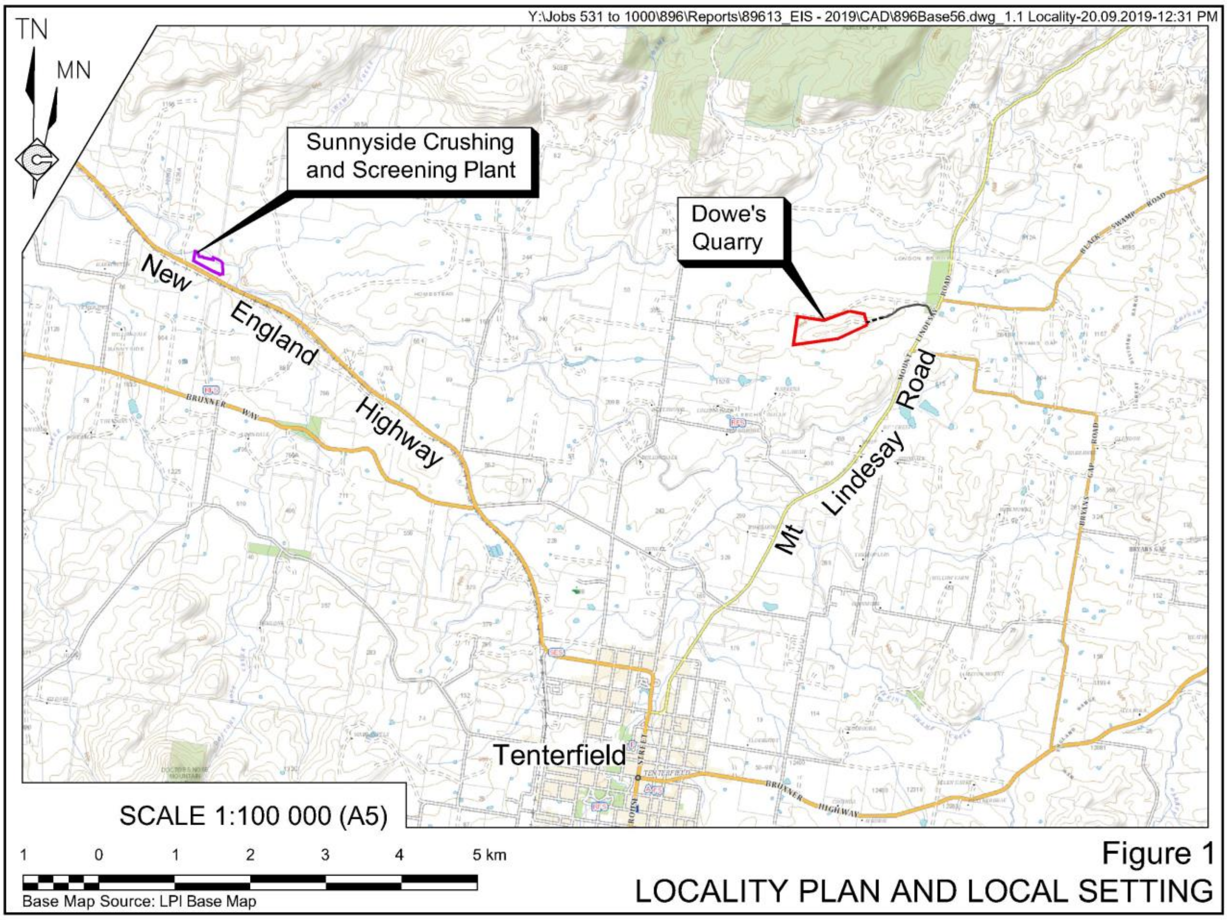


Figure 1
LOCALITY PLAN AND LOCAL SETTING

The Quarry has been operating in this location since 1987. The existing operations are approved under Development Consent 2014.078 (DA 2014.078), granted in March 2015. A modification to DA 2014.078 was approved in January 2016.

The proposed continued operation (and extension) of Dowe's Quarry ("the Proposal") would involve:

- Ongoing extraction of quartzose rock within the existing extraction area and a 4.5ha extension of the extraction area, producing up to 230 000tpa.
- Campaign crushing and screening on site using mobile processing equipment located on the floor of the extraction area. On-site processing would be undertaken in response to client requirements.

- Ongoing transportation of fragmented and crushed rock to the State road network, (i.e. the New England Highway), for delivery to the Sunnyside Crushing and Screening Plant, and other destinations. Material would also continue to be delivered locally within Tenterfield for Council-managed road and infrastructure activities and directly to the local community.
- Ongoing transportation of material directly to end points of use, where further processing at the Sunnyside Crushing and Screening Plant is not required.
- Ongoing backloading of clay fines and crusher fines from the Sunnyside Plant to the Quarry.
- Progressive emplacement of overburden and fines within and adjacent to the extraction area.
- Progressive and final rehabilitation of the Quarry to develop a landform suitable for native vegetation conservation.

The Quarry Site layout displayed in **Figure 2** incorporates the existing and proposed Quarry components.

The main components and the respective approximate area of disturbance within the Quarry Site are as follows.

- Extraction Area (Stage 1 – 6.9ha, Stage 2 – 10.1ha, Stage 3 – 11.4ha)
- Product Stockpiling Area (1.8ha)
- Bund (0.62ha) – 5m height as measured from the Product Stockpiling Area
- Overburden and fines stockpile (Stage 1 – 3.2ha, Stage 2 – 2.6ha, Stage 3 – 1.6ha)
- Overburden and fines Emplacement Area (Stage 2 – 1.9ha, Stage 3 – 2.9ha)
- Quarry Access Road (1.7km)
- Sediment dams (0.2ha)

1.2 DEPARTMENTAL REQUIREMENTS

This noise impact assessment has been undertaken in accordance with the Secretary's Environmental Assessment Requirements (SEARs) (EAR 1341) for the Proposal, issued by the NSW Department of Planning and Environment (DP&E) on 28 May 2019. Coverage of the SEARs within this report is summarized in **Table 1**.

This report also addresses noise issues raised by EPA in their review letter dated 27November 2019. The EPA issues and where they have been addressed in this report are also included in **Table 1**.

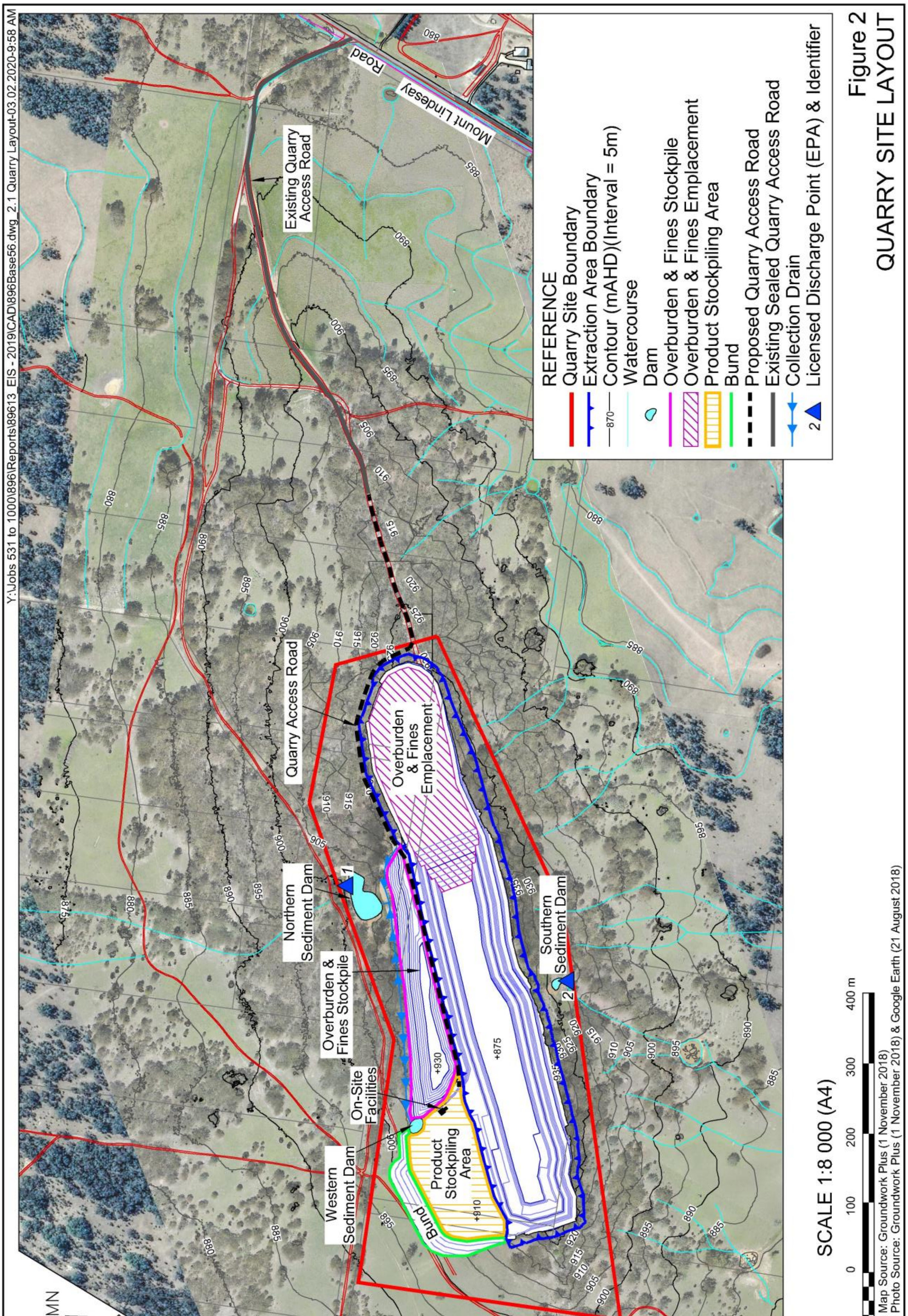


Figure 2
QUARRY SITE LAYOUT

Table 1
Coverage of Departmental Requirements

Page 1 of 2

Agency	Paraphrased Relevant Requirement	Relevant Section(s)
NOISE AND BLASTING		
DPE (SEAR's)	Include a quantitative assessment of potential: • construction and operational noise and off-site transport noise impacts of the development in accordance with the *Interim Construction Noise Guideline*, *NSW Noise Policy for Industry* and *NSW Road Noise Policy* respectively;	5.0
	• reasonable and feasible mitigation measures to minimise noise emissions; and	EIS 5.3.4
	• monitoring and management measures;	EIS 5.3.4 & 5.3.7
	• a description of the proposed blasting hours, frequency and methods; and	3.5 & 5.2
	• an assessment of the likely blasting and vibration impacts of the development, having regard to the relevant ANZEC guidelines and paying particular attention to impacts on people, buildings, livestock, infrastructure and significant natural features;	3.5 & 5.2
EPA (advice on SEAR's)	Assess and quantity noise and vibration Impacts associated with blasting, and operational noise particularly machinery and plant movements;	5.0
	Assess construction noise associated with the proposed development using the *Interim Construction Noise Guideline* (DECC, 2009).	N/A
	Assess vibration from all activities (including construction and operation) to be undertaken on the premises using the guidelines contained in the *Assessing Vibration: a technical guideline* (DEC, 2006).	5.0
	Demonstrate blast impacts are capable of complying with the guidelines contained in *Australian and New Zealand Environment Council- Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration* (ANZEC, 1990).	5.2
	Assess operational noise from all industrial activities (including private haul roads and private railway lines) using the guidelines contained in the *NSW Noise Policy for Industry* (EPA, 2017).	5.1
	Assess noise on public roads from increased road traffic generated by land use developments using the guidelines contained in the *NSW Road Noise Policy* and associated application notes (EPA, 2011)	5.3
EPA 27/11/19)	The proponent must clarify what method is to be used for the rock breaking and if the SWL in Table 5 includes this activity.	4.2
	The proponent must provide justification that the adopted SWL for the mobile crusher is achievable and by what means, or, update the noise assessment accordingly.	4.2
	The noise report needs to clarify the height of the bund	1.1
	The noise assessment must include an assessment of noise impacts associated with the establishment of the proposed quarry configuration including construction of the noise bund, clearing and grubbing of land to prepare for pit excavation.	4.1
	Further noise and vibration impacts associated with any road construction to be undertaken and provided for review.	4.1
	The noise report must include an assessment of modifying factors in accordance with NPfi Fact Sheet C	5.1

Table 1 (Cont'd)
Coverage of Departmental Requirements

Page 2 of 2

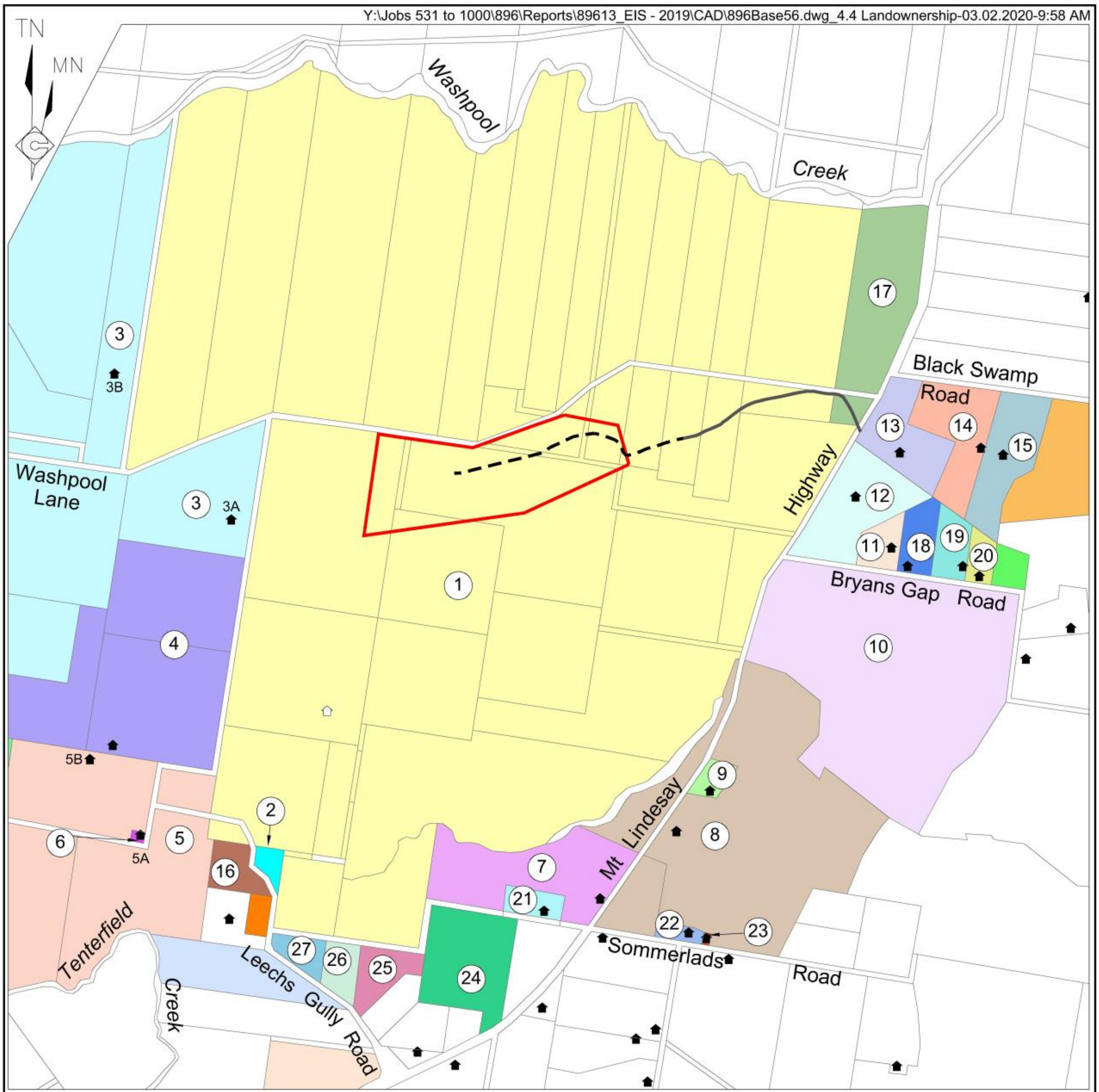
Agency	Paraphrased Relevant Requirement	Relevant Section(s)
	The road traffic noise assessment is to be assessed using the 1-hour assessment.	5.3
	The road traffic noise levels should be presented to the nearest integer in accordance with Section B2 of RNP.	5.3
	The road traffic noise assessment has only included a method that converts Lmax Leq noise levels but that method does not include how Leq noise levels are calculated at receivers. It has relied on assumptions which are not stated in the report which makes it difficult to assess. The noise report must include all assumptions relevant to the calculations.	4.4
	The proponent must update the assessment to include both light and heavy vehicles.	5.3

1.3 ASSESSED RECEIVERS

Privately owned residential properties considered in this assessment are shown in **Figure 3** and described in **Table 2**.

Table 2
Residential receivers

Receiver	Land Owner
East of Quarry Site	
R10	KR & LA Willcocks (vacant land)
R11	KH Baxman & CC Hatnes
R12	BL & JA Morrow
R13	RM Ibbett & S Ibbett
R14	GM O'Reilly, MP Watt
R15	AJ & BW Lawrence
R18	MN & DN Larsen
R19	GB & DK Phillips
R20	CA Jackson, D Bunic
South and Southeast of the Quarry Site	
R7	JM Dowe
R8	RB & CA Sewell
R9	MJ & NJ Lewis, RB & CA Sewell
R21	DM & AJ Mullins
R22	JP & SL Doye
R23	LD Merchant
R24	Harewood Investments Pty Limited
R25	D Puglisi
R26	BJ & RL Tom
R27	BJ Tom & Brad Tom Investments Pty Ltd
West and Southwest of the Quarry Site	
R2	J-P Jacquet, MJ Bielski
R3A	RF & LL Tumbridge
R3B	RF & LL Tumbridge
R4	RL Caldwell
R5A	GL & JM Smith
R5B	GL & JM Smith
R6	DB Weir, GR Smith & WF Marsden
R16	PJ Della & TM Curry



REFERENCE
- Quarry Site Boundary
- Cadastral Boundary
- Proposed Quarry Access Road
- Existing Sealed Quarry Access Road
- Residence (Project Related)
- Residence (Non-Project Related)
- 1 Landowner Reference (See Table)

Ref	Landowner	Ref	Landowner
1	RSH & MO Dowe	15	AJ & BW Lawrence
2	JP Jacquet, MJ Bielski	16	PJ Della & TM Curry
3A,3B	RF & LL Tumbridge	17	The State of New South Wales
4	RL Caldwell	18	MN & DN Larsen
5A,5B	GL & JM Smith	19	GB & DK Phillips
6	DB Weir, GR Smith, WF Marsden	20	CA Jackson, D Bunic
7	JM Dowe	21	DM & AJ Mullins
8	RB & CA Sewell	22	JP & SL Doyle
9	MJ & NJ Lewis, RB & CA Sewell	23	LD Merchant
10	KR & LA Willcocks	24	Harewood Investments Pty Limited
11	KH Baxman & CC Haynes	25	D Puglisi
12	BL & JA Morrow	26	BJ & RL Tom
13	RM Ibbett, S Ibbett	27	BJ Tom & Brad Tom Investments Pty Ltd
14	GM O'Reilly, MP Watt		

SCALE 1:25 000 (A4)

250 0 250 500 750 1000 1250 m

Cadastral Source: LPI (2014)
Landowner Source: Department of Lands Online Search - April 2019

Figure 3
LAND OWNERSHIP AND NOISE RECEIVERS

2. DESCRIPTION OF TERMS

Table 3 contains the definitions of commonly used acoustical terms and is presented as an aid to understanding this report.

Table 3
Definition of acoustical terms

Term	Description
dB(A)	The quantitative measure of sound heard by the human ear, measured by the A-Scale Weighting Network of a sound level meter expressed in decibels (dB).
SPL	Sound Pressure Level. The incremental variation of sound pressure above and below atmospheric pressure and expressed in decibels. The human ear responds to pressure fluctuations, resulting in sound being heard.
STL	Sound Transmission Loss. The ability of a partition to attenuate sound, in dB.
Lw	Sound Power Level radiated by a noise source per unit time re 1pW.
Leq	Equivalent Continuous Noise Level - taking into account the fluctuations of noise over time. The time-varying level is computed to give an equivalent dB(A) level that is equal to the energy content and time period.
L1	Average Peak Noise Level - the level exceeded for 1% of the monitoring period.
L90	"Background" Noise Level - the level exceeded for 90% of the monitoring period.

3. EXISTING ENVIRONMENT AND NOISE CRITERIA

The existing meteorological and acoustical environments surrounding the Quarry Site have been studied to determine prevailing conditions and to allow noise goals to be set.

3.1 METEOROLOGY

The atmospheric conditions most relevant to noise assessments are temperature inversions, gentle winds (indicative of possible wind shear) and relative humidity. The *NSW Noise Policy for Industry* (NPI 2017) states that wind effects need to be assessed where source to receiver winds (at 10m height) of 3m/s or below occur for 30% or more of the time in any season in any assessment period.

Wind conditions predicted by Northstar Air Quality Pty Ltd using the CSIRO TAPM model at the Site for 2015, were provided by R.W. Corkery & Co. Pty Limited for assessment of prevailing winds.

The analysis found that winds up to 3 m/s occurred less than 15% of the time during all seasons, from all directions. Winds are generally aligned from the east and west, with stronger winds in excess of 3 m/s dominating.

The following points are the most significant with respect to noise propagation and were adopted as parameters for noise modelling:

- A value of 70% Relative Humidity (RH) was adopted for average daytime conditions.
- Noise modelling was carried out under the prevailing condition of neutral atmospheric conditions (20°C, no wind).

The Proposal will only operate during the day and therefore nocturnal temperature inversions are not required to be considered under the NPI.

3.2 EXISTING ACOUSTIC ENVIRONMENT

It is anticipated that the background noise levels in the rural areas surrounding the Quarry Site would be below 30 dB(A) and, in accordance with section A1.2 of the NPI, a default minimum daytime background noise level of 35 dB(A),L_{90} has been adopted as the basis for determining project-specific noise goals.

3.3 PROJECT-SPECIFIC NOISE TRIGGER LEVELS

Project-generated noise within the Quarry Site is required to be assessed against the provisions of the NPI. In relation to the residences surrounding the Quarry Site, the NPI specifies two noise criteria: *intrusiveness and amenity criteria*.

The *Intrusiveness Criterion* limits Equivalent Continuous Noise Level (Leq) from the industrial source to a value of 'background plus 5dB'. That is, the Rating Background Level (RBL) for the time period, plus 5 dB(A). The RBL (L_{A90}) is defined as the overall single figure background level representing each assessment period.

The *Amenity Criterion* aims to protect against excessive noise levels where an area is becoming increasingly developed. Amenity criteria are dependent upon the nature of the receiver area and the existing level of industrial noise. There is minimal existing industrial noise in the area, apart from the existing quarry, and the residential area that is potentially affected by noise emissions from the Project is best described acoustically as rural.

Time periods for assessment as defined in the NPI are:

- Daytime – 7:00am (8:00am on Sundays) to 6:00pm;
- Evening – 6:00pm to 10:00pm; and
- Night – 10:00pm to 7:00am (8:00am on Sundays).

The project noise trigger levels for all residential receivers are derived from the lower of the existing intrusiveness criteria and the amenity criteria and the worst case or most conservative time period. If compliance is predicted during the worst case time period assessed, then compliance is assumed for the remaining time periods. In accordance with Section 2.4 of the NPI, the daytime amenity criterion is 45 dB(A), (11hr).

The project specific noise level for all receivers will therefore be the daytime intrusiveness criterion of **40 dB(A) $L_{eq(15\ min)}$.**

This criterion applies to all emissions from the site including road registered heavy vehicles moving about the Quarry Site.

3.4 SLEEP DISTURBANCE

As the Proposal would operate between 7:00am and 5:00pm, Monday – Saturday (i.e. during the day) the sleep disturbance criterion does not apply. It is noted that processing operations would be limited to 7:00am and 1:00pm on a Saturday.

3.5 BLASTING

Overpressure and vibration levels from blasting are assessable against criteria proposed by the Australian and New Zealand Environment and Conservation Council (ANZECC) in their publication *"Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration – September 1990"*. These criteria are summarised as follows.

- The recommended maximum overpressure level for blasting is 115dB.
- The level of 115dB may be exceeded for up to 5% of the total number of blasts over a 12-month period, but should not exceed 120dB at any time.
- The recommended maximum vibration velocity for blasting is 5mm/s Peak Vector Sum (PVS).
- The PVS level of 5mm/s may be exceeded for up to 5% of the total number of blasts over a 12-month period, but should not exceed 10mm/s at any time.
- Blasting should generally only be permitted during the hours of 9am to 5pm Monday to Saturday, and should not take place on Sundays and Public Holidays.

Blasting should generally take place no more than once per day.

3.6 TRAFFIC NOISE

In NSW, noise from vehicle movements associated with an industrial source is assessed in terms of the NPI if the vehicles are not on a public road. If the vehicles are on a public road, the *NSW Road Noise Policy* (RNP) applies. Noise from the Proposal must, therefore, be assessed against the Project-specific noise trigger levels of the NPI and also the criteria in the RNP.

The RNP recommends various criteria based on the functional categories of roads applied by the NSW Roads and Maritime Services (RMS). The RMS differentiates roads based on a number of factors including traffic volume, heavy vehicle use, through or local traffic, vehicle speeds and applicable traffic management options.

Vehicles accessing the Quarry Site and the Sunnyside Crushing and Screening Plant will do so via Mount Lindesay Road (sub-arterial road), Naas Street[1] (local road) and the New England Highway (arterial road), respectively. As shown in **Figure 4**, the proposed transport route for trucks returning to the Dowe's Quarry includes Old Ballandean Road which is a local road.

Table 4 below shows the noise criteria relevant to traffic on various road types extracted from *Table 3* of the RNP. For the assessment of traffic noise, the day time period is from 7am to 10pm, whilst night is from 10pm to 7am. For conservatism, the assessment will apply the night time criteria to potential vehicle movements before 7am.

Table 4
Road traffic noise criteria

Situation	**Recommended Criteria**	
	Day (7am to 10pm)	**Night* (10pm to 7am)**
Existing residences affected by additional traffic on existing freeway/arterial/sub-arterial roads generated by land use developments	Leq (15-hour) 60	Leq (9-hour) 55
Existing residences affected by additional traffic on local roads generated by land use developments	Leq (1-hour) 55	Leq (1-hour) 50

* It is not proposed to haul product at night, so only the daytime criteria are applicable.
Source: NSW Road Noise Policy, Table 3.

The setback distances to the residences adjacent to Mt Lindesay Road, New England Highway and Old Ballandean Road, are as follows.

Mount Lindesay Road

- 100kph Section (28m to 46m)
- 70kph Section (18m to 35m)
- 50kph Section (15m to 30m)

New England Highway.

- 100kph Section (18m to 190m)
- 80kph Section (32m to 60m)
- 50kph Section (10m to 30m)

Old Ballandean Road.

- 100kph Section (25m to 140m)

[1] There are no residences fronting the 200m section of Naas Street between Mount Lindesay Road (Logan Street) and the New England Highway.

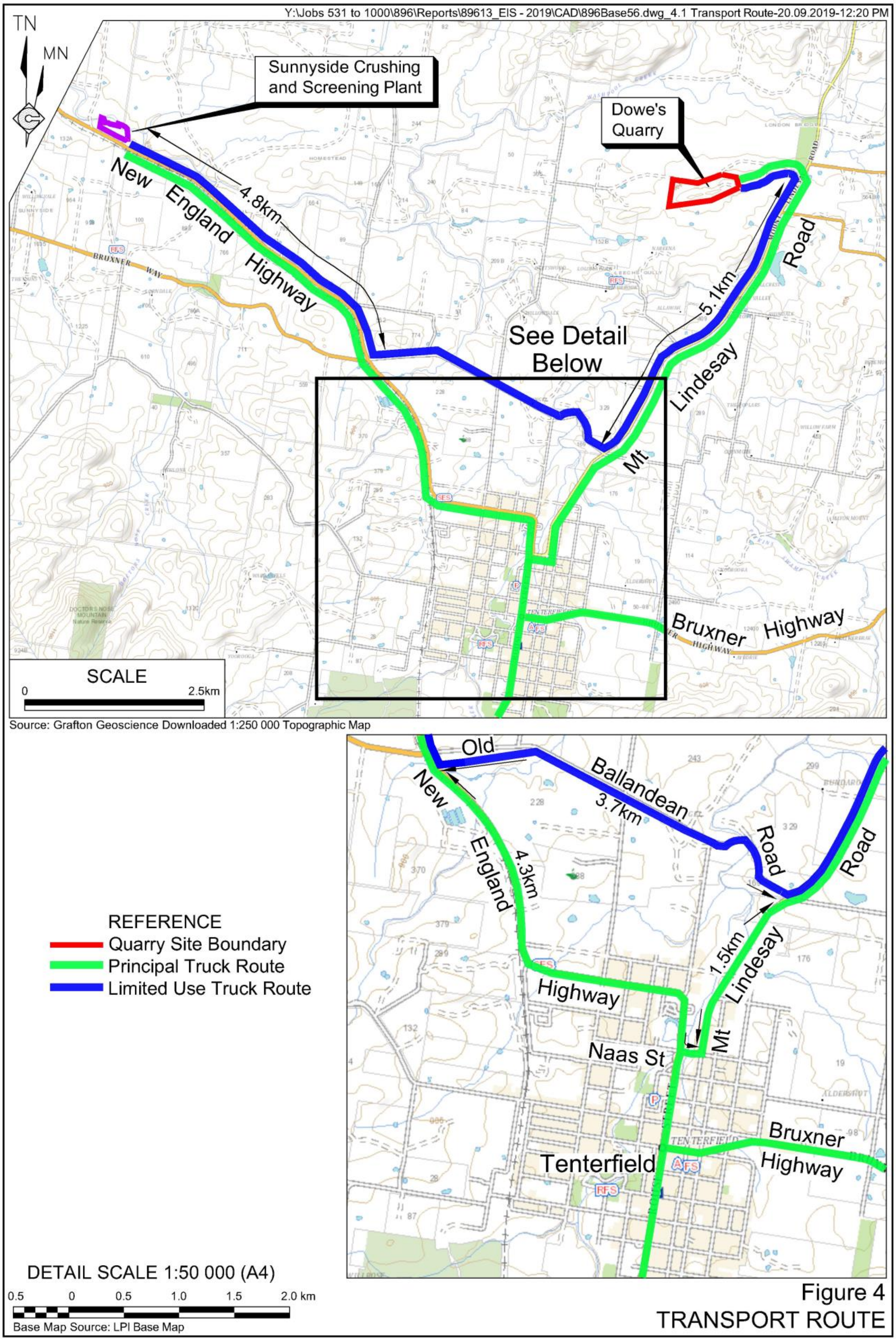


Figure 4
TRANSPORT ROUTE

4. ASSESSMENT METHODOLOGY

4.1 MODELLED SCENARIOS

A full description of the Proposal is given in Section 2 of the EIS.

A preliminary calculation of bund construction and ground clearing activities found levels of 27 dB(A),$L_{eq(15min)}$ and 25 dB(A),$L_{eq(15min)}$ at the nearest receivers R3A and R12, respectively. These levels are sufficiently low that a full quantitative assessment of these short term works is not considered necessary.

Preliminary calculations using point sources and receivers in the ENM software determined that noise levels generated during construction of the realigned section of the Quarry access road would be <20 dB(A),$L_{eq(15min)}$ and 33 dB(A),$L_{eq(15min)}$ at R3A and R12, respectively. These levels are also sufficiently low that a full quantitative assessment of these short-term works is not considered necessary.

In discussion with the client, it was determined that the following two operational noise scenarios represent worst case potential for noise impacts at residential receivers.

SCENARIO 1: Annual Production – up to 230 000 tonnes

Extraction Operations, Product Loading and Despatch (worst case 28 loads per day)

- Drill Rig (DR) drilling blast holes in preparation for blast at 925m AHD in the eastern end of extraction area.
- Excavator (EX1) (30t) undertaking secondary breakage (picking) of oversize rock and loading blasted rock into road trucks at 905m AHD in the eastern end of extraction area.
- Haul truck (HT) on overburden and fines stockpile at 945m AHD.
- Excavator (EX2) (30t) operating in the product stockpiling area at 910m AHD.
- Road truck (RT1) in product stockpiling area at 910m AHD.
- Mobile crushing and screening plant (MC) to be located on the pit floor at AHD 905.
- Road truck (RT2) (40t) unladen truck arriving at the quarry 927m AHD.

SCENARIO 2: Annual Production – up to 230 000 tonnes

Extraction Operations, Product Loading and Despatch (worst case 28 loads per day)

- Drill Rig (DR) drilling blast holes in preparation for blast at 910m AHD in the eastern end of extraction area.
- Excavator (EX1) (30t) undertaking secondary breakage (picking) of oversize rock and loading blasted rock into road trucks at 875m AHD in the eastern end of extraction area.
- Haul truck (HT) on overburden and fines stockpile at 945m AHD.
- Excavator (EX2) (30t) operating in the product stockpiling area at 910m AHD.
- Road truck (RT1) in product stockpiling area at 910m AHD.
- Mobile crushing and screening plant (MC) to be located on the pit floor at AHD 905.
- Road truck (RT2) (40t) unladen truck arriving at the quarry 920m AHD.

Figures 5 and **6** show source locations for the above scenarios. The modelling was undertaken for the atmospheric conditions described in Section 3.1.

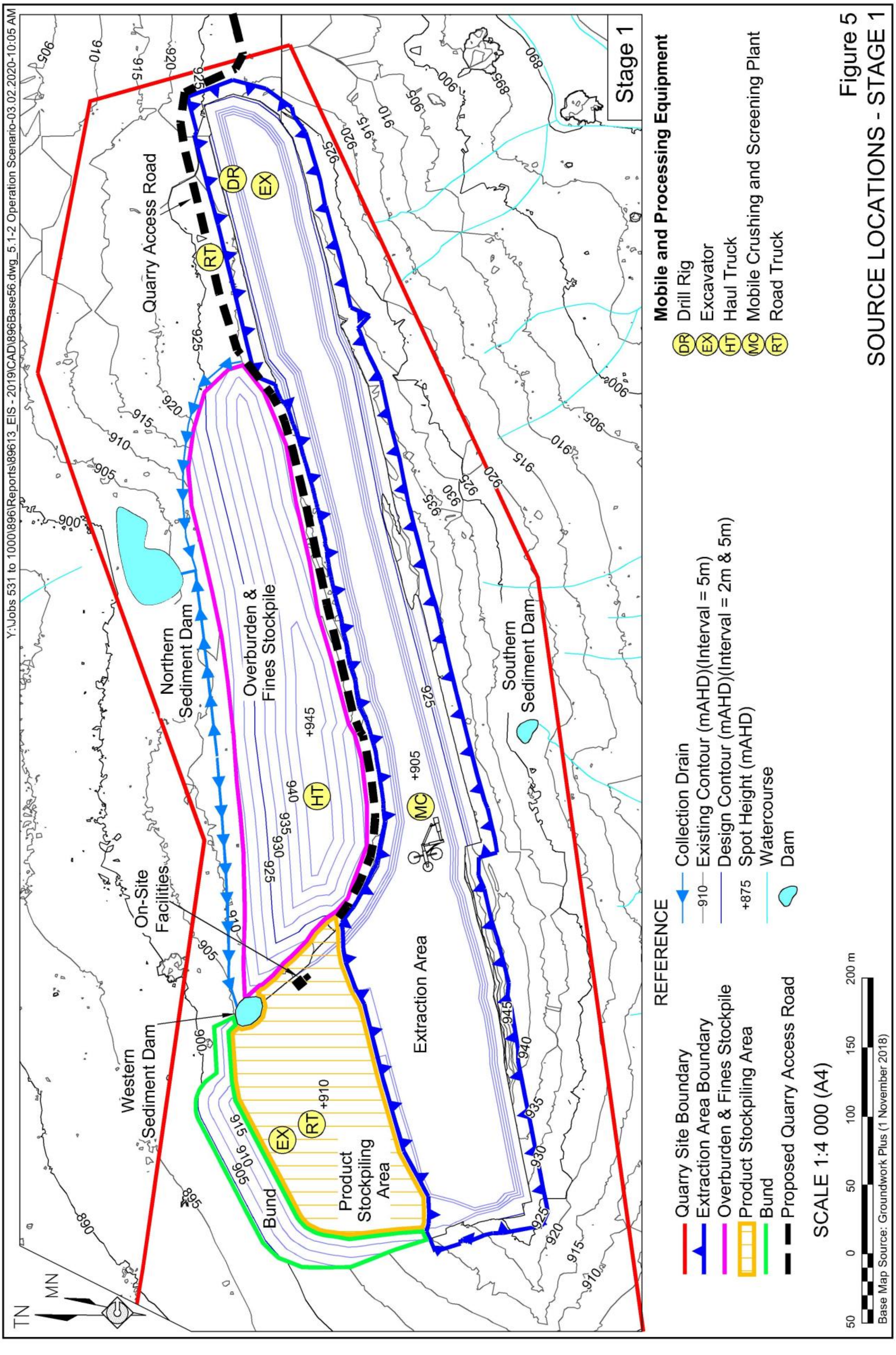
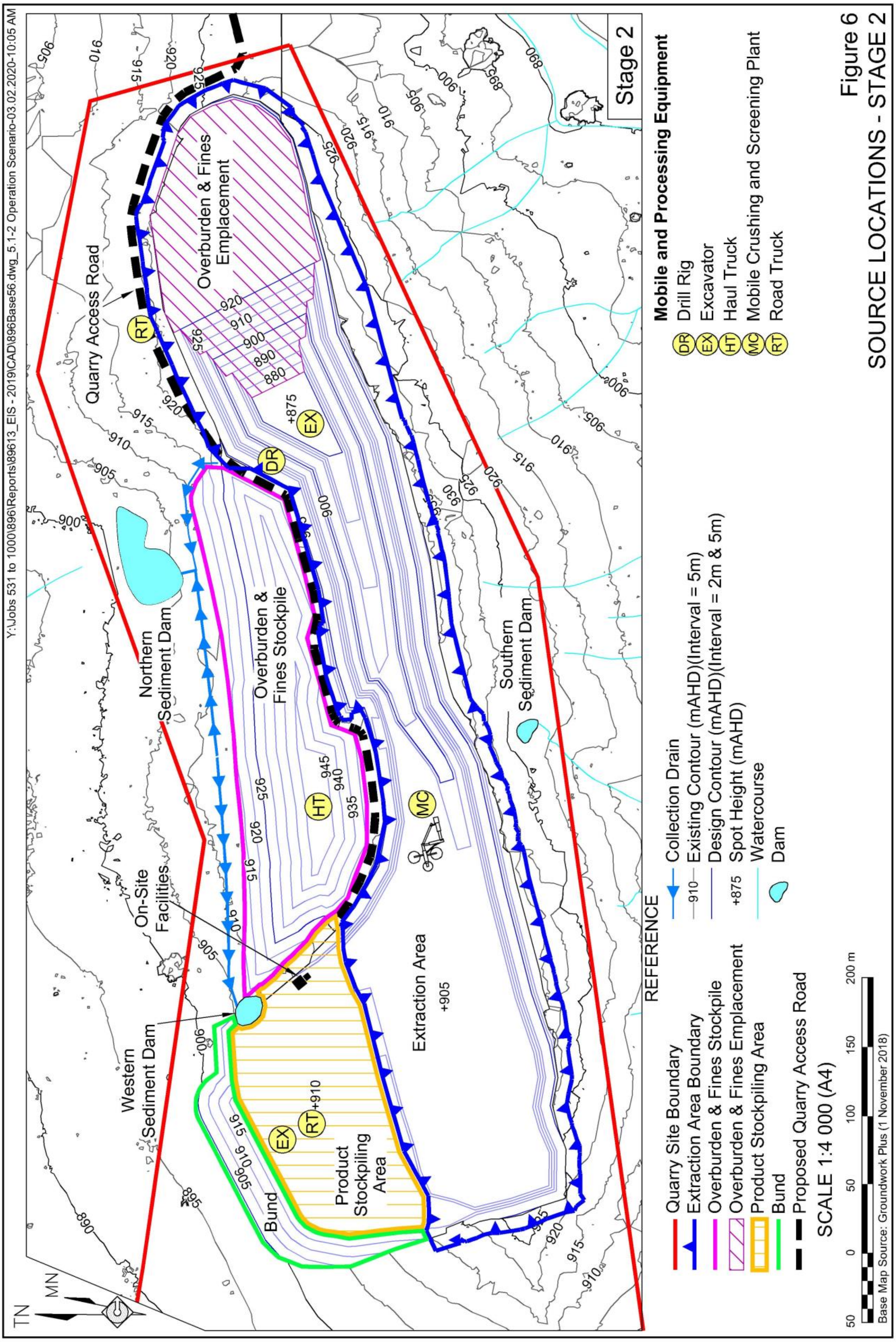


Figure 5
SOURCE LOCATIONS - STAGE 1



SPECTRUM ACOUSTICS
NOISE AND VIBRATION CONSULTANTS

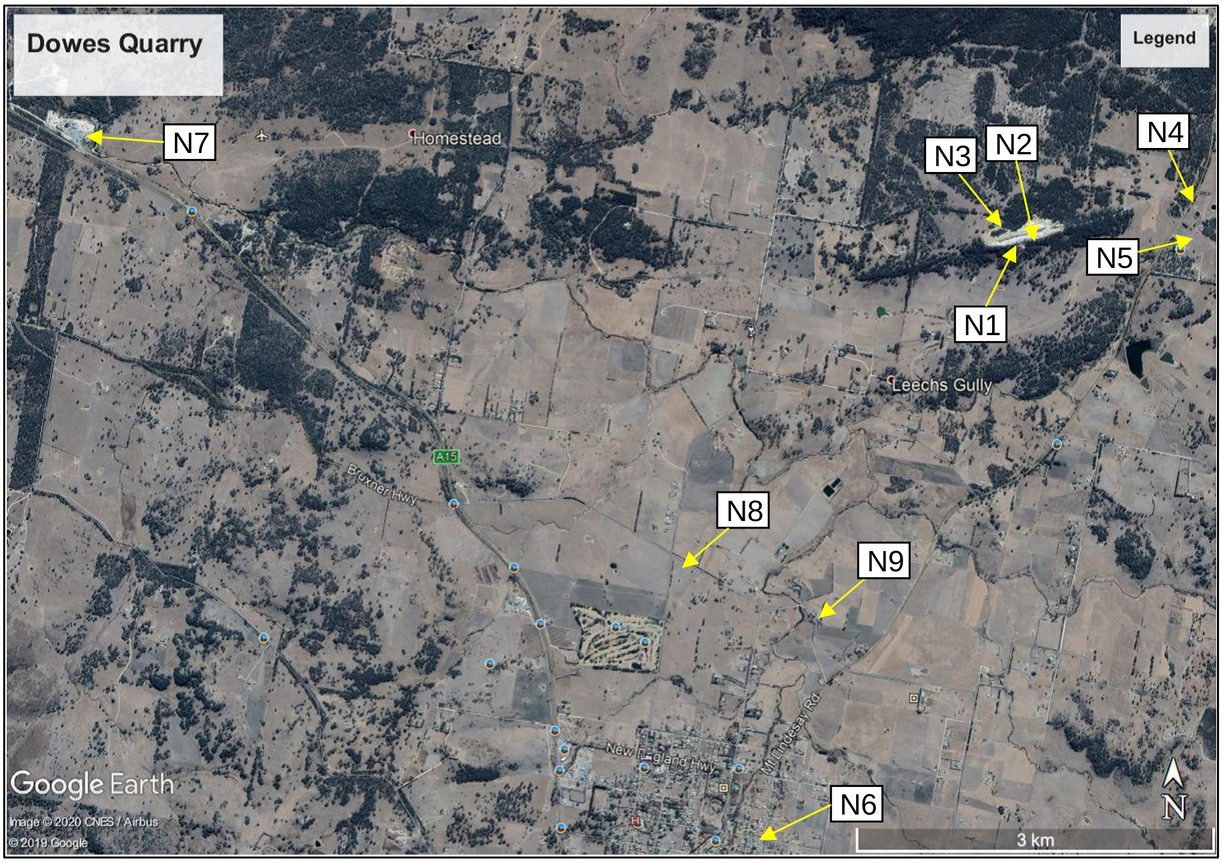
4.2 NOISE SOURCES

In response to review comments from EPA in November 2019, a site visit was conducted in December 2019 to measure noise emissions from existing plant, focussing on the rock breaker and processing plant, and off-site vehicle movements within Tenterfield and on Old Ballendean Road.

Hand held measurements were conducted on 16 December 2019 with an IEC Class 1 (Laboratory grade) Bruel & Kjaer Type 2250 spectrum analyser. Current calibration certificates are attached to this report. Sound power measurements were conducted generally in accordance with ISO 6393:2008 with regards to measurement equipment, distances and calculation techniques.

Noise measurement locations are shown in **Figure 7** and the quarry noise sources, based on file data and the site measurements, are summarised in **Table 5.**

Figure 7 Noise monitoring locations, 16 December 2019



The measured level of rock-breaking (picking) was 32 dB(A),$L_{eq(15min)}$ at N3 (site meteorological station west of extraction area) and the level at N4 (site entrance east of extraction area) was 38 dB(A),$L_{eq(15min)}$ confirming that noise from the loudest source on site did not exceed the 40 dB(A) noise trigger level outside the site boundary.

The measured level of a loaded truck exiting the site along the site access road was 27 dB(A),$L_{eq(15min)}$ at N5 (driveway to receiver R12). The measurement point was approximately 200m from the access road intersection which is approximately the distance from the intersection to receiver R13. Access road noise levels below 30 dB(A) are therefore expected at the most impacted receiver east of the site.

Table 5
Noise source sound power levels

Equipment	Indicative Number	Use	Lw dB(A),$L_{eq(15min)}$
Excavator (Komatsu PC300)	2	Soil stripping, excavation	104
		Loading trucks[1]	108
		Rock-picking[1]	118
Drill (Atlas Copco T35)	1	Drilling blast holes	114
Haul truck (15 m^3)	1	Transport material from extraction to process area	108
Kleeman crushing plant (N7)	1	Crushing and sizing of extracted material[1]	115
Light vehicle (utility)	--	1 x Employee vehicle[1,2]	41 (1-hour)
Haul trucks off-site	--	2 x empty truck pass-by (N8) @ 20m[1,2]	44 (1-hour)
	--	1 x empty truck near bridge (N7) @ 20m[1,2]	46 (1-hour)
	--	1 x full truck on Logan St (N6) @ 12m[1,2]	50 (1-hour)

[1] Attended measurement results 16 December 2019.
[2] Results normalised to LAeq(1-hr) as a basis for further calculation.

4.3 Blasting

The following sections provide standard equations for predicting blast overpressure and ground vibration levels, sourced from the United States Bureau of Mines.

4.3.1 Blast Overpressure

Unweighted airblast overpressure levels (OP) are predicted from **Equation 1** below.

$$OP = 165 - 24(\log_{10}(D) - 0.3\log_{10}(Q)), \quad \text{dB} \tag{1}$$

where *D* is distance from the blast to the assessment point (m) and
Q is the weight of explosive per delay (kg).

Equation 1 has been found through previous analysis of large quantities of blast data to underestimate overpressure levels by up to 3 dB for small blasts (MIC <400kg) and overestimate by 1 dB for larger blasts (MIC > 400kg). A +3dB correction will be applied for the relatively small blasts proposed for the project.

4.3.2 Blast Vibration

The basic equations for calculation of peak particle vibration (PPV) levels from blasting are as follows:

$$\mathrm{PPV} = 1140\left(\frac{D}{Q^{0.5}}\right)^{-1.6}$$, mm/s (for average ground type) (2)

$$\mathrm{PPV} = 500\left(\frac{D}{Q^{0.5}}\right)^{-1.6}$$, mm/s (for hard rock) (3)

where *D* and *Q* are defined as in Equation 1. The difference between Equations 2 and 3 is the value of the coefficient 1140 or 500 and, for the sake of taking a conservative approach to the assessment, the larger value of 1140 will be adopted.

4.4 TRAFFIC NOISE

Traffic noise levels at identified most impacted receivers have been based on attended noise measurements of pass-bys from the current truck fleet as recorded in **Table 5**. This avoids any need to apply assumptions about road surface type, vehicle speed, road condition (bends, potholes, inclines) that all introduce errors when estimating noise levels. Assessment locations are indicated as N6, N8 and N9 in Figure 7 and described as follows:

N6 – residence 12m from the road on Logan Street near Haas Street intersection.

N8 – residence 25m from Old Ballendean Road near crest of hill.

N9 – residence 25m from Old Ballendean Road near bridge over creek.

The measured levels were adjusted by simple calculation to account for different vehicle numbers and distances from the road.

5. RESULTS AND DISCUSSION

5.1 PREDICTED OPERATIONAL NOISE LEVELS

Noise levels were modelled using RTA's *Environmental Noise Model* v3.06 (ENM) software for each of the atmospheric scenarios described in Section 4.1. Point calculations were performed for all receivers in **Table 1**.

Predicted noise levels under various neutral atmospheric conditions for the two modelled scenarios are summarised in **Tables 6** and **7**.

Table 6
Predicted noise levels, dB(A),$L_{eq(15min)}$ Scenario 1

Receiver	Meteorological condition	Trigger level
	Neutral	
East of Quarry Site		
R10	<30	40
R11	<30	40
R12	33	40
R13	32	40
R14	<30	40
R15	<30	40
R18	32	40
R19	<30	40
R20	<30	40
South and Southeast of the Quarry Site		
R7	<30	40
R8	<30	40
R9	<30	40
R21	<30	40
R22	<30	40
R23	<30	40
R24	<30	40
R25	<30	40
R26	<30	40
R27	<30	40
West and Southwest of the Quarry Site		
R2	<30	40
R3A	32	40
R3B	30	40
R4	<30	40
R5A	<30	40
R5B	<30	40
R6	<30	40
R16	<30	40

Table 7
Predicted noise levels, dB(A),$L_{eq(15min)}$ Scenario 2

Receiver	Meteorological condition Neutral	Trigger level
East of Quarry Site		
R10	<30	40
R11	<30	40
R12	<30	40
R13	<30	40
R14	<30	40
R15	<30	40
R18	<30	40
R19	<30	40
R20	<30	40
South and Southeast of the Quarry Site		
R7	<30	40
R8	<30	40
R9	<30	40
R21	<30	40
R22	<30	40
R23	<30	40
R24	<30	40
R25	<30	40
R26	<30	40
R27	<30	40
West and Southwest of the Quarry Site		
R2	<30	40
R3A	32	40
R3B	30	40
R4	<30	40
R5A	<30	40
R5B	<30	40
R6	<30	40
R16	<30	40

The results in **Tables 6** and **7** show noise levels below the operational noise criterion at all assessed receivers. None of the noise sources were tonal in their Lw spectra, so an assessment of tonality at the receivers was not required. All sources are characteristically broad spectrum and intermittent noise was not assessable due to there being no night time operations. With the absence of annoyance noise characteristics in the source data, full quantitative assessment of annoyance characteristics in Fact Sheet C of the NPI is not warranted.

5.2 BLASTING

The client has advised that blasting within the quarry would typically be required approximately once per month, however, in the interest of practical limits of ongoing operations, blasting of no more than once per week is proposed. Blast design is as follows:

- Drill holes are 89mm diameter and have a maximum depth of 15m, with up to 1m of subdrill.
- Drill holes typically have a 3m x 3m spacing, 3m stemming and use 5.6kg/m of ANFO.
- Typical blasts use 3 rows with 8 drill holes per row and a combination of 17ms and 45ms delays on the detonators.

Based on the above data, each hole would contain up to 67.2 kg ANFO fired at one hole per delay, therefore maximum instantaneous charge (MIC) is 67.2 kg.

Calculated blast overpressure and ground vibration levels at the nearest receivers within each receiver group, based on this worst-case MIC, are summarised in **Table 8**.

Table 8
Predicted blast overpressure and ground vibration levels

Location	Distance m	Overpressure dB	Criterion	Vibration mm/s	Criterion
R12 (east)	1160	108.5	115	0.7	5.0
R9 (south east)	1295	107.4	115	0.6	5.0
R3A (west)	740	113.2	115	1.4	5.0

The above results show worst case blast impact levels well below the overpressure and ground vibration criteria at the potentially worst impacted receivers.

5.3 ROAD TRAFFIC NOISE

Based on the maximum annual production rate of 230,000t and including back-loading of material from the Sunnyside Crushing and Screening Plant to the quarry, the Proposal would generate up to 56 movements per day, Monday to Saturday. This equates to a maximum of half of these movements would be loaded trucks passing the nearest residences to Mt Lindesay Road and the New England Highway and half would pass by the nearest residences to Old Ballandean Road. There could also be up to 5 light vehicle movements on public roads during an hour around shift change. It is assumed that these vehicles would all access the site via Mt Lindesay Road and not Old Ballendean Road.

<u>N6 – residence 12m from the road on Logan Street near Naas Street intersection.</u>

Measured:	1 x full truck 50 dB(A),$L_{eq(1\ hour)}$ at 12m.
	1 x light vehicle 41 dB(A),$L_{eq(1\ hour)}$ at 20m
Criterion (night):	**55 dB(A),$L_{eq(15hour)}$**
Time correction:	$L_{Aeq(1\ hour)}$ to $L_{Aeq(15hour)}$ = 10log(1/15) = -12 dB
Distance correction:	Heavy: nil
	Light: 20log(20/12) = +4 dB
Vehicle numbers:	Heavy: 28 full trucks per 15 hours
	Light: 10 per 15 hours for 2 x shift changes
Noise at receiver:	Heavy: 50 dB(A) -12 dB + 10log(28) = 52 dB(A),$L_{eq(15\ hour)}$
	Light: 41 dB(A) -12 dB + 4 dB + 10log(10) = 43 dB(A),$L_{eq(15\ hour)}$
	TOTAL: **53 dB(A),$L_{eq(15\ hour)}$**

<u>N8 – residence 25m from Old Ballendean Road near crest of hill.</u>

Measured:	2 x empty trucks 44 dB(A),$L_{eq(1\ hour)}$ at 20m.
Criterion (night):	**50 dB(A),$L_{eq(1hour)}$**
Time correction:	Nil
Distance correction:	20log(20/25) = -2 dB
Vehicle numbers:	3 empty trucks per hour
Noise at receiver:	44 dB(A) -2 dB + 10log(3/2) = **44 dB(A),$L_{eq(15\ hour)}$**

<u>N9 – residence 25m from Old Ballendean Road near bridge over creek.</u>

Measured:	1 x empty truck 46 dB(A),$L_{eq(1\ hour)}$ at 20m.
Criterion (night):	**50 dB(A),$L_{eq(1hour)}$**
Time correction:	Nil
Distance correction:	20log(20/25) = -2 dB
Vehicle numbers:	3 empty trucks per hour
Noise at receiver:	46 dB(A) -2 dB + 10log(3/2) = **46 dB(A),$L_{eq(15\ hour)}$**

The results above show that noise levels from project-related traffic would be below the applicable criteria at the worst affected residential receivers.

6. SUMMARY OF RESULTS

A noise impact assessment of the proposed extension of Dowe's Quarry via Tenterfield NSW has been conducted. The study has found the following:

- No exceedance of operational noise criteria has been predicted at any receiver;
- No exceedance of blast overpressure and ground vibration criteria at any receiver;
- No exceedance of off-site traffic noise criteria at any receiver.

We therefore advise that the Proposal can operate within the EPA noise criteria and recommend approval of the Proposal, as far as acoustic issues are concerned.

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Appendix 5

Dowe's Quarry Targeted Species Search

prepared by

AREA Environmental Consultants and Communication

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Dowe's Quarry
Targeted Species Search
Tenterfield LGA
March 2020

AREA Environmental Consultants & Communication
(a) 6 Belmore Street Dubbo NSW 2830
(b) "Thieles Gate" (Type 2 Conservation Agreement Area) 79 Huonbrook Rd Mullumbimby NSW 2482
Ph 0409 852 098
phil@areaenvironmental.com.au

- Environmental impact assessment, approvals and adulting
- Preliminary environmental assessment (PEA)
- Review of environmental factors (REF) & Minor Work REF
- Ecology assessments & biodiversity offsetting (BAM and Biobanking)
- Aboriginal & heritage assessments and community walkovers
- Community engagement
- Peer review & quote or tender preparation or advice
- Landscape design and architecture

AREA Environmental Consultants & Communication acknowledges Traditional Owners of the country on which we work

Dowe's Quarry
Targeted Species Search

March 2020

Prepared by: **AREA Environmental Consultants & Communication Pty Ltd**
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ABN:29 616 529 867

Document Controls

Proponent	Darryl McCarthy Constructions Pty Ltd
Client	RW Corkery & Co Pty Limited Geological and Environmental Consultants
AREA Job No.	QU-0220
Document Description	Dowe's Quarry Targeted species survey report
Clients Representative Managing this Document	Nick Warren Principal Environmental Consultant
AREA Person(s) Managing this Document	Phil Cameron (PJC)
Cover page image	Dowe's Quarry

Document Status	Version	Date	Action
DRAFT (Internal document)	V1.0	13/11/19	DS to PJC
	V1.1	13/11/19	Reviewed / certified
DRAFT (AREA / Client)	V2.0	13/11/19	AREA to client
FINAL	V3.0	14/11/2019	AREA to Client
	V3.1	13/1232019	AREA to Client (minor revision)
	V3.1	20/01/2020	Client to AREA
	V3.2	20/02/2020	AREA to Client (minor revision)
	V3.3	17/03/2020	AREA to Client (minor revision after BCD guidance)

Prepared For	Nick Warren Principal Environmental Consultant B.Sc., M. Bus., M. Env.Sc. Phone: 02 9985 8511 Mobile: 0437 635 975 Email: nick@rwcorkery.com RW Corkery & Co Pty Limited Geological and Environmental Consultants
Prepared By	Dave Sturman - Environmental Consultant AREA Environmental Consultants & Communication Pty Ltd 6 Belmore Street Dubbo NSW 2830 M 0407 439 410 E dave@areaenvironmental.com.au
Certified by	Phillip Cameron CEnvP, NSW Biodiversity Assessment Method (BAAS17082) & Biobanking (0117) accredited The Common Seal of AREA Environmental Consultants & Communication ACN: 61605290867

Contents

1 Introduction

1.1 Background

Dowe's Quarry (subject site) is in the Tenterfield Shire approximately eight kilometres north east of Tenterfield. Access to the Quarry is via Mount Lindsay Road.

The Quarry operator/manager Darryl McCarthy Construction Pty Ltd (the Applicant) is seeking approval for the expansion of the existing Dowe's Quarry.

AREA Environmental Consultants & Communication (AREA) was engaged by R.W. Corkery to complete a targeted threatened species search for species credit species that were unable to be surveyed for during the initial surveys carried out for preparation of a Biodiversity Development Assessment Report (BDAR) (Eco Logical Australia, 2019) due to the seasonal timing / limitations of the initial assessment.

Figure 1-1:Regional Context

1.2 Previous Studies

On 22 April through to the 26 April 2019 Eco Logical Australia ecologists surveyed the development site for a Biodiversity Development Assessment Report (BDAR) to support an Environmental Impact Assessment (EIS) developed for the proposal.

Eco Logical Australia prepared the following BDAR following the Biodiversity Assessment Method (BAM) under section 6.7 of the BC Act:

- *Eco Logical Australia. 2019 Dowe's Quarry BDAR. Prepared for R.W. Corkery & Co Pty Ltd on behalf of Darryl McCarthy Constructions Pty Ltd* (Eco Logical, 2019).

AREA concurs with all the results and conclusions of the Eco Logical BDAR.

This survey found the subject site to contain one Plant Community Type (PCT) PCT568-*Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion.* This consisted of 4.63 hectares in good condition and 1.78 hectares in poor condition.

No threated species or threatened ecological communities were found within the development site. As the Eco Logical study was conducted in April 2019, the following 11 species credit species were not detectable at the time the assessment occurred and were assumed as present:

- Barking Owl (*Ninox connivens*)
- Powerful Owl (*Ninox strenua*)
- Masked Owl (*Tyto novaehollandiae*)
- Eastern Pygmy-possum *(Cercartetus nanus)*
- Eastern Cave-bat (*Vespadelus troughtoni*)
- Little Eagle (*Hieraaetus morphnoides*)
- Square-tailed Kite (*Lophoictinia isura)*
- White-bellied Sea Eagle (*Haliaeetus leucogaster*)
- Grey-headed Flying Fox (*Pteropus poliocephalus)*
- Austral Toadflax (*Thesium australe*)
- Bolivia Wattle (*Acacia pycnostachya)*

1.3 Study Area

Dowe's Quarry is located approximately eight kilometres north east of Tenterfield NSW in the Tenterfield local Government Area located on rural land. The land is privately owned and leased to the Applicant. Access is obtained via Mount Lindesay road with a 1.3-kilometre access road linking the Quarry to via Mount Lindesay Road.

The Manager/Operator of Dowe's Quarry has run the quarry since 1987 and is proposing to expand the disturbance area for the operation and increase the annual production rate from 150,000tpa to 230, 000tpa (Dowe's Quarry Environmental Impact Statement RWC, 2019).

Figure 1-3: Development Site

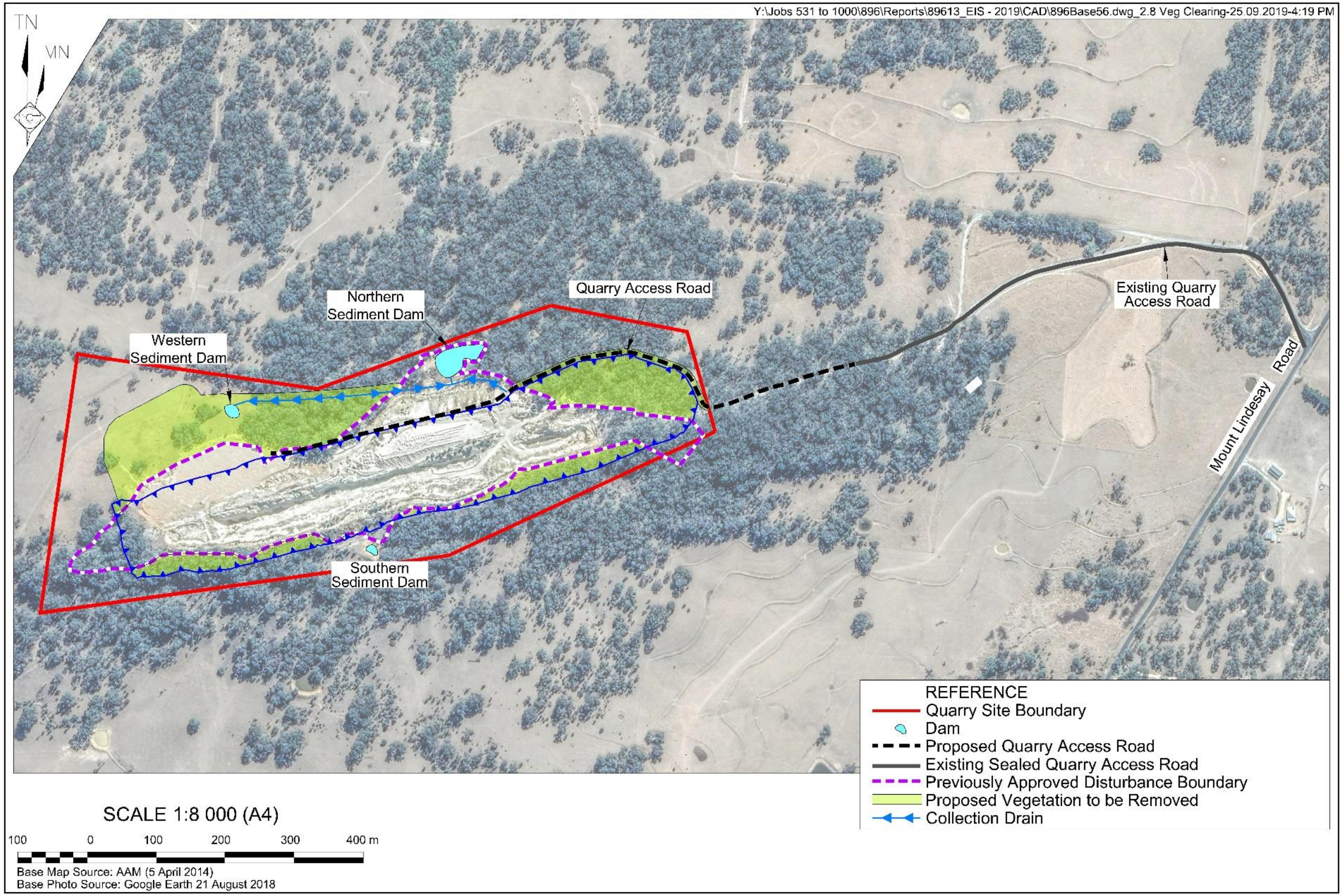


Image source: “Eco Logical Australia. 2019 Dowe’s Quarry BDAR. Prepared for R.W. Corkery & Co Pty Ltd on behalf of Darryl McCarthy Constructions Pty Ltd’

1.4 Scope

AREA was commissioned to complete targeted surveys for the species credit species identified in Section 1.2. Details of areas staff used in this project have been provided in **Table 1-1**.

Table 1-1: Contributors

Name	Position	CV Details	Relationship with this project
AREA	All staff	• NSW OEH Scientific License: 101087 • NSW DPI Ethics Approval 17/459 (3) P18/0035 Miscellaneous Blanket Permit – NSW Department of Primary Industries Fisheries	In accordance with the accredictation
Phillip Cameron	Principal consultant	• BSc. Major in Biology. Macquarie University • Ass Dip App Sci. University of Queensland • Certified Environmental Practitioner (EIANZ) • Lean Six Sigma Certificate (Sydney Uni) • NSW OEH BioBanking and Bio-certification Assessor: accreditation number 0117 • NSW OEH Scientific License: 101087 • NSW DPI Ethics Approval 11/5475 • Practicing member of the NSW Ecological Consulting Association • Practicing member of the Environment Institute of Australia and New Zealand (EIANZ) • National Railtrack Safety Induction (ARTC and John Holland Inductions) • WHS White Card and Blue Card • AHCPCM201- Recognising grasses	• Role • Project management • Report certification
Heidi Kolkert	Principal ecologist	• PhD candidate (Science) University of New England 2013 to current • BSc. (Hons) and Bachelor of Arts University of Tasmania Graduated 2005 • NSW OEH BioBanking and Bio-certification Assessor TAFE NSW • Practicing member of the NSW Ecological Consulting Association • WHS White Card and Blue Card • Apply First Aid (Medilife), Remote First Aid (St John)	• Role • Bat call analysis
Dave Sturman	Ecologist	• B. Env. Sc. Charles Sturt University • Cert III (Horticulture) • WHS White Card and Blue Card • White card – general construction induction card. • RMS-worker on foot training. • Senior First Aid • Chainsaw operator ticket • Confined Space worker and atmospheric monitoring. • Risk assessment training. • AHCPCM201- Recognising grasses	• Role • Ecology assessment, • Report writing. • Data analysis • Cartography

2 Method

2.1 Survey Requirements

The field assessment followed:

- *The Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities. Working Draft November 2004.*
- *'Species credit' threatened bats and their habitats NSW survey guide for the Biodiversity Assessment Method 2018*
- *Survey guidelines for Australia's threatened bats Guidelines for detecting bats listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999 Department of the Environment, Water, Heritage & the Arts*
- *NSW Guide to Surveying Threatened Plants 2016.*

Tables 2-1, **2-2**, **2-3** and **2-4** provide a copy of the survey requirement as well as methods employed by AREA staff in the field to meet this requirement. Rows in green fill show what relevant survey requirements for this assessment were completed for:

- Barking Owl (*Ninox connivens*)
- Powerful Owl (*Ninox strenua*)
- Masked Owl (*Tyto novaehollandiae*)
- Eastern Pygmy-possum *(Cercartetus nanus)*
- Eastern Cave-bat (*Vespadelus troughtoni*)
- Little Eagle (*Hieraaetus morphnoides*)
- Square-tailed Kite (*Lophoictinia isura)*
- White-bellied Sea Eagle (*Haliaeetus leucogaster*)
- Grey-headed Flying Fox (*Pteropus poliocephalus)*
- Austral Toadflax (*Thesium australe*)
- Bolivia Wattle (*Acacia pycnostachya).*

Table 2-1: Suggested survey methods and efforts for non-flying mammals

Page 1 of 2

Method	Effort per stratification unit up to 50 hectares, plus an additional effort for every additional 100 hectares	Animal sampled	Method used
Small Elliott traps	100 trap nights over 3-4 consecutive nights	small mammals	14 terrestrial traps of five nights totaling 70 trap nights. Less than required.
Large Elliott traps	100 trap nights over 3-4 consecutive nights	Medium to large mammals	N/A
Arboreal Elliott traps	24 trap nights over 3-4 consecutive nights	Arboreal mammals	11 Arboreal traps over five nights totalling 55 trap nights (collectively 125 trap nights for eastern pygmy possum including ground traps)
Wire cage traps	24 trap nights over 3-4 consecutive nights	Medium to large mammals	N/A
Pitfall traps with drift nets	24 trap nights over 3-4 consecutive nights	small mammals	N/A
Hair tubes	10 large and 10 small tubes in pairs for at least 4 days and 4 nights	small and medium mammals	N/A
Arboreal hair tubes	3 tubes in each of 10 habitat trees up to 100 hectares of stratification unit, for at least 4 days and 4 nights	arboreal mammals	N/A
Spotlighting on foot	2 x 1 hour and 1km up to 200 hectares of stratification unit, walking at approximately 1km per hour on 2 separate nights.	arboreal and terrestrial mammals	Completed five nights

Method	Effort per stratification unit up to 50 hectares, plus an additional effort for every additional 100 hectares	Animal sampled	Method used
Spotlighting from vehicle	2 x 1 km of track at maximum speed of 5km per hour up to 200 hectares of stratification. unit, on 2 separate nights	arboreal and terrestrial mammals	Completed one night
Sand plots	6 soil plots for 4 nights	mostly medium to large terrestrial mammals	N/A
Call playback	2 sites per stratification unit up to 200 hectares, plus an additional site per 100 hectares above 200 hectares. Each playback site must have the session conducted twice, on separate nights.	gliders, koalas	N/A

Table 2-1: Suggested survey methods and efforts for non-flying mammals (Cont'd)

Page 2 of 2

Method	Effort per stratification unit up to 50 hectares, plus an additional effort for every additional 100 hectares	Animal sampled	Method used
Stag-watching	Observing potential roost hollows for 30 minutes prior to sunset and 60 minutes following sunset	gliders and possums	Completed five nights.
Search for scats and signs	30 minutes searching each relevant habitat, including trees for scratch marks	all mammals	Opportunistically for five days
Track search	1km of track search with emphasis on where substrate is soft	mostly medium to large terrestrial mammals	N/A
Collection of predator scats	Opportunistic collection of predator scats for hair analysis	all mammals	N/A

Table 2-2: Suggested survey methods and effort for birds

Method	Effort per stratification unit up to 50 hectares, plus an additional effort for every additional 100 hectares or stratification unit up to 50 hectares, plus an additional effort for every additional 100 hectares	Time of assessment	Method used
Call playback	Sites should be separated by 800 metres – 1km, and each site must have the playback session repeated as follows: • at least 5 visits per site, on different nights are required for the Powerful Owl, Barking Owl and the Grass Owl; • at least 6 visits per site for the Sooty Owl, and 8 visits per site for the Masked Owl are required. Sites for Bush Stone-curlew surveys should be 2-4km apart and conducted during the breeding season.	All year	Completed five days / fiver nights
Day habitat search	Search habitat for pellets, and likely hollows. Flushing of Bush Stone-curlews by walking through potential habitat.	All year	Completed five days / four nights
Stag-watching	Observing potential roost hollows for 30mins prior to sunset and 60mins following sunset.	All year	Completed five days / five nights
Spotlighting	Spotlighting for Plains Wanderer and Bush Stone-curlew by foot or from a vehicle driven in first gear.	All year	Completed five days / five nights
Nesting observations	Observed characteristics of nesting construction. i.e.	All year	Completed

Method	Effort per stratification unit up to 50 hectares, plus an additional effort for every additional 100 hectares or stratification unit up to 50 hectares, plus an additional effort for every additional 100 hectares	Time of assessment	Method used
	Zero large stick nests were observed amongst the emergent canopy and the study area was not close to waterways.		five days / five nights

Table 2-3: Appropriate Survey Methods for Threatened Bat Species

Common name	Scientific Name	Roosts	Traps	Call Survey	Additional Methods
Eastern Cave Bat	*Vespadelus troughtoni*	S	□		Search rocks, overhangs and caves/mines
Grey-headed Flying Fox	*Pteropus poliocephalus*	Trees			Observed tree Canopies & spotlighting
Inland Forest Bat	*Vespadelus baverstocki*	H	□		
Large Pied Bat	*Chalinolobus dwyeri*	S	□	□	Search rocks, overhangs and caves/mines
Hoary Bat	*Chalinolobus nigrogriseus*	H	□	□	
Little Pied Bat	*Chalinolobus picatus*	H	□	□	
Greater Long-eared Bat	*Nyctophilus timoriensis*	H	□		Harp traps within vegetation
Northern Long-eared Bat	*Nyctophilus bifax*	H/V	□		
Greater Broad-nosed Bat	*Scoteanax rueppellii*	H		□	
Great Falsistrelle	*Falsistrellus tasmaniensis*	H	□		
Large-footed Myotis	*Myotis adversus* (also known as *Myotis macropus*)	S/H	□		Detector and spotlight around water bodies, trapping along riparian flyways
Golden-tipped Bat	*Kerivoula papuensis*	H/V	□		
Large Bentwing Bat	*Miniopterus schreibersii*	S	□		Search rocks, overhangs and caves/mines

Common name	Scientific Name	Roosts	Traps	Call Survey	Additional Methods
Little Bentwing Bat	*Miniopterus australis*	S/H	□	□	Search rocks, overhangs and caves/mines
Little Eastern Mastiff Bat	*Mormopterus norfolkensis*	H	□	□	

Table 2-4: Suggested Survey Method for Bats

Method	Effort per 100 hectares (or portion thereof) of stratification unit targeting preferred habitat	Survey Period
Harp trapping	Four trap nights over two consecutive nights (with one trap placed outside the flyways for one night)	October to March
Ultrasonic call recording	Two sound activated recording devices utilised ***for the entire night (a minimum of four hours)***, starting at dusk for two nights	October to March
Mist netting	For targeted survey: one trap set for at least two hours duration starting at dusk, for two nights	October to March
Trip line	For targeted survey of water bodies: at least two hours duration starting at dusk, for two nights	October to March
Spotlighting and transect walking	For targeted survey near likely food resources: 2 x 1 hour spotlighting on two separate nights	All year
Day habitat search	Search for bat excreta at or near potential habitats	All year

2.2 Field Survey Effort Summary

Field Surveys were conducted by AREA Ecologist Dave Sturman from 4/11/2019 to 9/11/2019 (**Table 2-5**).

Table 2-5: Field survey effort summary

Survey dates	Methods	Effort
November 2019 AREA Ecologist All activities occurred over five days and five nights.	Fauna • Bird watching • Nocturnal surveys • Looking for signs of small mammal activity, i.e. diggings, scats or tracks along linear transects • Targeted bird watching and habitat mapping for all species • Nocturnal surveys (Anabat) • Opportunistic sightings	4-full, 2-half days, 5 nights • Linear transects • Dawn, dusk and midday bird surveys • Opportunistic observations • Call playback (nocturnal) three nights • Anabat assessment five nights (two machines at separate locations) • Camera Trap set up (two separate locations) • Two-hour minimum spotlighting per evening. • Transects were employed across the property.
April 2019 Eco Logical Ecologist field survey and BAM plots completed	Fauna Targeted bird watching Opportunistic sightings Flora Four BAM Plots	BAM plots undertaken as per BAM methods

2.3 Field Survey

2.3.1 Terrestrial fauna surveys

The following resources were used in determining the outcomes of the targeted species search:

- Biodiversity Assessment Methodology (OEH, 2017)
- BAM Credit Calculator
- Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities – Working Draft (DEC, 2004)
- Survey requirements (birds, bats, reptiles, frogs, fish and mammals) for species listed under the EPBC Act
- Threatened biodiversity profile search
- NSW BioNet
- Vegetation Types databases
- Online Zoological Collections of Australian Museums
- Threatened Species Assessment Guideline - The Assessment of Significance (DECCW, 2007)
- Significant Impact Guidelines 1.1 - Matters of National Environmental Significance
- Threatened Bat Survey Guide.

Field assessment was carried out over five full days and five nights between 4 to 9 November 2019. An overview of survey effort is shown in **Figures 2-1 and 2-2**.

Figure 2-1: Overview of survey methods.

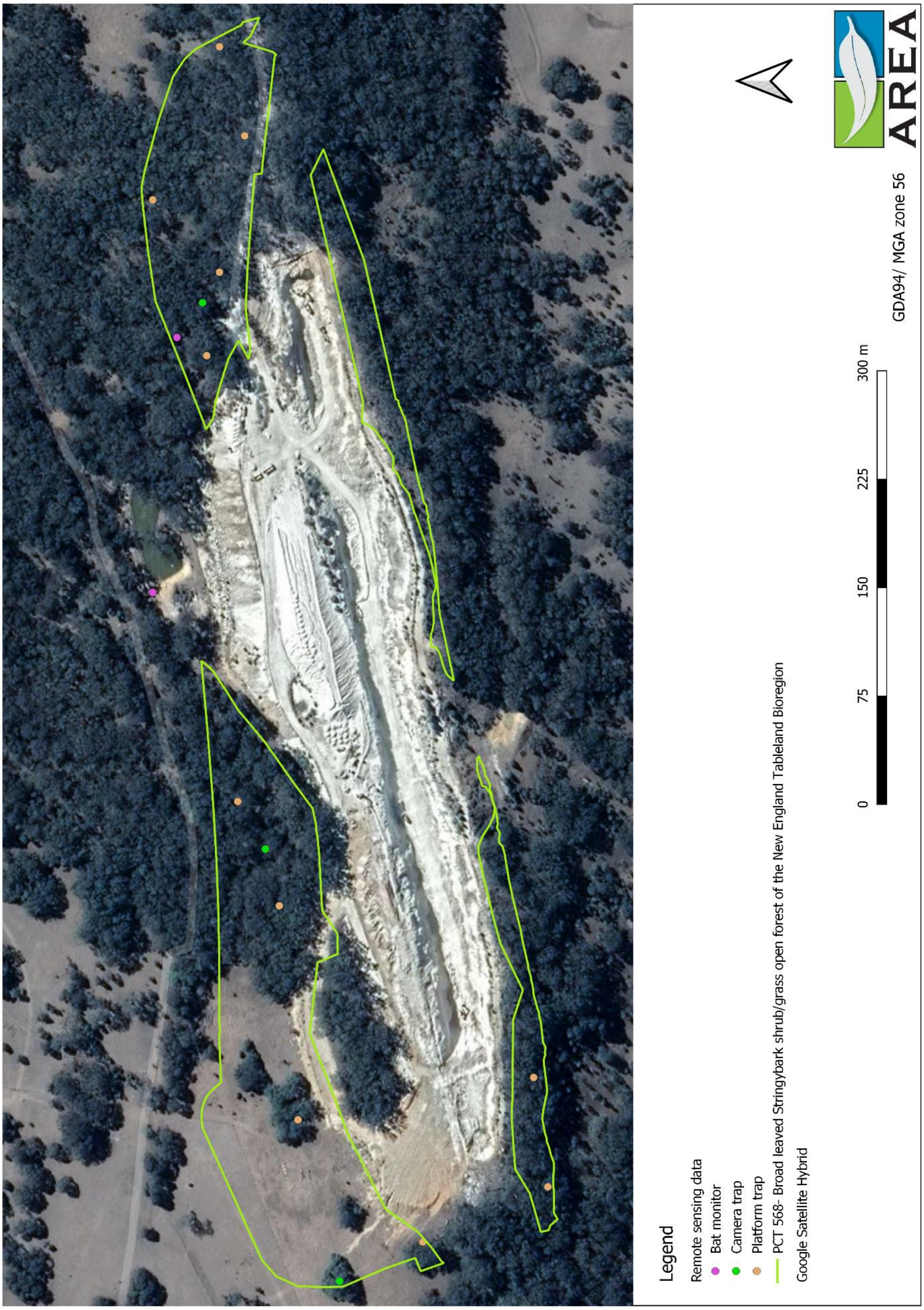
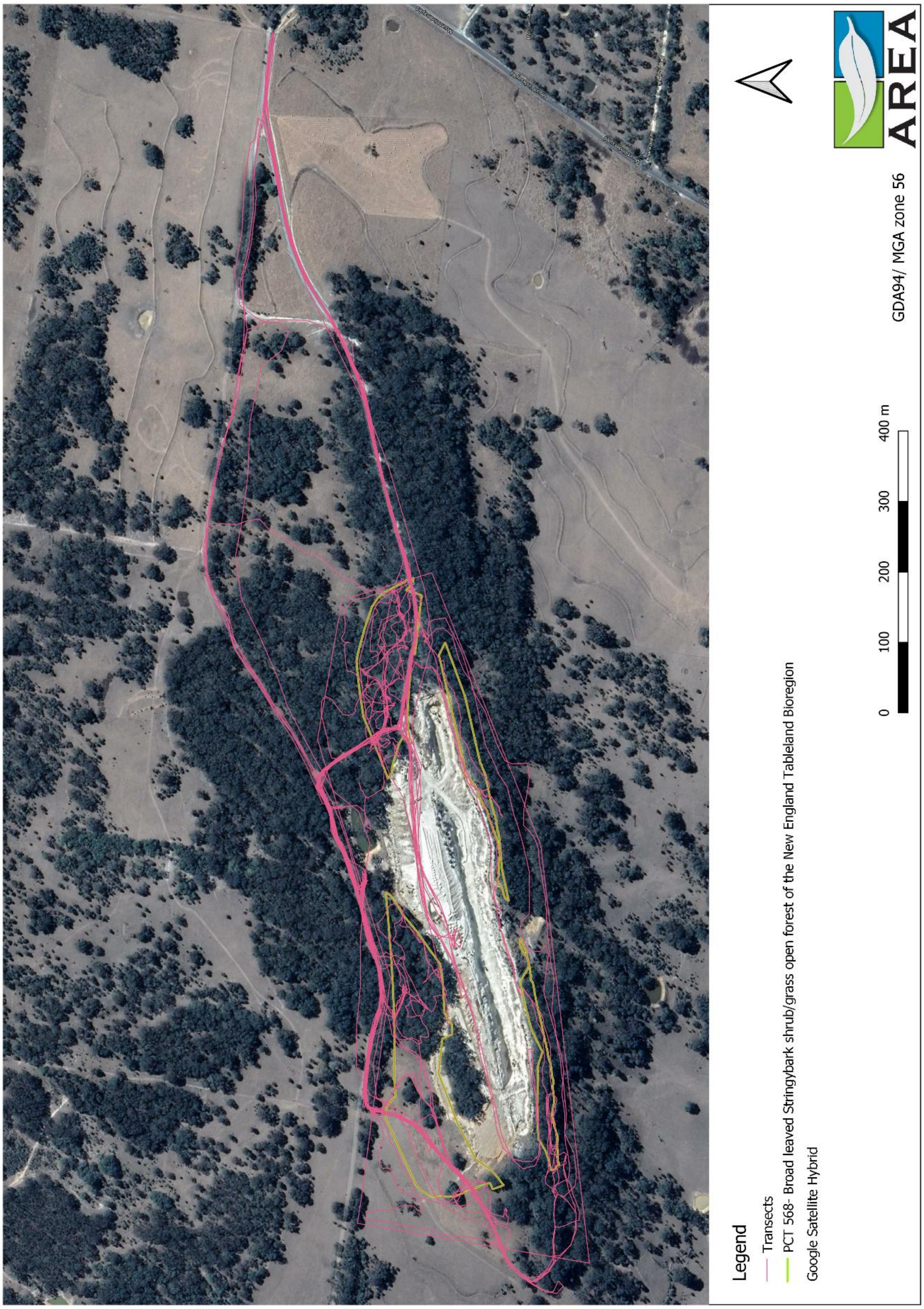


Figure 2-2: Survey Transects



2.4 Fauna

2.4.1.1 Habitat assessment

Habitat in the development site was assessed for its potential to provide resources for the targeted species. Preference of habitat for these species was determined by Department of Planning, Industry and Environment, Department of Primary Industries (DPI) Fisheries and the Australian Government Department of Environment and Energy (DoEE) Threatened online Species Profiles.

Database searches were undertaken before the assessment to inform the consultant of what species predicted or known in the 10 kilometre buffer may be recorded or should need a targeted search.

Any indirect evidence of fauna i.e. scats, tracks, calls, fur feathers, sloughed skins etc was assessed. Each mature tree in the subject site was inspected for hollows and to determine if they were used for breeding. All eucalyptus trees in the development site were also assessed for nests, feeding habitat including mistletoe or resting habitat. Where a tree with a hollow was observed it was given a score reflecting its habitat value. Where there was potential owl habitat identified (hollows >20cm) these were further assessed via stag watching- observing potential roost hollows for 30mins prior to sunset and 60mins following sunset and spotlight observations.

Specific detail on the fauna detection methods employed is found in the following sub-sections.

2.4.1.2 Echolocation

Echolocation detectors (SongMeters SM2+BAT and SM3+Bat, Wildlife Acoustics) were used to identify the possible presence of any microchiropterans (microbats) that may be present in the development site. The detectors were placed in habitats likely to be used by microchiropterans during their foraging and dispersal periods (i.e. adjacent to water bodies, and habitat ecotones) or as roosting sites (i.e. hollow-bearing trees present). Two detectors were placed for five nights respectively from the 4 November to 9 November 2019.

The detectors were set prior to dusk and left in place for the entire duration of each evening. Calls recorded were analysed by Dr Heidi Kolkert (Principal Ecologist AREA) using Anabat 6.3 computer software.

2.4.1.3 Call Playback

Nocturnal birds and marsupials were surveyed through call playback and spotlighting. Call playback followed the methods described by Kavanagh and Peake (1993) and Debus (1995). This method requires an initial listening period of ten to 15 minutes after playing the respective call, followed by a spotlight search for ten minutes to detect any animals in the immediate vicinity, followed by intermittently playing the call for another five minutes and a ten minute listening period. A general search of the immediate environs was then undertaken to see if any non-vocalising birds were present.

Use of the playback of pre-recorded sound bites (Nature Sound) for the detection of the following threatened species:

- Barking Owl (*Ninox connivens*)
- Powerful Owl (*Ninox strenua*)
- Masked Owl (*Tyto novaehollandiae*).

The sequence of the calls broadcast was as noted above, a short listening period occurring between the marsupial and owl calls.

To minimise stressing and disturbing the species targeted, if an animal responded to the call playbacks, calls of this species were not broadcast during subsequent playback sessions (unless those playbacks were proposed to be conducted beyond the limits of the documented habitat range of said target species).

2.4.1.4 Bird Survey (Diurnal and Nocturnal)

Taking into consideration the discussion in the DPIE working draft on methods to survey diurnal birds, an area-search method was used within the development site.

In addition to those dedicated bird surveys undertaken, any incidental observations or records made whilst traversing the site or conducting additional surveys (e.g. the herpetofauna searches) were noted.

All vegetation types were surveyed for bird species. Targeted bird watching was undertaken near any habitat trees to identify possible nesting or roosting areas. Birds were identified via visual observation and characteristic call.

Particular attention was paid to threatened species habitat and calls.

2.4.1.5 Spotlighting

During the nocturnal surveys, spotlighting (using a 163-lumen hand-held spotlight) was undertaken.

Spotlighting was undertaken on foot with tracks, clearings and access ways within the targeted development site. These environments were targeted to reduce the disturbance of those species present (i.e. through adverse noise generated by pushing through vegetation, stumbling over logs or crunching leaf litter and ground debris). The spotlighting sessions lasted up to 120 minutes and was undertaken:

- When traversing between the call playback sites
- As a sole operation.

Species targeted during the spotlighting session included

- Eastern Pygmy Possum (*Cercartus nanus*)
- Barking Owl (*Ninox connivens*)
- Powerful Owl (*Ninox strenua*)
- Masked Owl (*Tyto novaehollandiae*)
- Eastern Cave-bat (*Vespadelus troughtoni*).

2.4.1.6 Remote sensing cameras

Two remote sensing cameras were deployed over the duration of the assessment. One camera was placed focussed on a tree mounted Type A Elliott trap to determine if Eastern Pygmy Possum were in the area. A second remote sensing camera was set up over the duration of the assessment in a location suitable to detect Eastern Pygmy Possum. In this area a lure (roast chicken) was used to detect the species (see NSW ECA recent publication on the species success for camera trapping recording using this bait). The onsite ecologist reviewed the camera data.

2.4.1.7 Traps

Trap management followed requirements in the NSW DPI Animal Research Authority: Animal Care and Ethics Committee of the Director General of NSW.

The layout of the traps has been shown in **Figure 3-1**.

Type A Elliot traps

Eleven Type A Elliott traps were deployed over four consecutive nights for the assessment. 11 were on tree mounted platforms targeting Eastern Pygmy Possum. Each trap was baited with a standard mixture of rolled oats, peanut butter and fish oil. The Eastern Pygmy Possum traps and baits were laced with honey and misted with a honey water mix to encourage resident animals to the trap sites.

14 Type A Elliot traps were deployed on the ground over five consecutive nights for the assessment. The terrestrial Type A Elliot traps were baited in the same fashion as the arboreal Type A Elliot traps outlined above.

2.4.1.8 Threatened flora

Transects followed requirements in *NSW Guide to Surveying Threatened Plants 2016*.

The transects walked has been shown in **Figure 2-2**.

3 Results

Scientific name	Common name	Habitat constraints	BC Act listing	EPBC Act listing	Survey timing	Survey effort
Cercartetus nanus	Eastern Pygmy-possum	• Patch size less than <5ha • Percentage of Native cover between 11 and 30% • Found in a broad range of habitats from rainforest through sclerophyll (including Box-Ironbark) forest and woodland to heath, but in most areas woodlands and heath appear to be preferred, except in north-eastern NSW where they are most frequently encountered in rainforest.	Vulnerable	Not Listed	November Day and Night	The surveyed followed the NSW publication *Threatened Biodiversity Survey and Assessment Guidelines for Development Activities (Draft) 2004.* The entire development footprint was surveyed on foot by an ecologist over five days and nights. Spotlighting over all nights and 25 Type A Elliot Traps were also used with no result (Trapping exceeded the minimum required survey effort by 31 trap nights **Table 1-1**). All trees in the development footprint were surveyed and no individuals were observed. This species was not detected.
Vespadelus troughtoni	Eastern Cave Bat	• Patch size 5-24ha • Percentage of Native cover between 11 and 30% • A cave-roosting species that is usually found in dry open forest and woodland, near cliffs or rocky overhangs; has been recorded roosting in disused mine workings, occasionally in colonies of up to	Vulnerable	Not Listed	November Day and Night	The surveyed followed the *Threatened Bat Survey Guide and Survey requirements bats, for species listed under the EPBC Act.* Two Echolocation detectors (SongMeters SM2+BAT and SM3+Bat, Wildlife Acoustics) were used for a combined total of nine entire nights from dawn until dusk (exceeding the minimum of two nights by seven whole nights). Bat calls were interpreted by a suitably qualified professional who identified the presence of *Vespadelus troughtoni* on

Scientific name	Common name	Habitat constraints	BC Act listing	EPBC Act listing	Survey timing	Survey effort
		500 individuals.				three separate trap nights.
Ninox connivens	Barking Owl (breeding)	• Patch size 25-100ha • Percentage of Native cover between 11 and 30% • Living or dead trees with hollows greater than 20 cm diameter and greater than 4 m above the ground (breeding) • Inhabits woodland and open forest, including fragmented remnants and partly cleared farmland. It is flexible in its habitat use, and hunting can extend in to closed forest and more open areas. Sometimes able to successfully breed along timbered watercourses in heavily cleared habitats (e.g. western NSW) due to the higher density of prey on these fertile riparian soils	Vulnerable	Not Listed	November Day and Night	The surveyed followed the *NSW publication Threatened Biodiversity Survey and Assessment Guidelines for Development Activities (Draft) 2004.* The entire development footprint was surveyed on foot by an ecologist over five days. Spotlighting over five nights and camera traps were also used with no result. All trees in the development footprint were surveyed for suitable breeding hollows and no individuals were observed. This species nor its breeding habitat was not detected.
Ninox strenua	Powerful Owl (Breeding)	• Patch size less than <5ha • Percentage of Native cover between 11 and 30% • Living or dead trees with hollow greater than 20cm diameter	Vulnerable	Not Listed	November Day and Night	The surveyed followed the *NSW publication Threatened Biodiversity Survey and Assessment Guidelines for Development Activities (Draft) 2004.* The entire development footprint was surveyed on foot by an ecologist over five days. Spotlighting over five nights and camera traps were also used with no

Scientific name	Common name	Habitat constraints	BC Act listing	EPBC Act listing	Survey timing	Survey effort
		• The Powerful Owl inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest. • The Powerful Owl requires large tracts of forest or woodland habitat but can occur in fragmented landscapes as well. The species breeds and hunts in open or closed sclerophyll forest or woodlands and occasionally hunts in open habitats. It roosts by day in dense vegetation comprising species such as Turpentine *Syncarpia glomulifera*, Black She-oak *Allocasuarina littoralis*, Blackwood *Acacia melanoxylon*, Rough-barked Apple *Angophora floribunda*, Cherry Ballart *Exocarpus cupressiformis* and a number of eucalypt species.				result. All trees in the development footprint were surveyed and no individuals were observed. This species nor its breeding habitat was not detected.
Tito novaehollandiae	Masked Owl (Breeding)	• Patch size less than <5ha • Percentage of Native	Vulnerable	Not Listed	November Day and Night	The surveyed followed the *NSW publication Threatened Biodiversity Survey and Assessment Guidelines for Development Activities (Draft) 2014.*

Scientific name	Common name	Habitat constraints	BC Act listing	EPBC Act listing	Survey timing	Survey effort
		cover between 11 and 30% • Living or dead trees with hollow greater than 20cm diameter • Lives in dry eucalypt forests and woodlands from sea level to 1100 m. • Roosts and breeds in moist eucalypt forested gullies, using large tree hollows or sometimes caves for nesting.				The entire development footprint was surveyed on foot by an ecologist over five days. Spotlighting over five nights and camera traps were also used with no result. All trees in the development footprint were surveyed and no individuals were observed. This species nor its breeding habitat was not detected.
Thesium australe	*Austral Toadflax*	• Occurs in grassland on coastal headlands or grassland and grassy woodland away from the coast. • Often found in association with Kangaroo Grass (Themeda australis). • A root parasite that takes water and some nutrient from other plants, especially Kangaroo Grass.	Vulnerable	Vulnerable	November	The entire development footprint was surveyed on foot by an ecologist over five days.
Acacia pycnostachya	*Bolivia Wattle*	• Acacia pycnostachya typically grows in dry sclerophyll forest amongst granite outcrops, on hillsides at altitudes of 700 to 900 m. Soil types range from acid volcanics to sandy	Vulnerable	Vulnerable	November	The entire development footprint was surveyed on foot by an ecologist over five days.

Scientific name	Common name	Habitat constraints	BC Act listing	EPBC Act listing	Survey timing	Survey effort
		and skeletal on exposed outcrops, to shallow sandy loams in less exposed sites. It often grows in stands in areas sheltered from fire.				

Key- Species identified in development site.

4 Eastern Cave Bat *(Vespadelus troughtoni)*

Two Echolocation detectors (SongMeters SM2+BAT and SM3+Bat, Wildlife Acoustics) were used for a combined total of nine entire nights from dawn until dusk (exceeding the minimum of two nights by seven complete nights).

Analysis of the data collected was conducted by bat expert Heidi Kolkert using Analook V4.1 bat call analysis software.

A review of the data produced 14 positively recorded species and an additional two species which may be present in the development site **(Appendix 1).** Bat call analysis identified the presence of Eastern Cave Bat *Vespadelus troughtoni* on three separate trap nights (Table 4-1).

Table 4-1 Eastern Cave Bat record nights

Scientific name	Common Name	11/4/2019	11/5/2019	11/6/2019	11/8/2019	11/4/2019	11/5/2019	11/6/2019	11/7/2019	11/8/2019
Bats species identified										
Vedpadelus troughtoni	Eastern cave bat	x		x	x					

Heidi Kolkert (PhD candidate) a bat subject matter expert analysed the calls and noted there were calls from the Eastern Cave Bat as well as a few other species of cave dependant species indicating likely roosting habitat is locally available. She noted there is good woodland and water locally available which is probably why on the last night in particular of recording there was a lot of bat activity showing up as feeding and socialising type calls.

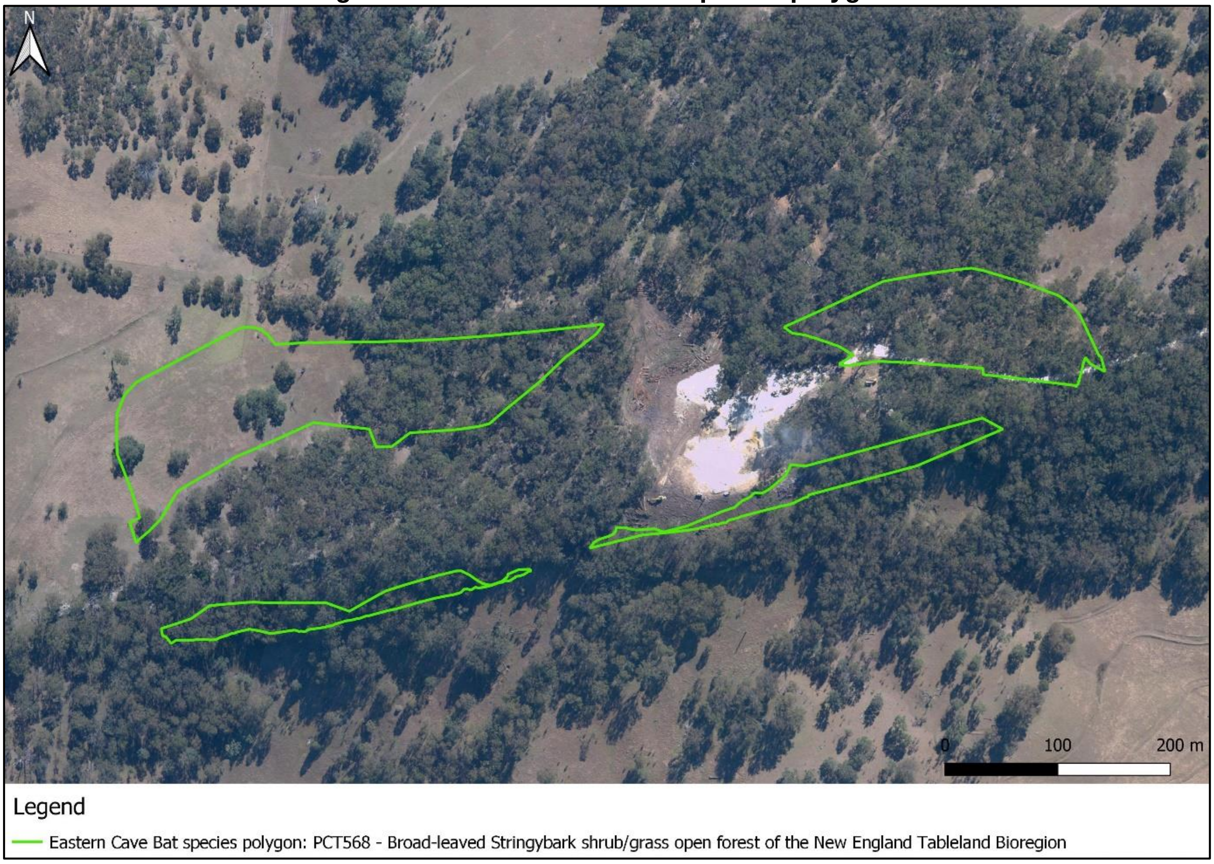
A study area based search by Eco Logical Australia April 2019 and AREA in November 2019 combined with desktop searches following 'Species credit' threatened bats and their habitats NSW survey guide for the Biodiversity Assessment Method 2018 did not identify any shafts, adits, rock formations, bridges or rock overhangs in or immediacy next to the development site.

As calls from the species was recorded on the study area but breeding habitat was not present guidance from Biodiversity and Conservation | Department of Planning, Industry and Environment - Planning, North East Branch was sought. As a result of this consultation the Eastern cave bat will be managed as a species credit species, where the species polygon is all plant community types affected by the proposal (Table 4-2. Figure 4-1).

Table 4-2 Eastern Cave Bat species polygon and offsetting obligation details

Credits Required	Area	Credits Required
Ecosystem Credits		
568 - Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion	4.63ha	134
Species Credits		
Eastern Cave Bat (*Vespadelus troughtoni*)	4.63ha	230
Source: Modified after ELA (2020) – Table 31 and Table 32		

Figure 4-1: Eastern Cave Bat Species polygon



5 Limitations of the survey effort

Not all animals and plants can be fully accounted for within any given development site. The presence of threatened species is not static. It changes over time, often in response to longer term natural forces which can, at any time, be dramatically influenced by man-made disturbance or weather. In order to overcome some of these limitations, database searches were conducted for threatened species, populations and ecological communities known to occur within the region. A 'precautionary approach' for species occurrence has been adopted where required.

This report is based upon data acquired from recent and current surveys; however, it should be recognised that data gathered is indicative of the environmental conditions of the site at the time the report was prepared.

6 Conclusion

The Biodiversity Development Assessment Report prepared by Eco Logical Australia identified five species credit species requiring further survey at the correct time of year (*"Eco Logical Australia. 2019 Dowe's Quarry BDAR. Prepared for R.W. Corkery & Co Pty Ltd on behalf of Darryl McCarthy Constructions Pty Ltd").*
These species are;

- Barking Owl (*Ninox connivens*)
- Powerful Owl (*Ninox strenua*)
- Masked Owl *(Tyto novaehollandiae*)

- Eastern Pygmy-possum *(Cercartetus nanus)*
- Eastern Cave-bat (*Vespadelus troughtoni*)

AREA followed the guidelines for survey set out in *Threatened Biodiversity Survey and Assessment Guidelines for Development Activities (Draft) 2004* to survey for these species credit species. Using the methods outlined in this document AREA did not detect the presence of the following species within the development site.

- Barking Owl (*Ninox connivens*)
- Powerful Owl (*Ninox strenua*)
- Masked Owl (*Tyto novaehollandiae*)
- Eastern Pygmy-possum (*Cercartetus nanus*)
- Little Eagle (*Hieraaetus morphnoides*)
- Square-tailed Kite (*Lophoictinia isura*)
- White-bellied Sea Eagle (*Haliaeetus leucogaster*)
- Grey-headed Flying Fox (*Pteropus poliocephalus*)
- Austral Toadflax (*Thesium australe*)
- Bolivia Wattle (*Acacia pycnostachya*).

The Biodiversity Assessment Method Calculator can be updated to reflect the findings of the study to reflect that **the above species credit species are not present in** the development site**.**

Following the guidelines for survey set out in *Threatened Biodiversity Survey and Assessment Guidelines for Development Activities (Draft) 2004* using two Echolocation detectors (SongMeters SM2+BAT and SM3+Bat, Wildlife Acoustics) recorded the presence of the Eastern Cave-bat (*Vespadelus troughtoni*).

The Biodiversity Assessment Method Calculator can be updated to reflect the findings of the study to reflect that **the above species credit species is present** in the development site, but breeding habitat is not present**.**

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8 Appendix 1-Insectivorous Bat Data

Table 1: Insectivorous bats recorded in the study area via echolocation

			Machine 1				Machine 2				
	Scientific name	Common Name	11/4/2019	11/5/2019	11/6/2019	11/8/2019	11/4/2019	11/5/2019	11/6/2019	11/7/2019	11/8/2019
No.	Bats species identified										
1	*Austronomus australis*	White-striped freetail bat	x	x	x	x	x	x	x	x	x
2	*Chalinolobus gouldii*	Gould's wattled bat	x	x	x	x	x	x	x	x	x
3	*Chalinolobus morio*	Chocolate wattled bat	x	x	x	x	x	x	x	x	x
4	*Falsistrellus tasmaniensis #*	Eastern falsistrelle	x		x	x		x		x	x
5	*Miniopterus schreibersii oceanensis #*	Eastern bentwing bat	x		x		x	x	x	x	x
6	*Mormopterus ridei*	Ride's free-tailed bat		x	x		x		x	x	x
7	*Scotorepens balstoni*	Inland broad-nosed bat					x	x			x
8	*Scotorepens orion*	Eastern broad-nosed bat	x	x	x	x	x	x	x	x	x
9	*Scoteanax rueppellii #*	Large broad-nosed bat			x	x	x	x		x	x
10	*Vespadelus darlingtoni*	Large forest bat	x	x	x	x	x		x	x	x
11	*Vespadelus regulus*	Southern forest bat	x	x	x			x	x	x	x
12	*Vespadelus troughtoni #*	Eastern cave bat	x		x	x					
13	*Vespadelus vulturnus*	Little forest bat	x		x		x	x	x	x	x
	Unidentified bat species										
	V. troughtoni or V. pumilus								x	x	x
	S. orion or S. rueppellii # or F. tasmaniensis #		x				x		x		
	V. darlingtoni or M. s. oceanensis			x			x	x	x		
14	*Nyctophilus gouldi or geoffroyi*		x		x		x				x
	Myotis macropus #	Large-footed myotis					1P		1P		1P
	Total files		158	23	188	364	153	93	459	717	1392

x Species identified in the study
P Potential record of species and number of passes.
species listed under the Biodiversity Conservation Act 2016
* species listed under the Environmental Protection and Biodiversity Act

Appendix 6

Biodiversity Development Assessment Report

prepared by
Eco Logical Australia Pty Ltd

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Dowe's Quarry
Biodiversity Development Assessment Report

Prepared for R.W. Corkery & Co Pty Ltd on behalf of Darryl McCarthy Constructions Pty Ltd

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DOCUMENT TRACKING

Project Name	Dowe's Quarry Biodiversity Assessment
Project Number	19BRI12960
Project Manager	Steven Jarman
Prepared by	Kirsten Velthuis
Reviewed by	Steve Jarman, Robert Cawley
Approved by	Robert Cawley
Status	**Final**
Version Number	**V2**
Last saved on	**18 March 2020**

This report should be cited as 'Eco Logical Australia. 2019 Dowe's Quarry BDAR Version 2. Prepared for R.W. Corkery & Co Pty Ltd on behalf of Darryl McCarthy Constructions Pty Ltd.'

Template 2.8.1

Executive Summary

Eco Logical Australia (ELA) were engaged by R.W. Corkery & Co Pty Ltd on behalf of Darryl McCarthy Constructions Pty Ltd to prepare a Biodiversity Development Assessment Report (BDAR) for the proposed expansion of the existing Dowe's Quarry, located at 811 Mount Lindesay Highway, Tenterfield.

The proposal is designated local development under Part 4 of the *Environmental Planning and Assessment Act* 1979 (EP&A Act) and an Environmental Impact Statement (EIS) is required to be submitted as part of the Development Application to Tenterfield Shire Council. This BDAR addresses the Secretary's Environmental Assessment Requirements (SEARs) Application Number EAR 1341 issued for the development. As part of the SEARs, Tenterfield Shire Council identified that the proposed development triggers the Biodiversity Offset Scheme (BOS) under the *Biodiversity Conservation Act 2016* (BC Act) and that a BDAR is required. This report has been prepared to meet the requirements of the Biodiversity Assessment Method (BAM) established under Section 6.7 of the *Biodiversity Conservation Act* 2016 (BC Act). This report has also been prepared to meet requirements for biodiversity and impact assessment pursuant to Sections 7.2 and 7.7 of the BC Act.

The development site was surveyed on two occasions. Firstly, by ELA's accredited BAM assessors Steve Jarman and Liz Brown during April 2019, and secondly during November 2019. The latter survey was conducted by Area Environmental Consultants and Communication Pty Ltd, and was led by Philip Cameron (also an accredited BAM assessor).

The development site was found to contain one Plant Community Type (PCT), *Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion*. This consisted of 4.63 ha in good condition and 1.78 ha in poor condition as it consisted largely of grassland with a high percentage of non-native grasses.

No threatened ecological communities were recorded within the development site. However, one species credit species was identified during the November survey – the Eastern Cave-bat (*Vespadelus troughtoni*). This species is listed as *vulnerable* under the BC Act.

This BDAR outlines the measures taken to avoid, minimise and mitigate impacts on the vegetation and species habitat present within the development footprint and measures to minimise impacts during construction and operation of the development. The Biodiversity Assessment Method Credit Calculator (BAMC) was then used to calculate the credits required to offset all residual impacts of the development.

A total of 134 ecosystem credits and 230 species credits are required to offset the residual impacts of the proposed project (Table 1 and Table 2).

Table 1 Ecosystem credit requirement of the project

PCT ID	PCT Name	Condition	BC Act	EPBC Act	Vegetation Integrity Score	Direct impact (ha)	Credits required
568	*Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion*	Good	Not listed	Not listed	66.4	4.63	134
568	*Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion*	Poor	Not listed	Not listed	3 (below offset threshold)	1.78	0
Total ecosystem credits to be offset							**134**

Table 2 Species credit requirement of the project

Species	Common Name	Direct impact habitat (ha)	Relevant Veg Zone	Credits required
Vespadelus troughtoni	Eastern Cave Bat	4.63	Zone 2 (good)	230

Serious and Irreversible Impacts (SAII) values have been considered in this assessment. The Eastern Cave-bat is a candidate entity for SAII for impacts to breeding habitat, however, no breeding habitat for this species was identified within the development site (potential breeding habitat includes PCTs associated with the species within 100m of rocky areas, caves, overhangs crevices, cliffs and escarpments, or old mines or tunnels, old buildings and sheds within the potential habitat).

A significance assessment under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) for Matters of National Environmental Significance (MNES) considered to have the potential to occur within the site, found that the proposal is unlikely to have a significant impact on EPBC Act listed threatened and migratory species.

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Abbreviations

Abbreviation	Description
BAM	Biodiversity Assessment Method
BAMC	Biodiversity Assessment Method Credit Calculator
BC Act	NSW Biodiversity Conservation Act 2016
BDAR	Biodiversity Development Assessment Report
BSSAR	Biodiversity Stewardship Site Assessment Report
CEEC	Critically Endangered Ecological Community
DoEE	Commonwealth Department of Environment and Energy
DPE	NSW Department of Planning and Environment
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
ELA	Eco Logical Australia Pty Ltd
EP&A Act	NSW Environmental Planning and Assessment Act 1979
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
IBRA	Interim Biogeographic Regionalisation for Australia
LGA	Local Government Area
NSW	New South Wales
OEH	NSW Office of Environment and Heritage
PCT	Plant Community Type
SAII	Serious and Irreversible Impacts
SEPP	State Environmental Planning Policy
SEARs	Secretary's Environmental Approval Requirements
TEC	Threatened Ecological Community

Definitions

Terminology	Definition
Biodiversity credit report	The report produced by the Credit Calculator that sets out the number and class of biodiversity credits required to offset the remaining adverse impacts on biodiversity values at a development site, or on land to be biodiversity certified, or that sets out the number and class of biodiversity credits that are created at a biodiversity stewardship site.
BioNet Atlas	The BioNet Atlas (formerly known as the NSW Wildlife Atlas) is the database of flora and fauna records. The Atlas contains records of plants, mammals, birds, reptiles, amphibians, some fungi, some invertebrates (such as insects and snails) and some fish.
Broad condition state	Areas of the same PCT that are in relatively homogenous condition. Broad condition is used for stratifying areas of the same PCT into a vegetation zone for the purpose of determining the vegetation integrity score.
Connectivity	The measure of the degree to which an area(s) of native vegetation is linked with other areas of vegetation.
Credit Calculator	The computer program that provides decision support to assessors and proponents by applying the BAM, and which calculates the number and class of biodiversity credits required to offset the impacts of a development or created at a biodiversity stewardship site.
Development	Has the same meaning as development at section 4 of the EP&A Act, or an activity in Part 5 of the EP&A Act. It also includes development as defined in section 115T of the EP&A Act.
Development footprint	The area of land that is directly impacted on by a proposed development, including access roads, and areas used to store construction materials.
Development site	An area of land that is subject to a proposed development that is under the EP&A Act.
Ecosystem credits	A measurement of the value of EECs, CEECs and threatened species habitat for species that can be reliably predicted to occur with a PCT. Ecosystem credits measure the loss in biodiversity values at a development site and the gain in biodiversity values at a biodiversity stewardship site.
High threat exotic plant cover	Plant cover composed of vascular plants not native to Australia that if not controlled will invade and outcompete native plant species.
Hollow bearing tree	A living or dead tree that has at least one hollow. A tree is considered to contain a hollow if: (a) the entrance can be seen; (b) the minimum entrance width is at least 5 cm; (c) the hollow appears to have depth (i.e. you cannot see solid wood beyond the entrance); (d) the hollow is at least 1 m above the ground. Trees must be examined from all angles.
Important wetland	A wetland that is listed in the Directory of Important Wetlands of Australia (DIWA) and SEPP 14 Coastal Wetlands.
Linear shaped development	Development that is generally narrow in width and extends across the landscape for a distance greater than 3.5 kilometres in length.
Local population	The population that occurs in the study area. In cases where multiple populations occur in the study area or a population occupies part of the study area, impacts on each subpopulation must be assessed separately.
Local wetland	Any wetland that is not identified as an important wetland (refer to definition of Important wetland).
Mitchell landscape	Landscapes with relatively homogeneous geomorphology, soils and broad vegetation types, mapped at a scale of 1:250,000.

Terminology	Definition
Multiple fragmentation impact development	Developments such as wind farms and coal seam gas extraction that require multiple extraction points (wells) or turbines and a network of associated development including roads, tracks, gathering systems/flow lines, transmission lines.
Operational Manual	The Operational Manual published from time to time by OEH, which is a guide to assist assessors when using the BAM
Patch size	An area of intact native vegetation that: a) occurs on the development site or biodiversity stewardship site, and b) includes native vegetation that has a gap of less than 100 m from the next area of native vegetation (or ≤30 m for non-woody ecosystems). Patch size may extend onto adjoining land that is not part of the development site or stewardship site.
Proponent	A person who intends to apply for consent to carry out development or for approval for an activity.
Reference sites	The relatively unmodified sites that are assessed to obtain local benchmark information when benchmarks in the Vegetation Benchmarks Database are too broad or otherwise incorrect for the PCT and/or local situation. Benchmarks can also be obtained from published sources.
Regeneration	The proportion of over-storey species characteristic of the PCT that are naturally regenerating and have a diameter at breast height <5 cm within a vegetation zone.
Remaining impact	An impact on biodiversity values after all reasonable measures have been taken to avoid and minimise the impacts of development. Under the BAM, an offset requirement is calculated for the remaining impacts on biodiversity values.
Retirement of credits	The purchase and retirement of biodiversity credits from an already-established biobank site or a biodiversity stewardship site secured by a biodiversity stewardship agreement.
Riparian buffer	Riparian buffers applied to water bodies in accordance with the BAM.
Sensitive biodiversity values land map	Development within an area identified on the map requires assessment using the BAM.
Site attributes	The matters assessed to determine vegetation integrity. They include: native plant species richness, native over-storey cover, native mid-storey cover, native ground cover (grasses), native ground cover (shrubs), native ground cover (other), exotic plant cover (as a percentage of total ground and mid-storey cover), number of trees with hollows, proportion of over-storey species occurring as regeneration, and total length of fallen logs.
Site-based development	a development other than a linear shaped development, or a multiple fragmentation impact development
Species credits	The class of biodiversity credits created or required for the impact on threatened species that cannot be reliably predicted to use an area of land based on habitat surrogates. Species that require species credits are listed in the Threatened Biodiversity Data Collection.
Subject land	Is land to which the BAM is applied in Stage 1 to assess the biodiversity values of the land. It includes land that may be a development site, clearing site, proposed for biodiversity certification or land that is proposed for a biodiversity stewardship agreement.
Threatened Biodiversity Data Collection	Part of the BioNet database, published by OEH and accessible from the BioNet website.
Threatened species	Critically Endangered, Endangered or Vulnerable threatened species as defined by Schedule 1 of the BC Act, or any additional threatened species listed under Part 13 of the EPBC Act as Critically Endangered, Endangered or Vulnerable.

Terminology	Definition
Vegetation Benchmarks Database	A database of benchmarks for vegetation classes and some PCTs. The Vegetation Benchmarks Database is published by OEH and is part of the BioNet Vegetation Classification.
Vegetation zone	A relatively homogenous area of native vegetation on a development site, land to be biodiversity certified or a biodiversity stewardship site that is the same PCT and broad condition state.
Wetland	An area of land that is wet by surface water or ground water, or both, for long enough periods that the plants and animals in it are adapted to, and depend on, moist conditions for at least part of their life cycle. Wetlands may exhibit wet and dry phases and may be wet permanently, cyclically or intermittently with fresh, brackish or saline water.
Woody native vegetation	Native vegetation that contains an over-storey and/or mid-storey that predominantly consists of trees and/or shrubs.

1. Stage 1: Biodiversity assessment

1.1 Introduction

Darryl McCarthy Constructions Pty Ltd (DMC) is the manager and operator of Dowe's Quarry near Tenterfield, NSW. DMC is seeking approval under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) for the expansion of the existing Dowe's Quarry, to extract and process up to 230,000 tonnes of quartzose material per year, until 2045.

The proposal is designated local development under Part 4 of the EP&A Act and an EIS is required to be submitted as part of the Development Application to Tenterfield Shire Council. SEARs were issued for the project on 28 May 2019 by the Secretary of the NSW Department of Planning and Environment (DPE) for Application Number EAR 1341.

The SEARs require the following biodiversity items to be included in the EIS:

- *accurate predictions of any vegetation clearing on site, including the location and amount of clearing and types of communities and species affected.*
- *a detailed assessment of the potential biodiversity impacts of the development, paying particular attention to threatened species, populations and ecological communities and groundwater dependent ecosystems undertaken in accordance with Sections 7.2 and 7.7 of the BC Act, and having regard to advice from the Office of Environment and Heritage (OEH).*
- *a detailed description of the proposed measures to maintain or improve the biodiversity values of the site in the medium to long term, as relevant.*

As part of the SEARs, OEH advised that:

- *The EIS must assess the impacts of the proposed development on biodiversity values to determine if the proposed development is "likely to significantly affect threatened species" for the purposes of Section 7.2 of the BC Act.*
- *More specifically, as part of the SEARs, Tenterfield Shire Council identified that the proposed development triggers the BOS under the BC Act that a BDAR under the BC Act is required.*

This BDAR addresses the above requirements from OEH, Tenterfield Shire Council, and the SEARs. The BDAR structure follows the report sections and minimum information requirements for a BDAR provided in the BAM. The BDAR has been undertaken by Liz Brown, Steve Jarman and Kirsten Velthuis; who are all Accredited Persons under the BC Act.

This BDAR has also relied on supplementary survey undertaken and reported on by AREA Environmental Consultants and Communication Pty Ltd (Appendix A). This supplementary study was led by Philip Cameron, who is also an accredited assessor under the BC Act. Where the results of the AREA study have been relied upon, reference to the source is provided. Eco Logical Australia is not responsible for, and does not guarantee, the accuracy of information contained within the Area Environmental report (Appendix A); however, it is assumed that this information is true and accurate for the purposes of this BDAR as the survey was led by an accredited assessor.

1.1.1 General description of the development site

The proposed development is situated within the Tenterfield Shire Council area and is located 8 km north east of Tenterfield at 811 Mount Lindesay Highway, Tenterfield. The Quarry Site is located on rural land within:

- Lots 3 and 4 DP 42044;
- Lots 308 and 309 DP 751540; and
- Lots 239 and 260 DP 751540.

Under the Proposal the Quarry Site would extend into Lots 1, 2 and 3 DP1092215. The following lots will also be added to enable access to the site:

- 4 DP1092215
- 245 DP751540
- 246 DP751549

The boundary of the Quarry Site has been determined principally to define an area in which all activities are proposed, recognising that not all land within the Quarry Site would be disturbed. The Quarry Site would comprise approximately 26.8ha of land owned by Mr Rod Dowe and leased by the Applicant. The northern boundary of the Quarry Site coincides with a Crown Road that traverses Lot 308 DP 751540.

The site currently contains:

- An extraction area, including constructed dams and associated collection drains.
- An internal access and haulage road.

Due to the large area of land associated with the lots listed above, the development site relevant to this BDAR has been rationalised to include the overall potential area of direct disturbance by the project. This includes development areas that may be either temporary (for construction) or permanent (for operational infrastructure). The proposed development site assessed includes the location of operational infrastructure and construction work sites proposed for:

- Access and haulage routes.
- Construction laydown areas.

This report includes two base maps, the Site Map (Figure 1) and the Location Map (Figure 2). Each of these show the development site boundary relevant to this BDAR.

Figure 1 shows that some of the proposed development footprint includes "previously approved disturbance" areas. This includes areas proposed to be developed under Development Consent 2014.078 (DA 2014.078, granted in March 2015) as well as the modification to DA 2014.078, which was approved in January 2016. These areas have been excluded from assessment within this BDAR due to the existing approval.

The areas within the proposed development footprint that are "proposed disturbance" (see Figure 1) are the areas which are not part of the aforementioned approvals and therefore are assessed within this BDAR.

The development proposes the following elements:

- An area for overburden and fines emplacement
- A realigned access road
- An overburden and fines stockpile area
- A processing area
- A bund around the processing area.

Each of these project elements is shown within Chapter 2 (Figure 2.1) of the EIS.

1.1.2 Data Sources used

The following data sources were reviewed as part of this report:

- BioNet Vegetation Classification
- BioNet Atlas 5 km database search
- Threatened Biodiversity Data Collection
- Directory of Important Wetlands Australia
- EPBC Act Protected Matters Search Tool (5 km radius linear search)
- National Flying-fox Monitoring Viewer
- Dowe's Quarry Ecological Assessment (Eco Logical Australia, 2014)
- *Ecological Assessment Additional Information – Dowe's Quarry (DA2014/078)* (Eco Logical Australia 2014)
- *Dowe's Quarry Targeted Species Search, Tenterfield LGA, February 2020* (AREA Environmental Consultants and Communication Pty Ltd, Version 3.3 dated 3/02/2020 (Appendix A).

A full refence list is included in Section 3.

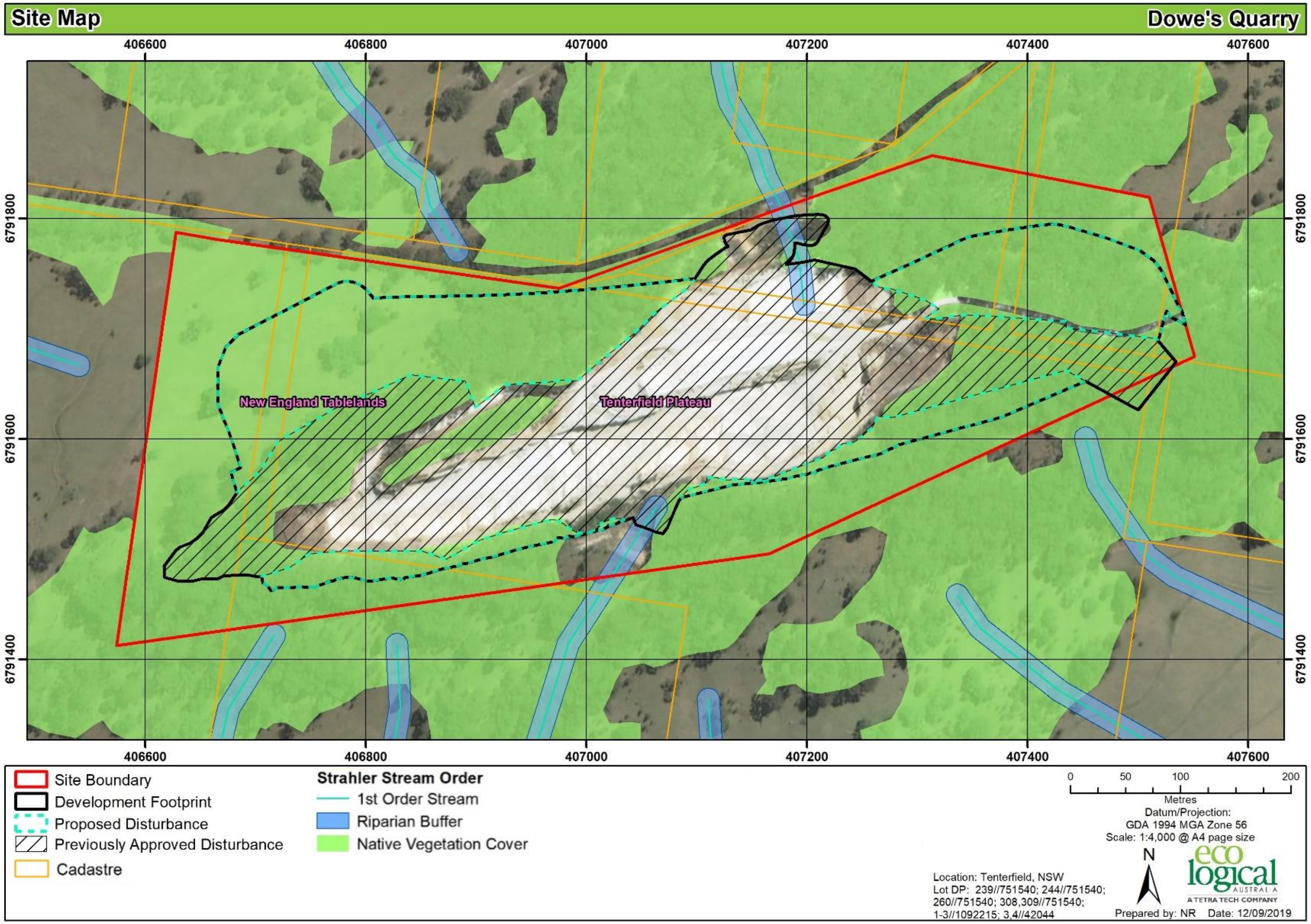

Figure 1: Site Map

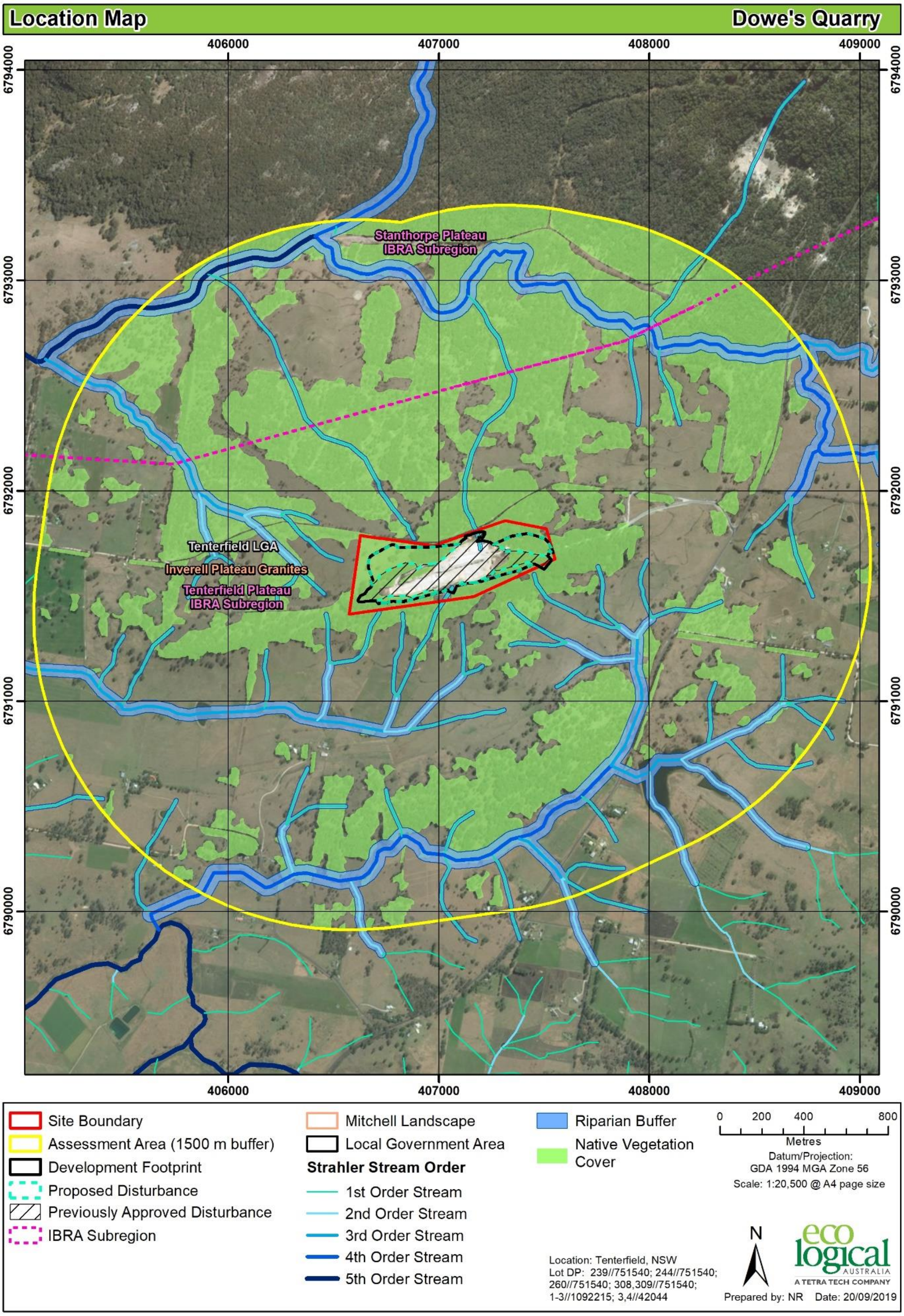

Figure 2: Location Map

1.2 Legislative context

Table 3: Legislative context

Name	Relevance to the project	Report Section
Commonwealth		
Environment Protection and Biodiversity Conservation Act 1999	This report assesses impacts to MNES and concludes that the development is unlikely to have significant impacts on threatened species.	2.5
NSW		
Environmental Planning and Assessment Act 1979	The proposed development requires consent under Part 4 of the EP&A Act.	N/A
Biodiversity Conservation Act 2016	The proposed development exceeds the BAM threshold and requires submission of a Biodiversity Development Assessment Report.	BDAR
Planning Instruments		
SEPP 44 – Koala Habitat Protection	SEPP 44 applies to the local government area in which the development is proposed. An assessment of Koala habitat has been made in accordance with the SEPP.	2.5
Tenterfield Shire Council Local Environment Plan	The subject site is zoned RU1 under the Tenterfield LEP and requires development consent.	N/A

1.3 Landscape features

1.3.1 IBRA regions and subregions

The development site falls within the IBRA region and subregions as outlined in Table 4 and Table 5. IBRA subregions are shown on Figure 2.

Table 4: IBRA regions

IBRA region	Area within development site (ha)
New England Tablelands	6.53

Table 5: IBRA subregions

IBRA subregion	Area within development site (ha)
Tenterfield Plateau	6.53

1.3.2 Native vegetation extent

The extent of native vegetation within the development site and buffer is outlined in Table 6.

Table 6: Native vegetation extent

Area within the development site (ha)	Area within the 1,500 m buffer area (ha)
6.41	473

There are differences between the mapped vegetation extent and the aerial imagery. As mentioned above, part of the site contains an area which has previously been approved for disturbance; and some of the vegetation shown in the aerial has since been cleared or disturbed, as part of the previous approval for disturbance.

1.3.3 Rivers and streams

There are two unnamed 1st order streams (with a 10m riparian buffer) within the development site boundary but there are no rivers or streams within the development footprint. The two unnamed streams are ephemeral drainage lines and are not well formed (barely visible).

1.3.4 Wetlands

There are no mapped important wetlands within the development site. There are two dams within the development site boundary, but none within the development footprint.

1.3.5 Connectivity features

Vegetation at and immediately adjacent to the development site is connected to a large area of contiguous vegetation to the north (approximately 1.5 km away) which includes Bald Rock National Park (approximately 3km to the north of the site), and further afield, Girraween, Boonoo and Basket Swamp National Parks. However, there is limited vegetation further southwards; eastwards and westward of the development site which limits ongoing connectivity.

1.3.6 Areas of geological significance and soil hazard features

The development site does not contain areas of geological significance and soil hazard features.

1.4 Native vegetation

1.4.1 Survey effort

Vegetation survey was undertaken within the development site by Liz Brown and Steve Jarman between 22 to 26 April 2019 to identify PCTs, collect vegetation integrity data and note potential threatened species habitat. A total of four vegetation integrity plots were undertaken on the in accordance with the BAM (Table 7) to assess the composition, condition and integrity of PCTs.

Note that one vegetation integrity plot was undertaken just outside the northern boundary of the site, however vegetation within the plot was considered to be representative of the nearest vegetation just inside the boundary of the site.

All field data collected at full-floristic and vegetation integrity plots is included in Appendix B.

1.4.2 Plant Community Types present

A total of one PCT was identified on the development site (Table 7, Figure 3). This was stratified into two vegetation zones as per Table 7 and Figure 4

Justification for the selection of this PCT occurring on the development site is based on a quantitative analysis of full-floristic plot data. Key reasons for selection of PCT 568 include the following:

- A significant area of PCT 524 is mapped as part of existing VIS mapping in the wider area and on the site. However, the plot data shows the vegetation is not 'shrubby', therefore PCT 568 is considered more suitable. PCT 568 is also mapped in the area.
- Onsite observations confirmed the vegetation class was New England Dry Sclerophyll Forests, and this aligned with Keith's vegetation class mapping downloaded from <<https://data.nsw.gov.au>>
- PCT 568 occurs on granitic slopes and ridges, consistent with site observations.
- *Eucalyptus caliginosa* was present in the upper stratum, forming approximately 15 to 25% cover within each plot.
- The following species within PCT 568's VIS scientific description were also observed within the plots: *Angophera subvelutina, Lissanthe strigosa, Olearia visidula, Lomandra longifolia, Dianella revoluta,* and *Microlaena stipoides*.

Table 7: Plant Community Types

PCT ID	PCT Name	Vegetation Class / Formation	Area	Vegetation Zone	Plots surveyed	Percent cleared
568	*Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion*	New England Dry Sclerophyll Forests / Dry Sclerophyll Forest (Shrub/grass sub-formation)	1.78	Poor	1	0.59
568	*Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion*	New England Dry Sclerophyll Forests / Dry Sclerophyll Forest (Shrub/grass sub-formation)	4.63	Good	3	0.59

1.4.3 Vegetation integrity assessment

A vegetation integrity assessment using the Credit Calculator (BAMC) was undertaken and the results are outlined in Table 8. The two vegetation zones are shown in Figure 4.

Vegetation Zone 1 was in a poor condition due to prior vegetation clearing. It was dominated by the exotic high threat weed *Eragrostis curvula* (African Love Grass).

Vegetation Zone 2 was open in forest in good condition. It generally consisted of a mature canopy of *Eucalyptus caliginosa*, *Eucalyptus biturbinata* and *Eucalyptus moluccana,* and had a grassy understory. The average canopy height was 25m.

Photos of both vegetation zones are provided in Appendix B.

Table 8: Vegetation integrity

Veg Zone	PCT ID	Condition	Area (ha)	Composition Condition Score	Structure Condition Score	Function Condition Score	Current vegetation integrity score
1	568	Poor	1.78	27.1	0	30.1	3
2	568	Good	4.63	60.5	49.6	97.3	66.4

1.4.4 Threatened Ecological Community

The development site does not contain any listed TECs under the BC Act and EPBC Act.

1.4.5 Groundwater Dependent Ecosystems

Site survey confirmed that the development site does not contain groundwater dependent ecosystems.

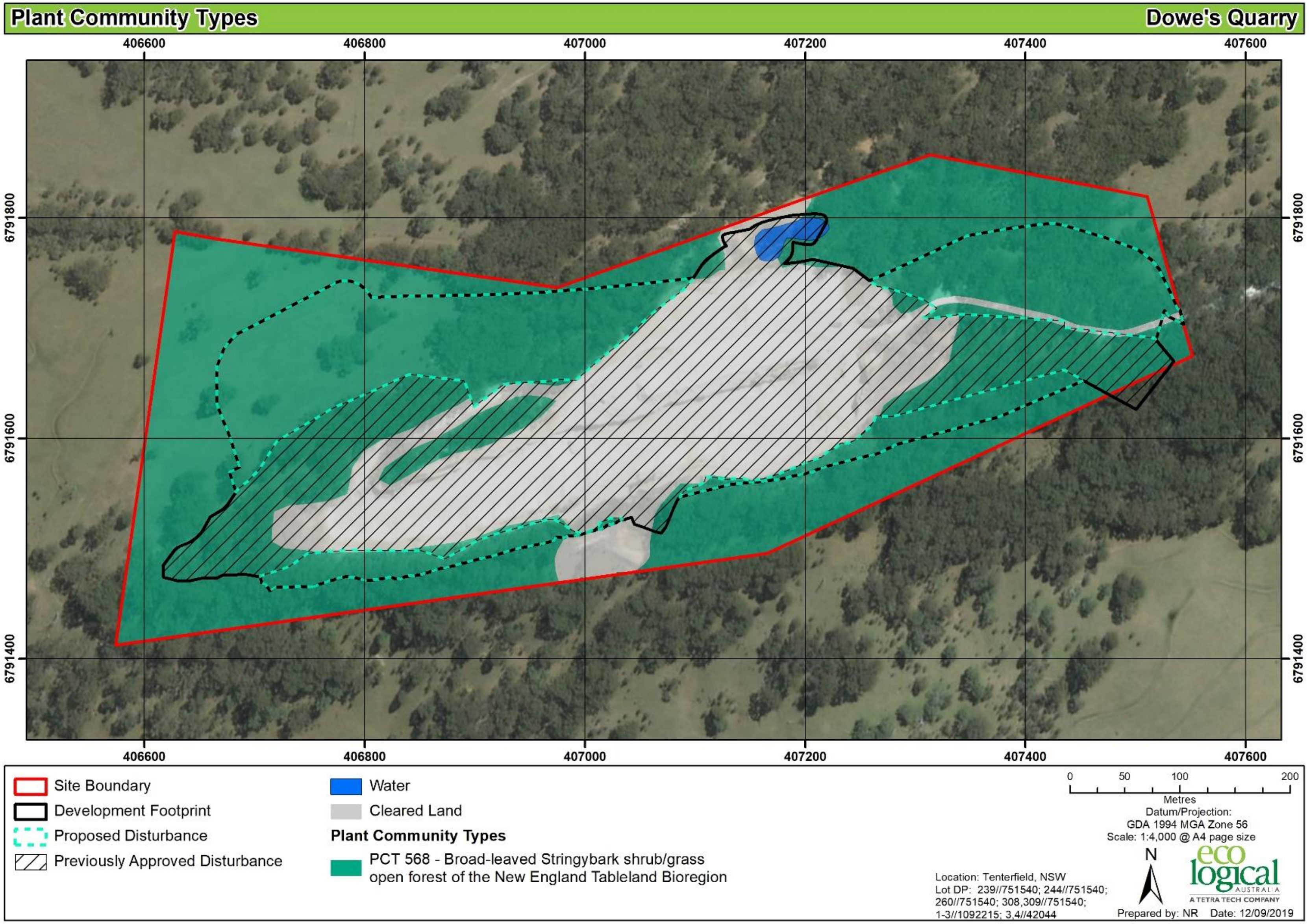

Figure 3: Plant Community Types

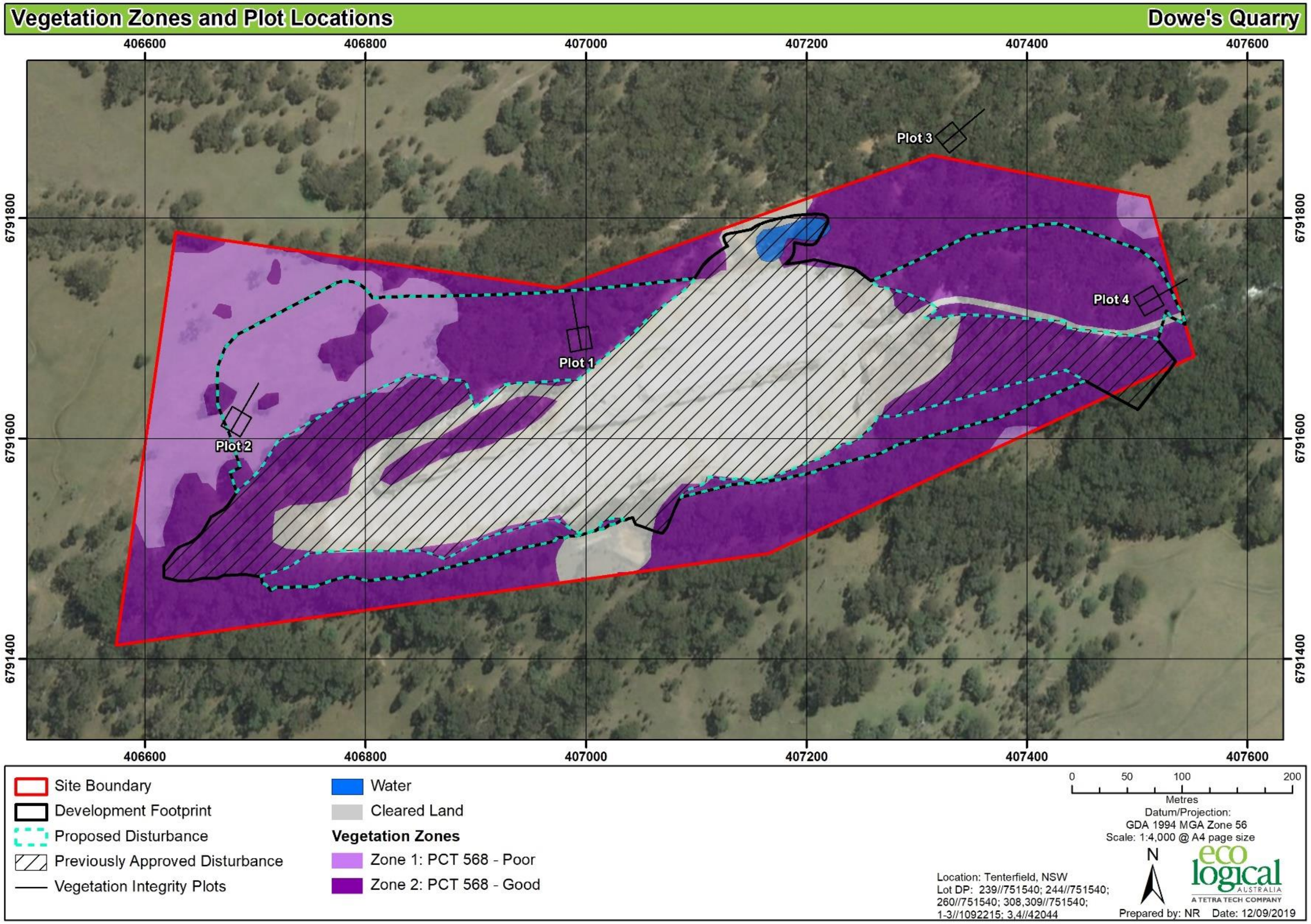

Figure 4: Vegetation zones and plot locations

1.5 Threatened species

1.5.1 Ecosystem credit species

Ecosystem credit species predicted to occur at the development site, their associated habitat constraints, geographic limitations and sensitivity to gain class is included in Table 9.

Table 9: Predicted ecosystem credit species

Species	Common Name	Habitat Constraints	Geographic limitations	Sensitivity to gain class	NSW listing status	EPBC Listing status	Included or excluded in assessment
Artamus cyanopterus cyanopterus	Dusky Woodswallow	Nil	Nil	Moderate	Vulnerable	Not Listed	Included
Calypthorychus lathami	Glossy Black Cockatoo (Foraging)	Presence of *Allocasuarina* and *Casuarina* species	Nil	High	Vulnerable	Not Listed	Included
Chalinolobus nigrogriseus	Hoary Wattled Bat	Nil	Nil	Moderate	Vulnerable	Not Listed	Included
Chthonicola sagittate	Speckled Warbler	Nil	Nil	High	Vulnerable	Not Listed	Included
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies	Nil	Nil	High	Vulnerable	Not Listed	Included
Daphoenositta chrysoptera	Varied Sitella	Nil	Nil	Moderate	Vulnerable	Not Listed	Included
Dasyurus maculatus	Spotted-tailed Quoll	Nil	Nil	High	Vulnerable	Endangered	Included
Falsistrellus tasmaniensis	Eastern False Pipistrelle	Nil	Nil	Moderate	Vulnerable	Not Listed	Included
Grantiella picta	Painted Honeyeater	Mistletoes present at >5/ha	Nil	Moderate	Vulnerable	Vulnerable	Included
Haliaeetus leucogaster	White-bellied Sea Eagle	Nil	Nil	High	Vulnerable	Not Listed	Included
Hieraaetus morphnoides	Little Eagle (Foraging)	Nil	Nil	Moderate	Vulnerable	Not Listed	Included
Lathamus discolour	Swift Parrot (Foraging)	Nil	Nil	Moderate	Endangered	Critically Endangered	Included
Lophoictinia isura	Square-tailed Kite (Foraging)	Nil	Nil	Moderate	Vulnerable	Not Listed	Included
Melanodryas cucullata cucullata	Hooded Robin (South-eastern form)	Nil	Nil	Moderate	Vulnerable	Not Listed	Included

Species	Common Name	Habitat Constraints	Geographic limitations	Sensitivity to gain class	NSW listing status	EPBC Listing status	Included or excluded in assessment
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat (Foraging)	Nil	Nil	High	Vulnerable	Not Listed	Included
Ninox connivens	Barking Owl	Nil	Nil	Moderate	Vulnerable	Not Listed	Included
Ninox strenua	Powerful Owl	Nil	Nil	High	Vulnerable	Not Listed	Included
Petaurus australis	Yellow-bellied Glider	Hollow bearing trees with hollows >25m	Nil	Moderate	Vulnerable	Not Listed	Included
Petroica boodang	Scarlet Robin	Nil	Nil	Moderate	Vulnerable	Not Listed	Included
Petroica phoenicea	Flame Robin	Nil	Nil	Moderate	Vulnerable	Not Listed	Included
Phascolarctos cinereus	Koala (Foraging)	Nil	Nil	High	Vulnerable	Vulnerable	Included
Pteropus poliocephalus	Grey-headed Flying-fox (foraging)	Nil	Nil	High	Vulnerable	Vulnerable	Included
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	Nil	Nil	Moderate	Vulnerable	Not Listed	Included
Scoteanax reuppellii	Greater Broad-nosed Bat	Nil	Nil	Moderate	Vulnerable	Not Listed	Included
Stagonopleura guttata	Diamond Firetail	Nil	Nil	Moderate	Vulnerable	Not Listed	Included
Tyto novaehollandiae	Masked Owl (Foraging)	Nil	Nil	High	Vulnerable	Not Listed	Included

1.6 Species credit species

Species credit species predicted to occur at the development site (i.e. candidate species), their associated habitat constraints, geographic limitations and sensitivity to gain class is included in Table 10.

Table 10: Candidate species credit species

Species	Common Name	Habitat Constraints	Geographic limitations	Sensitivity to gain class	NSW listing status	EPBC Listing status	Included or excluded
Acacia macnuttiana	MacNutt's Wattle	Nil	Nil	High	Vulnerable	Vulnerable	Included
Acacia pycnostachya	Bolivia Wattle	Rocky area, granite or acid volcanic outcrops	None	High	Vulnerable	Vulnerable	Included
Arthraxon hispidus	Hairy Jointgrass	Nil	None	High	Vulnerable	Vulnerable	Included
Calyptorhynchus lathami	Glossy Black-Cockatoo (Breeding)	Trees with hollows >15cm diameter and at >5m height above ground	Nil	High	Vulnerable	Not Listed	Included
Cercatetus nanus	Eastern Pygmy-possum	Nil	Nil	High	Endangered	Not Listed	Included
Eucalyptus nicholii	Narrow-leaved Black Peppermint	Nil	None	High	Vulnerable	Vulnerable	Included
Haliaeetus leucogaster	White-bellied Sea Eagle	Nil	None	High	Vulnerable	Not listed	Included
Hieraaetus morphnoides	Little Eagle (Breeding)	Nest trees - live (occasionally dead) large old trees within suitable vegetation and the presence of a male and female; or female with nesting material; or an individual on a large stick nest in the top half of the tree canopy.	Nil	Moderate	Vulnerable	Not Listed	Included

Species	Common Name	Habitat Constraints	Geographic limitations	Sensitivity to gain class	NSW listing status	EPBC Listing status	Included or excluded
Lathamus discolour	Swift Parrot (Breeding)	As per Mapped Areas provided by DoPE	Nil	Moderate	Endangered	Critically Endangered	Excluded No mapped areas present
Litoria subglandulosa	Glandular Frog	Nil	East of New England Highway	Very High	Vulnerable	Not Listed	Included
Lophoictinia sura	Square-tailed Kite (Breeding)	Nil	Nil	Moderate	Vulnerable	Not Listed	Included
Miniopterus orianae oceanensis	Large Bentwing-bat (Breeding)	Cave, tunnel, mine, culvert or other structure known or suspected to be used for breeding	Nil	Very High	Vulnerable	Not Listed	Excluded No breeding habitat present
Ninox connivens	Barking Owl (Breeding)	Hollow bearing trees with hollows >20 cm diameter and > 4m above ground.	Nil	Moderate	Vulnerable	Not Listed	Include
Ninox strenua	Powerful Owl (Breeding)	Hollow bearing trees with hollows >20 cm diameter	Nil	High	Vulnerable	Not Listed	Included
Petaurus norfolcensis	Squirrel Glider	Nil	Nil	High	Vulnerable	Not Listed	Included
Petrogale penicillata	Brush-tailed Rock-wallaby	Land within 1 km of rocky escarpments, gorges, steep slopes, boulder piles, rock outcrops or cliffl ines	Nil	High	Endangered	Vulnerable	Excluded Not within 1km of rocky escarpments, gorges, steep slopes, boulder piles, rock outcrops or clifflines

Species	Common Name	Habitat Constraints	Geographic limitations	Sensitivity to gain class	NSW listing status	EPBC Listing status	Included or excluded
Phascogale tapoatafa	Brush-tailed Phascogale	Hollow Bearing Trees	Nil	High	Vulnerable	Not Listed	Included
Phascolarctos cinereus	Koala (Breeding)	Presence of 'Important' habitat. Note that this is not a mapped important habitat area but is defined by the density of koalas and quality of habitat determined by on-site survey.	Nil	High	Vulnerable	Vulnerable	Included
Pteropus poliocephalus	Grey-headed Flying-fox (Breeding)	Breeding camps	Nil	High	Vulnerable	Vulnerable	Included
Thesium australe	Austral Toadflax	Nil	None	Moderate	Vulnerable	Vulnerable	Included
Tyto novaehollandiae	Masked Owl (Breeding)	Hollow bearing trees with hollows >20cm diameter	Nil	High	Vulnerable	Not Listed	Included
Vespadelus troughtoni	Eastern Cave Bat	Caves. Within 2 km of rocky areas containing caves, overhangs, escarpments, outcrops, crevices, boulder piles, or old mines, tunnels, old buildings or sheds.	Nil	Moderate	Vulnerable	Not Listed	Included – however only Vegetation Zone 2 is presumed to be suitable habitat

1.6.1 Targeted surveys

Two targeted surveys were undertaken – Survey #1 during April 2019 and Survey #2 during November 2019. Details are provided below.

1.6.1.1 Targeted Survey #1

The first targeted surveys for species credit species were undertaken at the development site on the dates outlined in Table 11 by accredited BAM assessors Steve Jarman and Liz Brown.

Survey effort undertaken during Targeted Survey #1 is outlined in Table 12. Some of the cameras used for remote camera survey were located outside but near the project boundary and in similar habitat to habitat within the project boundary, such that the survey results would be considered representative for survey within project area.

The locations of targeted surveys are shown on Figure 5 with the results of the surveys shown as individual species polygons on Figure **8**.

Table 11: Targeted surveys and weather conditions

Date	Rainfall (mm)	Minimum temperature (degrees Celsius)	Maximum temperature (degrees Celsius)	Relative humidity (%)
22 April 2019	0.4	11.6	19.9	81
23 April 2019	0.4	11.8	21.5	77
24 April 2019	0.2	12.2	20.2	76
25 April 2019	0.2	10.9	22.8	90
26 April 2019	0	7.2	24.0	74

Table 12: Survey effort undertaken during Targeted Survey #1

Species	Common Name	Survey Method / Effort and Timing Required	Survey Method Undertaken	Survey effort	Survey Month Undertaken	Survey Effort method and timing met?	Species recorded?
Flora species							
Acacia macnuttiana	MacNutt's Wattle	Survey period is July to November. Survey via parallel transects.	Random Meander	2 ecologists/ 2 day	April	Yes, with regards to method* **No with regards to survey timing - outside of survey period. See Table 15 however.**	No
Acacia pycnostachya	Bolivia Wattle	Survey period is July to November. Survey via parallel transects.	Random Meander	2 ecologists/ 2 days	April	Yes, with regards to method* **No with regards to survey timing - outside of survey period. See Table 15 however.**	No
Arthraxon hispidus	Hairy Jointgrass	Survey period is November to May. Survey via parallel transects.	Random Meander	2 ecologists/ 2 days	April	Yes*	No
Eucalyptus nicholii	Narrow-leaved Black Peppermint	Survey via parallel transects at any time of year.	Random Meander	2 ecologists/ 2 days	April	Yes*	No
Thesium australe	Austral Toadflax	Survey via parallel transects at any time of year.	Random Meander	2 ecologists/ 2 days	April	Yes*	No
Birds							
Calyptorhynchus lathami	Glossy Black-Cockatoo (Breeding)	Survey period is March to August. Survey for suitable feed trees and then targeted survey for tell-tale signs of crushed fruits.	Habitat Search	2 ecologists/ 2 days	April	Yes	No
Haliaeetus leucogaster	White-bellied Sea Eagle (Breeding)	Survey period is July to December. Search for breeding habitat (e.g. stick nests)	Nest search	2 ecologists/ 2 days	April	**No – outside of survey period. See Table 15 however.**	No
Hieraaetus morphnoides	Little Eagle (Breeding)	Survey period is August to October. Search for breeding habitat (e.g. stick nests)	Nest search	2 ecologists/ 2 days	April	**No – outside of survey period. See Table 15 however.**	No

Species	Common Name	Survey Method / Effort and Timing Required	Survey Method Undertaken	Survey effort	Survey Month Undertaken	Survey Effort method and timing met?	Species recorded?
Lophoictinia isura	Square-tailed Kite (Breeding)	Survey period is September to January. Search for breeding habitat (e.g. stick nests)	Nest search	2 ecologists/ 2 days	April	**No – outside of survey period. See Table 15 however.**	No
Ninox connivens	Barking Owl (Breeding)	Survey period is May to December. Minimum five nights of call playback.	Call Playback Spotlighting	2 ecologists/ 3 nights 2 ecologists/ 3 nights	April	**No – outside of survey period; however Targeted Survey #2 was undertaken within the survey period (Table 13).**	No
Ninox strenua	Powerful Owl (Breeding)	Survey period is May – August. Minimum eight nights of call playback.	Call Playback Spotlighting	2 ecologists/ 3 nights 2 ecologists/ 3 nights	April	**No – outside of BAM Calculator survey period. However, see note below this table.****	No
Tyto novaehollandiae	Masked Owl (Breeding)	Survey period is May – August. Minimum eight nights of call playback.	Call Playback Spotlighting	2 ecologists/ 3 nights 2 ecologists/ 3 nights	April	**No – outside of BAM Calculator survey period. However, see note below this table.*****	No
Arboreal mammals							
Cercartetus nanus	Eastern Pygmy-possum	Survey period is October to March. Installation of nest boxes or 24 camera trap nights over three consecutive nights.	Remote camera traps Spotlighting	7 cameras/ 4 nights 2 ecologists /3 nights	April	**No – outside of survey period; however Targeted Survey #2 was undertaken within the survey period (Table 13).**	No
Petaurus norfolcensis	Squirrel Glider	All year. Camera traps set on rough-barked trees for a minimum of 24 camera trap nights over three consecutive nights. Surveys method	Remote camera traps	7 cameras/ 4 nights	April	Yes	No

Species	Common Name	Survey Method / Effort and Timing Required	Survey Method Undertaken	Survey effort	Survey Month Undertaken	Survey Effort method and timing met?	Species recorded?
		also includes observation of marks on potential feed trees.	Search for scats / signs Spotlighting	2 ecologists /2 days 2 ecologists/ 3 nights			
Phascogale tapoatafa	Brush-tailed Phascogale	All year. Minimum 24 camera trap nights over three consecutive nights.	Remote camera traps Spotlighting	7 cameras/ 4 nights 2 ecologists/ 3 nights	April	Yes	No
Phascolarctos cinereus	Koala (Breeding)	All year. Direct observation, scat and scratch searches in breeding habitat.	Search for scats/ signs Spotlighting	2 ecologists/ 1 day 2 ecologists /3 nights	April	Yes	No
Bats							
Pteropus poliocephalus	Grey-headed Flying-fox (Breeding)	All year. Daytime camp surveys.	Habitat Search (day)	2 ecologists/ 2 days	April	Yes	No
Vespadelus troughtoni	Eastern Cave Bat	Survey period November to January. No survey required if breeding habitat is within 2 km. Otherwise, harp trap (or mist net) placed in areas of potential breeding habitat.	Not surveyed	Not surveyed	April	**No – outside of survey period; however Targeted Survey #2 was undertaken within the survey period (Table 13).**	N/A
Amphibians							
Litoria subglandulosa	Glandular Frog	Survey Period October to November. Systematic daytime searches for tadpoles and adult frogs in areas of suitable habitat. Nocturnal surveys - listening for frog calls, spotlighting,	Search for suitable habitat. Listening for call in the dams.	Meander of the development site	April	**No – outside of survey period. No suitable habitat exists for this species. See Table 15.**	No (however **no suitable habitat exists** for this species)

Species	Common Name	Survey Method / Effort and Timing Required	Survey Method Undertaken	Survey effort	Survey Month Undertaken	Survey Effort method and timing met?	Species recorded?
		searching within habitat and call recording should be used.					

* Due to the size of the site, flora survey via random meander was able to cover the entire site, covering the same area as the parallel transects.

** The Powerful Owl or its breeding habitat was not recorded onsite during the surveys. Nesting occurs from late autumn to mid-winter, but is slightly earlier in north-eastern NSW (late summer - mid autumn) (OEH, no date). The Australian Museum (2019a) also states that breeding occurs between April and September. Targeted Survey #1 was within this timeframe.

*** The Masked Owl or its breeding habitat was not recorded onsite during the surveys. Breeding is irregular and unpredictable, occurring from late summer to spring but mostly March to July (DEC, 2006). Targeted Survey #1 was within this DEC (2006) timeframes. The Australian Museum (2019b) also states that breeding can occur at any time of the year when conditions are favourable and food items are plentiful.

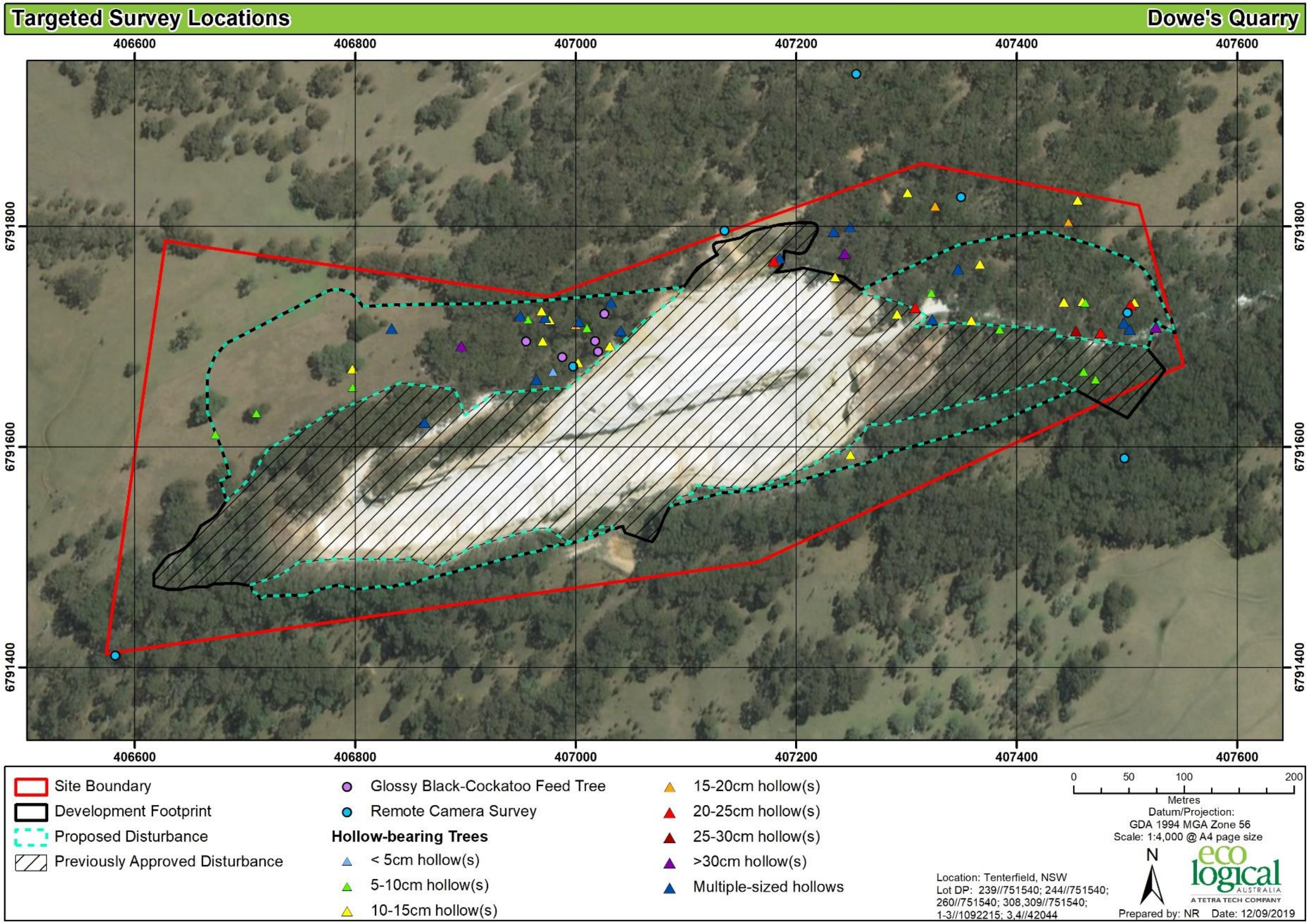

Figure 5: Targeted survey locations

1.6.1.2 Targeted Survey #2

Targeted Survey #2 was undertaken by AREA Environmental Consultants and Communication Pty Ltd. Methods of this survey are provided in Table 13, and reported on in full within Appendix A.

The report (Appendix A) states that Targeted Survey #2 followed the *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities. Working Draft November 2004.*

This survey specifically targeted:

- Barking Owl (*Ninox connivens*)
- Powerful Owl (*Ninox strenua*)
- Masked Owl (*Tyto novaehollandiae*)
- Eastern Pygmy-possum (*Cercartetus nanus*)
- Eastern Cave-at (*Vespadelus troughtoni*)

None of the first four species listed above were recorded during Targeted Survey #2. The Eastern Cave Bat was identified on three separate nights during Targeted Survey #2. A species polygon map is provided in Figure **8**.

No other threatened species were observed.

Table 13: Survey effort undertaken during Targeted Survey #2

Species	Common Name	Timing Requires	Survey Method / Effort and Timing Required	Survey Effort method and timing met?
Ninox connivens *Ninox strenua* *Tyto novaehollandiae*	Barking Owl Powerful Owl Masked Owl	May- Dec May-Aug May-Aug	Call playback: Sites should be separated by 800 metres – 1km, and each site must have the playback session repeated as follows: • at least 5 visits per site, on different nights are required for the Powerful Owl, Barking Owl and the Grass Owl; • at least 6 visits per site for the Sooty Owl, and 8 visits per site for the Masked Owl are required. Day habitat search: Search habitat for pellets, and likely hollows. Flushing of Bush Stone-curlews by walking through potential habitat. Observing potential roost hollows for 30mins prior to sunset and 60mins following sunset. Spotlighting	Yes. The *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities. Working Draft November 2004* state that the survey period for these owls is all year. All of the survey methods in the column to the left were undertaken over five days and five nights, with the exception of the day habitat search, which was undertaken for four days. The entire development footprint was surveyed on foot by an ecologist over five days. Spotlighting over five nights and camera traps were also used with no result. All trees in the development footprint were surveyed and no individuals were observed. These species nor their breeding habitat was not detected. Combined with Targeted Survey #1, each owl was surveyed for 8 nights (spotlighting and call playback), which meets/exceeds requirements.
Cercartetus nanus	Eastern Pygmy-possum	Oct-Mar	• Arboreal Elliot trap - 24 trap nights over 3-4 consecutive nights • Spotlighting - 2 x 1 hour and 1km up to 200 hectares of stratification unit, walking at approximately 1km per hour on 2 separate nights. • Spotlighting from vehicle - 2 x 1 km of track at maximum speed of 5km per hour up to 200 hectaresof stratification. unit, on 2 separate nights	Yes. All of the survey methods in the column to the left were undertaken. 11 arboreal traps were deployed (over five nights totalling 55 trap nights collectively 125 trap nights for Eastern Pygmy-possum. Five nights of spotlighting on foot was undertaken, whilst one night of spotlighting from the vehicle was undertaken.

Species	Common Name	Timing Requires	Survey Method / Effort and Timing Required	Survey Effort method and timing met?
Vespadelus troughtoni	Eastern Cave Bat	Nov to Jan	• Active searching - Search rocks, overhangs and caves / mines • Ultrasonic call recording - Two sound activated recording devices utilised for the entire night (a minimum of four hours), starting at dusk for two nights. • Spotlighting and transect walking - For targeted survey near likely food resources: 2 x 1 hour spotlighting on two separate nights • Day habitat search - Search for bat excreta at or near potential habitats	Yes. All of the survey methods in the column to the left were undertaken. Two Echolocation detectors (SongMeters SM2+BAT and SM3+Bat,Wildlife Acoustics) were used for a combined total of nine entire nights from dawn until dusk (exceeding the minimum of two nights by seven whole nights). Bat calls were interpreted by a suitably qualified professional who identified the presence of *Vespadelus troughtoni* on three separate trap nights.

All information within the above table was sourced from AREA Environmental Consultants and Communication, 2020 (Appendix A)

Figure 6: Targeted Survey #2 – Overview of survey methods

Source of figure: AREA Environmental Consultants and Communication, 2020 (Appendix A)

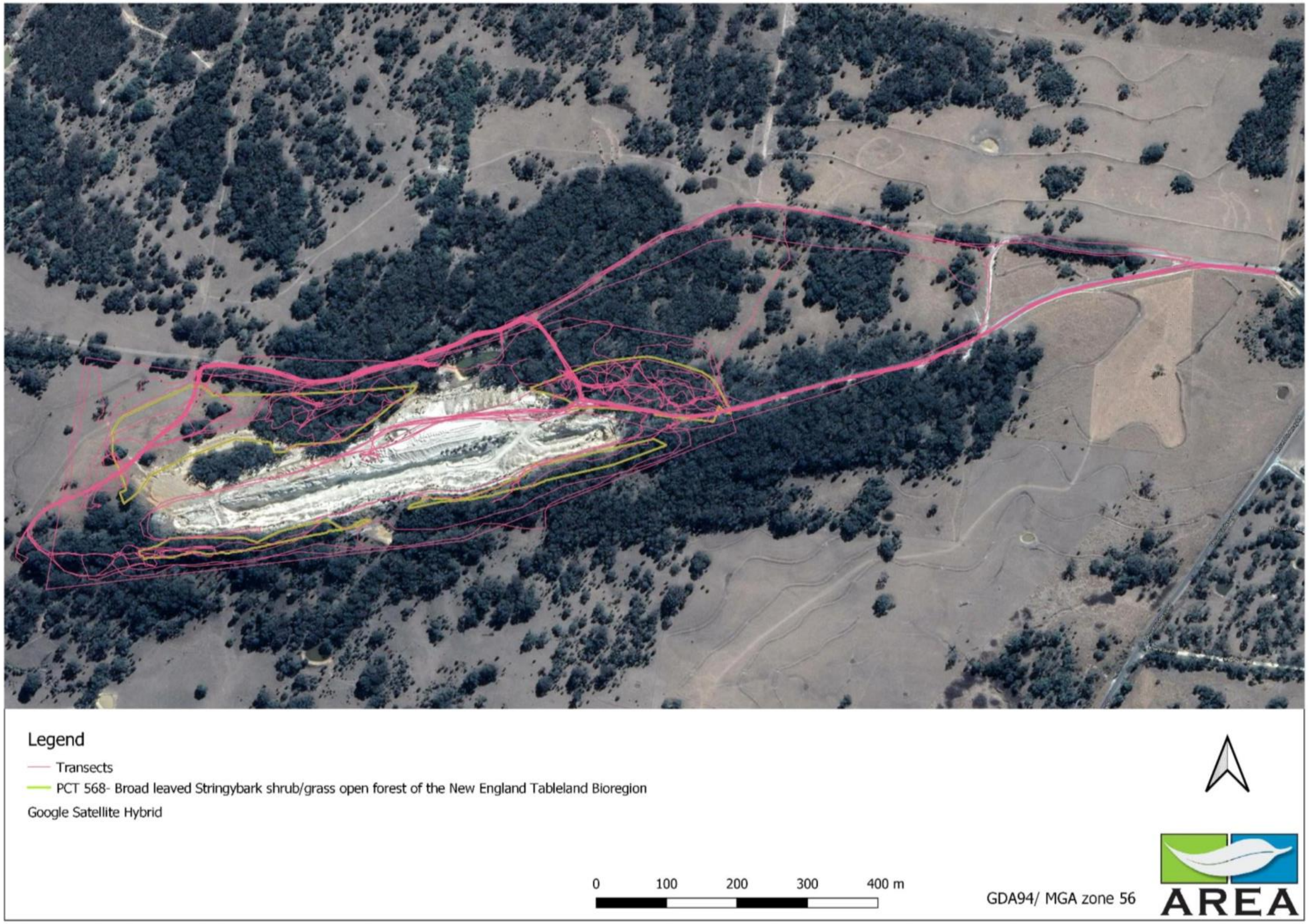

Figure 7: Targeted Survey #2 – Survey Transects

Source of figure: AREA Environmental Consultants and Communication, 2020 (Appendix A)

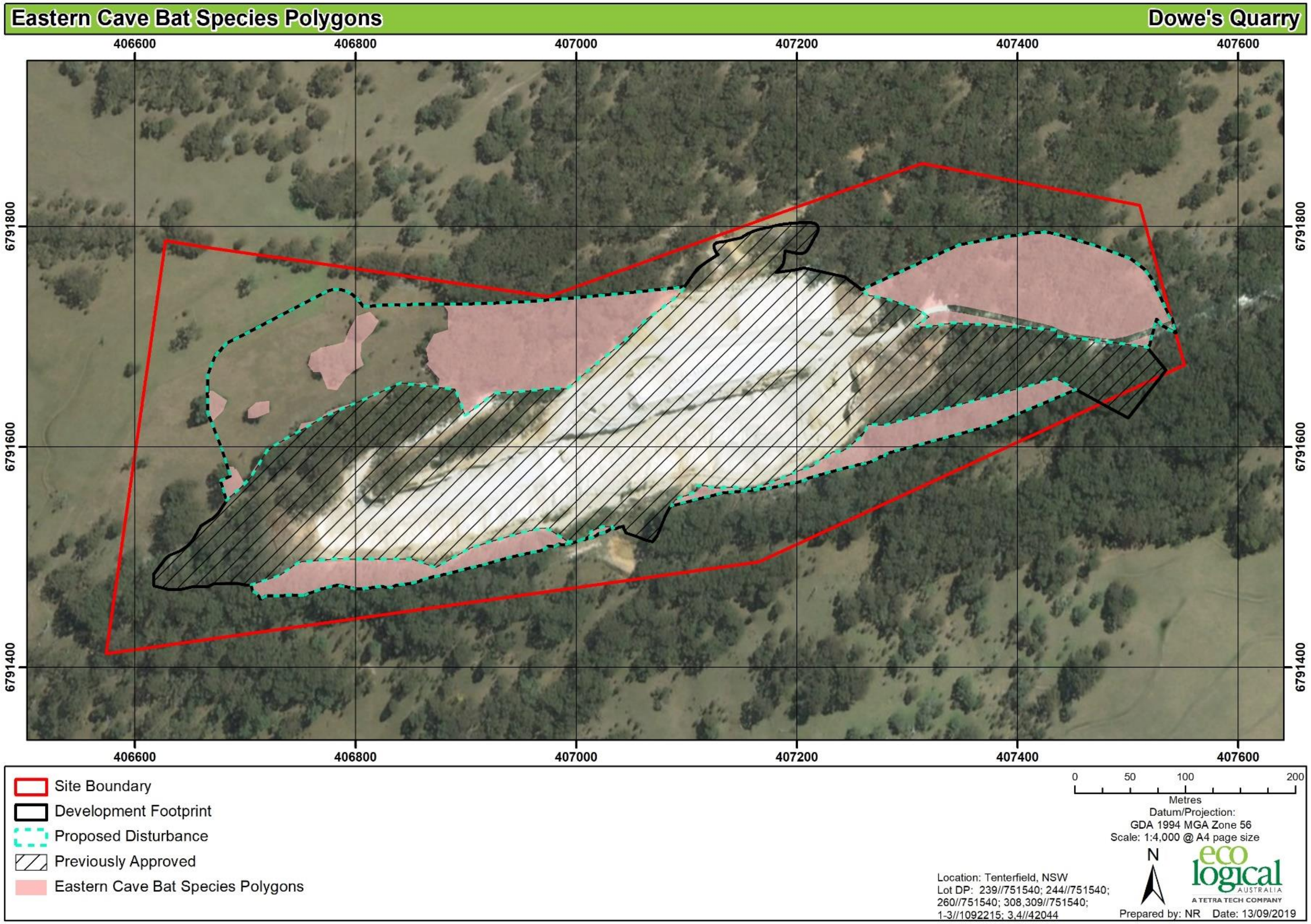

Figure 8**: Species Polygon – Eastern Cave Bat**

1.6.2 Species included in the assessment

Following completion of targeted surveys, the species credit species included in the assessment are outlined in Table 14 and species credit species excluded are outlined in Table 15.

Table 14: Details of species credit species included in the assessment

Species	Common Name	Survey Method	Habitat Impact Area (ha)	Relevant Veg Zone	Biodiversity Risk Weighting
Vespadelus troughtoni	Eastern Cave Bat	See Table 13 for survey method and effort. Bat call analysis of recordings made during Targeted Survey #2 (Appendix A) identified the presence of Eastern Cave Bat on three separate trap nights.	4.63	Zone 2	3.00

Table 15: Justification for exclusion of candidate species credit species

Species	Common Name	Justification for exclusion of species
Acacia macnuttiana	MacNutts Wattle	Not recorded during survey. It is noted that *Acacia macnuttiana* was not surveyed within the required survey period during flowering, which aims to ensure the species is not confused with the similar *Acacia acrionastes.* However, as neither *Acacia acrionastes* nor *Acacia macnuttiana* were identified during the survey, no such potential confusion could have arisen. As such, *Acacia macnuttiana* is not considered present.
Acacia pycnostachya	*Bolivia Wattle*	Not recorded during survey.
Arthraxon hispidus	*Hairy Jointgrass*	Not recorded during survey.
Calyptorhynchus lathami	Glossy Black Cockatoo (breeding)	While breeding habitat (hollows >15cm diameter) has been identified to occur within the study area, no individuals were recorded during the surveys.
Cercartetus nanus	Eastern Pygmy Possum	Not recorded onsite during survey.
Eucalyptus nicholii	Narrow-leaved Black Peppermint	Not recorded onsite during survey.
Haliaeetus leucogaster	White-bellied Sea-Eagle	No nests recorded during survey.
Hieraaetus morphnoides	Little Eagle (Breeding)	No nests recorded during survey. While the survey was outside of required survey period, remains of these large nests would still have been evident at the time of survey.
Litoria subglandulosa	Glandular frog	No suitable habitat exists within the development site. As per the *National Recovery Plan for Stream Frogs of South-east Queensland 2001-2005*, this species lives along streams in upland areas (altitude range of 500-1400m) in a range of habitats, usually associated with dense overhanging vegetation. Populations usually inhabit streams that are slow-flowing, with sections of permanent pools, and surrounded by dry and wet sclerophyll forest, rainforest, montane forest and heathland.

Species	Common Name	Justification for exclusion of species
Lophoictinia isura	Square-tailed Kite (Breeding)	No nests recorded during survey. While the survey was outside of required survey period, remains of these large nests would still have been evident at the time of survey.
***Ninox connivens* (breeding)**	Barking Owl	Not recorded onsite during survey.
***Ninox strenua* (breeding)**	Powerful Owl	This species or its breeding habitat was not recorded onsite during the surveys. Nesting occurs from late autumn to mid-winter, but is slightly earlier in north-eastern NSW (late summer - mid autumn) (OEH, no date). The Australian Museum (2019a) also states that breeding occurs between April and September. Targeted Survey #1 was within this timeframe.
Petaurus norfolcensis	Squirrel Glider	Not recorded during survey in accordance with BAM requirements.
Phascogale tapoatafe	Brush-tailed Phascogale	Not recorded during survey in accordance with BAM requirements.
Phascolarctos cinereus	Koala (Breeding)	Excluded as a species credit species for the following reasons. • The area was not considered to contain 'important habitat based on the density and quality of breeding habitat onsite'. • No individuals or signs/ records of the species were recorded during survey in line with BAM requirements. • No primary food tree species and only two species of secondary food tree species *(Eucalyptus moluccana and E. caliginosa)* of the Northern Tablelands (as detailed in Koala Recovery Plan [DECC 2008] and the Northern Tablelands Koala Recovery Strategy 2015-2025 [Northern Tablelands Local Land Services, 2016]) was identified within the site during the survey. • While it is noted that signs of this species were identified in 2014 within the site boundary (ELA, 2014), including in the area mapped as 'previously assessed clearing' in this report, this vegetation has since been largely cleared. Additionally, the 2014 survey identified that the signs (scratches in trees) were old and concluded that there was a low density of Koala activity across the site. Note that this species is still included as an ecosystem credit species in this report.
Pteropus poliocephalus	Grey-headed Flying-fox (Breeding)	No camps have been recorded within or in vicinity to the site on the National Flying-fox Monitoring Viewer (viewed 3 Sep 2019). No breeding habitat was recorded during the survey. Note that this species is still included as an ecosystem credit species in this report.
Thesium australe	Austral Toadflax	Not recorded during survey. While the survey was outside of required survey period, this species is considered unlikely to occur within the development site.
***Tyto novaehollandiae* (breeding)**	Masked Owl	This species or its breeding habitat was not recorded onsite during the surveys. Breeding is irregular and unpredictable, occurring from late summer to spring but mostly March to July (DEC, 2006). Targeted Survey #1 was within this DEC (2006) timeframes. The Australian Museum (2019b) also states that breeding can occur at any time of the year when conditions are favourable and food items are plentiful.

2. Stage 2: Impact assessment (biodiversity values)

2.1 Avoiding impacts

2.1.1 Locating a project to avoid and minimise impacts on vegetation and habitat

The development has been located in a way which avoids and minimises impacts as outlined in Table 16.

Table 16: Locating a project to avoid and minimise impacts on vegetation and habitat

Approach	How it is addressed	Justification
Locating the project in areas where there are no biodiversity values.	The project has been located predominantly in areas where there are no biodiversity values.	The project is centred around an existing quarry, and an area around this quarry which has previously been approved for disturbance and which has been cleared since approval. The project area also includes existing access roads. The location of the proposed quarry expansion is constrained due to the location of the existing quarry, and the location of the resource.
Locating the project in areas where the native vegetation or threatened species habitat is in the poorest condition.	Part of the project is located in areas where native vegetation is in poor condition.	The project includes an area of 1.78ha of PCT 568 which is of poor condition (vegetation integrity score 3) of as it has been largely cleared of native vegetation and consists largely of non-native grassland.
Locating the project in areas that avoid habitat for species and vegetation in high threat categories (e.g. an EEC or CEEC), indicated by the biodiversity risk weighting for a species.	The project is not located in an area where native vegetation is part of an EEC or CEEC. The project has impact on habitat of high threat category threatened species.	There is no EEC or CEEC within the project footprint. The project impacts on 4.63 ha of habitat of the Eastern Cave Bat which has a very high (3) biodiversity risk weighting. The project impacts on 4.68 ha of habitat for the Powerful Owl, Masked Owl and Barking Owl and on 4.63 ha of habitat for the Eastern Pygmy-possum, all of which have a high (2) biodiversity weighting.
Locating the project such that connectivity enabling movement of species and genetic material between areas of adjacent or nearby habitat is maintained.	Connectivity enabling movement of species and genetic material between areas of nearby habitat will be maintained.	The project is located such that connectivity to adjacent habitat is maintained by retaining a corridor of vegetation along the southern boundary of the site. This is connected to a large area of vegetation to the north.

2.1.2 Designing a project to avoid and minimise impacts on vegetation and habitat

The development has been designed in a way which avoids and minimises impacts as outlined in Table 17.

Table 17: Designing a project to avoid and minimise impacts on vegetation and habitat

Approach	How addressed	Justification
Reducing the clearing footprint of the project.	The clearing footprint is 6.41ha of native vegetation.	The clearing footprint is 6.41ha of native vegetation, of which 1.78 ha in poor condition. Through design, the proposed access road has been realigned to be coterminous with the northern boundary of the quarry expansion. This has significantly reduced the impact footprint of the original proposal. The original design planned for the road to sweep to the north (where the position of Plot 3 is – See Figure 4).
Locating ancillary facilities in areas where there are no biodiversity values.	Ancillary facilities will be located within the proposed operational footprint and not result in additional impact to biodiversity value areas.	Ancillary features will be located within the operational footprint, avoiding additional impacts to areas containing biodiversity values.
Locating ancillary facilities in areas where the native vegetation or threatened species habitat is in the poorest condition (i.e. areas that have a lower vegetation integrity score).	Ancillary facilities will be located within the proposed operational footprint and not result in additional impact to biodiversity value areas.	Ancillary features will be located within the operational footprint, avoiding additional impacts to areas containing biodiversity values.
Locating ancillary facilities in areas that avoid habitat for species and vegetation in high threat status categories (e.g. an EEC or CEEC).	Ancillary facilities will be located within the proposed operational footprint and not result in additional impact to biodiversity value areas.	Ancillary features will be located within the operational footprint, avoiding additional impacts to areas containing biodiversity values.
Providing structures to enable species and genetic material to move across barriers or hostile gaps.	The development will not include structures to enable species and genetic material to move across barriers or hostile gaps.	The project is located such that connectivity to adjacent habitat is maintained by retaining a corridor of vegetation along the southern boundary of the site. This is connected to a large area of vegetation to the north.
Making provision for the demarcation, ecological restoration, rehabilitation and/or ongoing maintenance of retained native vegetation habitat on the development site.	Recommendations for the demarcation and maintenance of retained native vegetation have been include as mitigation measures in this report.	Recommendations for the demarcation and maintenance of retained native vegetation have been include as mitigation measures in this report.

2.1.3 Prescribed biodiversity impacts

The development site does not have any prescribed biodiversity impacts (Table 18).

Table 18: Prescribed biodiversity impacts

Prescribed biodiversity impact	Description in relation to the development site
Impacts of development on the habitat of threatened species or ecological communities associated with: • karst, caves, crevices, cliffs and other geological features of significance, or • rocks, or • human made structures, or • non-native vegetation	With regards to non-native vegetation: An area of 1.78ha of PCT568 in poor quality will be impacted by the development, which has been cleared of canopy and shrub layer and now largely consists of non-native grassland. It is unlikely that this would be habitat for threatened species given the proximity of better-quality native vegetation. The project will not result in impacts to: • karst, caves, crevices, cliffs and other geological features of significance, or • significant rocks, or • human made structures
Impacts of development on the connectivity of different areas of habitat of threatened species that facilitates the movement of those species across their range.	N/A. The project is located such that connectivity to adjacent habitat is maintained by retaining a corridor of vegetation along the southern boundary of the site, which retains the connection between habitat to the east and west of the project and the retention of a thin strip of vegetation to the east of the site, which retains connectivity to a large area of vegetation to the north. The vegetation is part of a contiguous vegetation patch of approximately 340ha.
Impacts of development on movement of threatened species that maintains their lifecycle.	N/A The project is located such that connectivity to adjacent habitat is maintained by retaining a corridor of vegetation along the southern boundary of the site, which retains the connection between habitat to the east and west of the project and the retention of a thin strip of vegetation to the east of the site, which retains connectivity to a large area of vegetation to the north. The vegetation is part of a contiguous vegetation patch of approximately 340ha.
Impacts of development on water quality, water bodies and hydrological processes that sustain threatened species and threatened ecological communities (including from subsidence or upsidence resulting from underground mining).	N/A. No water bodies are located within the project footprint. Two sediment dams, located outside the project footprint to the north and south of the project footprint, will contain all surface water runoff from the quarry overburden and fines stockpile and other disturbed areas around the extraction areas.
Impacts of vehicle strikes on threatened species or on animals that are part of a TEC.	N/A. The development aims to progressively increase the truck capacity, which would allow an increase in the material despatched from the Quarry without increasing traffic levels.

2.2 Assessment of Impacts

2.2.1 Direct impacts

The direct impacts of the development on:

- native vegetation are outlined in Table 19
- threatened species and threatened species habitat are outlined in Table 20
- prescribed biodiversity impacts are outlined in Section 2.1.3.

Direct impacts including the final project footprint (construction and operation) are shown on Figure 9. All construction and operational works will be constrained to the development footprint.

'Construction' includes vegetation clearing activities, cut and fill for a work pad and works associated with the road realignment. 'Operations' includes excavation, processing and haulage of quarry materials. More detail is provided in Chapter 2 of the EIS for the proposed development.

Within Table 20, the differences between the direct impact area (ha) is due to the method used to calculate impact areas. That is, for Eastern Cave Bat, the entire area of PCT 568 (good condition) is included as an impact area (4.63 ha). On the other hand, the direct impact to PCT 568 (6.41 ha) includes both the good and poor condition areas of the PCT.

Table 19: Direct impacts to native vegetation

PCT ID	PCT Name	Condition	Vegetation Class	Vegetation Formation	Direct impact (ha)
568	Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion	Poor	New England Dry Sclerophyll Forest	Dry Sclerophyll Forest (Shrub/grass sub-formation)	1.78
568	Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion	Good	New England Dry Sclerophyll Forest	Dry Sclerophyll Forest (Shrub/grass sub-formation)	4.63

Table 20: Direct impacts on threatened species and threatened species habitat

Species	Common Name	Direct impact number of individuals / habitat (ha)	Relevant Veg Zone	NSW listing status	EPBC Listing status
Vespadelus troughtoni	Eastern Cave Bat	4.63	Zone 2 (good)	Vulnerable	Not Listed
PCT 568	Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion	6.41	Both	N/A	N/A

2.2.2 Change in vegetation integrity

The change in vegetation integrity as a result of the development is outlined in Table 21.

Table 21: Change in vegetation integrity

Veg Zone	PCT ID	Condition	Area (ha)	Current vegetation integrity score	Future vegetation integrity score	Change in vegetation integrity
1	568	Poor	1.78	3	0	-3
2	568	Good	4.63	64.5	0	-64.5

Figure 9: Final project footprint including construction and operation

2.2.3 Potential indirect impacts

Potential indirect impacts are considered pursuant to Section 9.1.4 of the BAM. The potential indirect impacts of the development are outlined in Table 22. For assessment purposes, indirect impacts identified in a context where no management occurs. In reality however, mitigation and management of these impacts will occur, as outlined in Section 2.2.3.1.

Indirect impacts are generally expected to be negligible to minor in nature, and generally consistent with the indirect impacts of existing operations. Furthermore, the project will not result in indirect impacts that threaten the bioregional persistence of threatened ecological communities, threatened species or their habitats.

Table 22: Indirect impacts

Indirect impact	Project phase	Nature	Extent	Frequency	Duration	Timing
Sedimentation and contaminated and/or nutrient rich run-off	Construction / operation	Runoff during construction and operation	Potential sedimentation and contaminated runoff into adjacent creek and dams	During heavy rainfall or storm events	Throughout construction and operation period	Potentially long-term impacts
Noise	Construction / operation	Noise from operations (machinery, blasting) is expected to be similar in nature as compared to baseline, with exception of additional diurnal noise due to the proposed new mobile processing equipment. See Section 2.2.3.1 for more information.	Adjacent vegetation	Daily, during construction works and operational phases	Throughout construction and operation period	Potentially long-term impacts (during day only)
Dust	Construction / operation	Dust from operations is expected to generally consistent with baseline conditions (i.e. the pre-existing quarry operations)	Adjacent vegetation	Daily, during construction works and operational phases	Throughout construction and operation period	Potentially long-term impacts
Light spill	Construction / operation	Light spill into adjacent vegetation / habitat	None expected – no night works proposed	N/A	N/A	N/A

Indirect impact	Project phase	Nature	Extent	Frequency	Duration	Timing
Inadvertent impacts on adjacent habitat or vegetation	Construction / operation	Potential physical damage to adjacent habitat or vegetation	Adjacent vegetation	Daily, during construction works and operational phases	Throughout construction and operation period	Potentially long-term impacts
Transport of weeds and pathogens from the site to adjacent vegetation	Construction / operation	Spread of weed seed and pathogens from incoming machinery and equipment	Potential spread into nearby habitat	Daily, during construction and operational phases	Throughout construction and operation period	Potentially long-term impacts
Vehicle strike	Construction / operation	Potential for native fauna to be struck by working machinery and moving vehicles	Within development site and adjacent	Daily, during construction and operational phases	Throughout construction and operation period	Potentially long-term impacts
Rubbish dumping	Construction / operation	Illegal dumping by workers	Potential for rubbish to spread into adjacent vegetation and outside development site	Daily, during construction and operational phases	Throughout life of project	Potentially long-term impacts
Wood collection	Construction / operation	Unregulated removal of wood in vegetation adjacent to development site	Throughout adjacent vegetation	Potential to occur at any time during construction or operational phases	Throughout life of project	Short-term impacts
Bush rock removal and disturbance	Construction / operation	Unregulated removal of rocks in vegetation adjacent to development site	Potential for disturbance in adjacent vegetation and area surrounding the development site	Potential to occur at any time during construction or operational phases	Throughout life of project	Short-term impacts
Increase in predatory species populations	Construction / operation	Negligible potential for an increase in predatory species in the locality through disturbance to vegetation	Throughout adjacent vegetation	Potential to occur gradually after disturbance to habitat and vegetation takes place	During construction phase of project	Potentially negligible long-term impacts

Indirect impact	Project phase	Nature	Extent	Frequency	Duration	Timing
Increase in pest animal populations	Construction / operation	Potential to increase if food scraps/rubbish is left on site. Potential to increase -/+ decrease due to disturbance to existing vegetation.	Throughout adjacent vegetation	Potential to occur gradually after disturbance to habitat and vegetation takes place	During construction phase of project	Potentially long-term impacts
Increased risk of fire	Construction / operation	Potential for fire to spark during construction and operation from any machinery or electrical works	Throughout adjacent vegetation	Potential to occur at any time throughout the operational or construction phases	During operating/ construction hours	During operational /construction hours
Disturbance to specialist breeding and foraging habitat, e.g. beach nesting for shorebirds.	Construction / operation	Potential to impact potential breeding habitat of species relying in tree hollows for breeding	Hollow-bearing trees within and adjacent the site	Potential to occur at any time throughout the operational or construction phases	Throughout life of project	Potentially long-term impacts

2.2.3.1 Further Assessment of noise during operations

The operational processes that generate noise (e.g. blasting, excavation, traffic noise, loading) proposed as part of the expansion are generally consistent with pre-existing operations, with the exception of the mobile processing equipment that is proposed to be installed on the pit floor. The addition of this mobile processing equipment is expected to result in a noticeable change in noise generation during the daytime as it is conservatively assumed that it will be operating during all daytime hours of operation. This provides a change to both the source of noise generated on site and the duration of noise impacts.

The change in noise due to the mobile processing equipment is not expected to impact the foraging habitat of the eastern cave bat due to the bat's nocturnal feeding behaviour. Furthermore, the mobile processing equipment is expected to generate a steady noise source and a level of habituation of local wildlife is therefore expected.

The *Noise and Vibration Impact Assessment* prepared for the project by Spectrum Acoustics (2020) provides an assessment of noise impacts to adjacent anthropic sensitive receivers. This therefore provides an indication of the predicted noise in the wider area. The results of the study show noise levels are mostly <30 dB(A),$L_{eq(15min)}$ and do not exceed 33 dB(A),$L_{eq(15min)}$ at surrounding residential receivers for both modelled scenarios. This demonstrates that noise is not expected to be an issue for wildlife in the wider area.

2.2.4 Mitigating and managing impacts

Measures proposed to mitigate and manage both direct and indirect impacts at the development site before, during and after construction are outlined in Table 23. A vegetation clearing protocol that will be implemented during works is also provided in Appendix D.

As mentioned in Section 2.2, 'construction' includes vegetation clearing activities, cut and fill for a work pad and works associated with the road realignment. 'Operations' includes blasting, excavation, processing and haulage of quarry materials. More detail is provided in Chapter 2 of the EIS for the proposed development.

Table 23: Measures proposed to mitigate and manage direct and indirect impacts

Measure	Action	Outcome	Timing	Responsibility
Implement clearing protocols for fauna	Protocol to include pre-clearing surveys for active breeding places (nests, burrows, hollows etc), daily surveys and staged clearing, the presence of a trained ecological or licensed wildlife handler during clearing events, fauna handling protocol, and identification of fauna release areas. Due to the existence of hollows, use of burrow-scope during pre-clearing survey is recommended. Where breeding threatened species are identified, works shall cease until the species is confirmed and necessary approvals are obtained. The breeding place will be fenced off and excluded from works. Works shall not continue until the breeding place is no longer active.	Prevent injury and disturbance of wildlife	Before and during construction	Project manager Project ecologist/wildlife handler Clearing contractor
Replace habitat resources lost onsite in retained vegetation	Place any habitat features removed from the development site, including logs, rocks and hollows (where saved) in retained and adjacent vegetation, particularly along the eastern boundary and riparian buffer zones.	Habitat features retained offsite	Before and during construction	Project manager Clearing contractor
Implement clearing protocols for flora	Include clear delineation of vegetation to be retained, including around riparian zones in proximity to the works. Removal of native vegetation by chain-saw, rather than heavy machinery where possible.		Before and during construction	Project manager Project ecologist Clearing contractor
Implement sediment and erosion controls to control the quality of water released from the site into the receiving environment	Install sediment barriers and erosion controls during and post construction to prevent runoff into adjacent streams. Maintain controls throughout construction and undertake weekly inspections.	No sediment impacting on the receiving environment	For the life of the project	Project manager Clearing contractor
Implement a waste control plan to reduce risk of pest species onsite	Waste control plan to include covered waste receptacles for food wastes, regime for disposal offsite and staff awareness.	Minimise attracting pest species onsite	For the life of the project	Project manager Clearing contractor Quarry operator
Staff training and site briefing to communicate environmental features	All staff to receive environmental induction. This induction will include items such as:	All staff entering the site are fully aware of all environmental	To occur for all staff entering / working at the site and when	Project manager Clearing contractor

Measure	Action	Outcome	Timing	Responsibility
to be protected and measures to be implemented	• Site environmental procedures (vegetation management, traffic noise control via an operator code of conduct, sediment and erosion control, exclusion fencing and noxious weeds) • What to do in case of environmental emergency (chemical spills, fire, injured fauna) • Key contacts in case of environmental emergency Site briefings should be updated based on phase of the work and associated risks.	aspects relating to the development and know what to do in case of any environmental emergencies	environmental issues become apparent	Quarry operator (all staff)
Risk of fire	Site Emergency Plan and bushfire management to be implemented.	Reduced fire risk	For the life of the project	Quarry operator
Weed washdown	All new machinery to arrive on site free of caked mud and dirt (which can potentially carry weed seed).	Reduced risk of weed spread	For the life of the project	Clearing contractor Quarry operator
Implement Dust Management	During construction, unsealed, regularly trafficked areas such as access tracks, work areas and haul roads will be watered by truck mounted sprays as conditions require. Please refer to Section 8 of the Air Quality Assessment (Northstar Air Quality 2020, submitted as part of the EIS) for actions that will be implemented regarding dust management during operations	Reduce dust impacts	For the life of the project	Clearing contractor Quarry operator
Implement design features and protocols to reduce noise	The mobile processing plant is proposed to be placed at the bottom of the pit, therefore reducing potential noise impacts to surrounding areas. Noise generated by traffic will also be managed via driver code of conduct requiring drivers to minimise excess engine and breaking noise. Traffic management would also include an in-vehicle monitoring system (IVMS) that utilises GPS monitoring to records driver speed and behaviour. These additional precautions would limit the potential for vehicle strike of fauna (particularly Koala).	Reduced noise impacts on wildlife habitat	For the life of the project	Quarry operator

Measure	Action	Outcome	Timing	Responsibility
	Drop height of loads into trailers will be minimised to reduce noise. Broad band reversing alarms will be used instead of beeper style alarms on all mobile equipment. Annual and ad-hoc reviews will identify opportunities for best management practice in controlling noise at the source through the elimination of noisy equipment, relocating equipment or re-orientating equipment to reduce the noise impacts. Blasting will only occur between the hours permitted through the Development Consent.			

2.2.5 Serious and Irreversible Impacts (SAII)

The Eastern Cave Bat is a potential candidate Serious and Irreversible Impact species. The threshold for the SAII for this species is:

- Potential breeding habitat and presence of breeding individuals. Potential breeding habitat is PCTs associated with the species within 100m of rocky areas, caves, overhangs crevices, cliffs and escarpments; or old mines, tunnels, old buildings and sheds within the potential habitat.

A map showing topography within 100m of the site is shown in Figure 10. This provides an indication that no breeding habitat for the Eastern Cave Bat exists within 100m. Site observations also confirmed this. It is also assumed that the quarry pit itself (cliffs and cervices) does not provide breeding habitat due to the ongoing operational disturbances. Nonetheless, it is conservatively assumed that breeding habitat exists within 2km of the development site due to:

- The results of Targeted Survey #2 showing the species forages within habitat on site;
- topography (mountainous areas exist to the north – see Figure 11), and
- survey of all potential breeding habitat (e.g. old buildings and sheds) within a 2km radius is not practical.

As the potential breeding habitat as described above is not present within the development site or within 100m of the development site, the SAII threshold is not met and the species not further assessed for SAII.

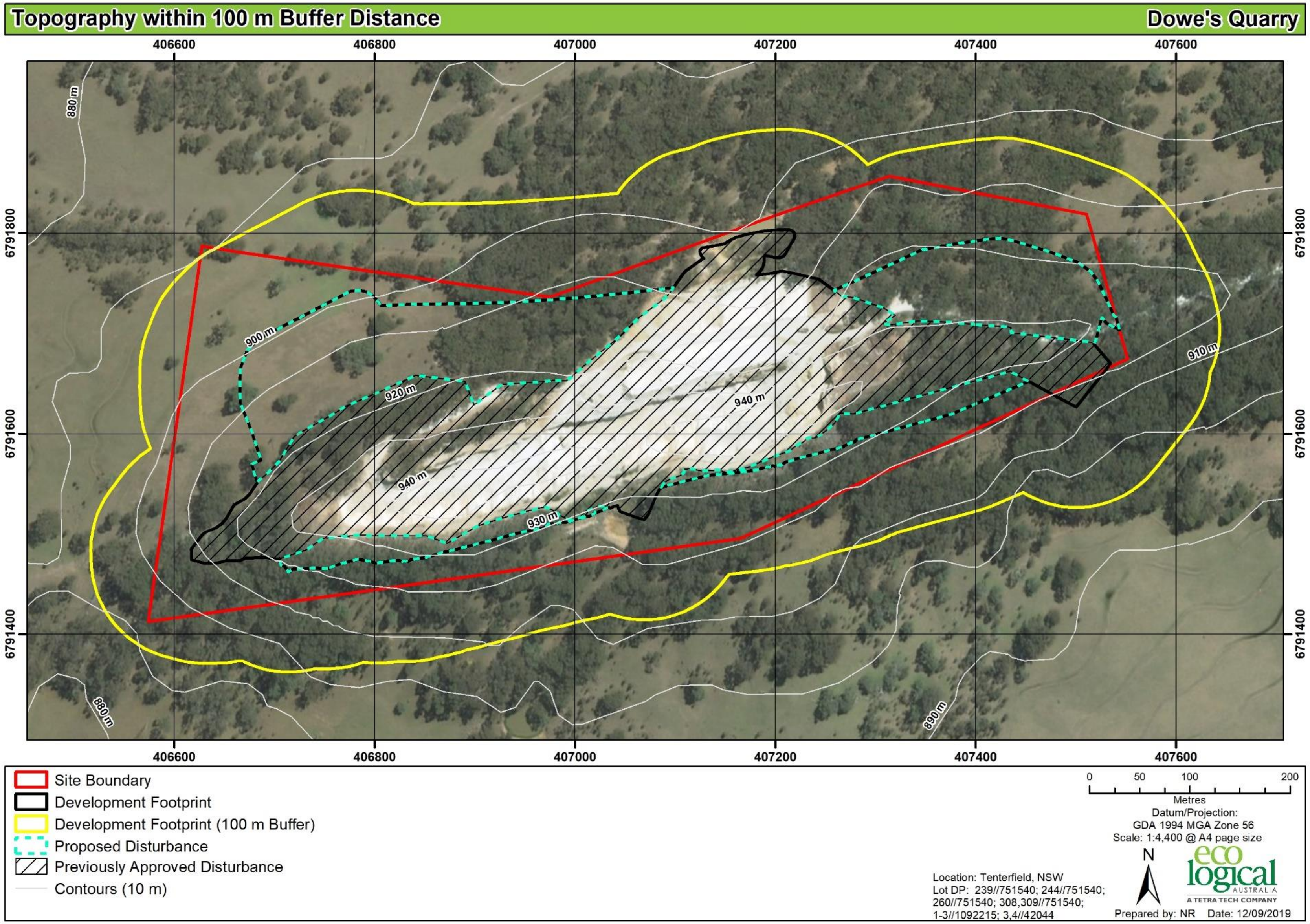

Figure 10: Topography within 100m of the development site

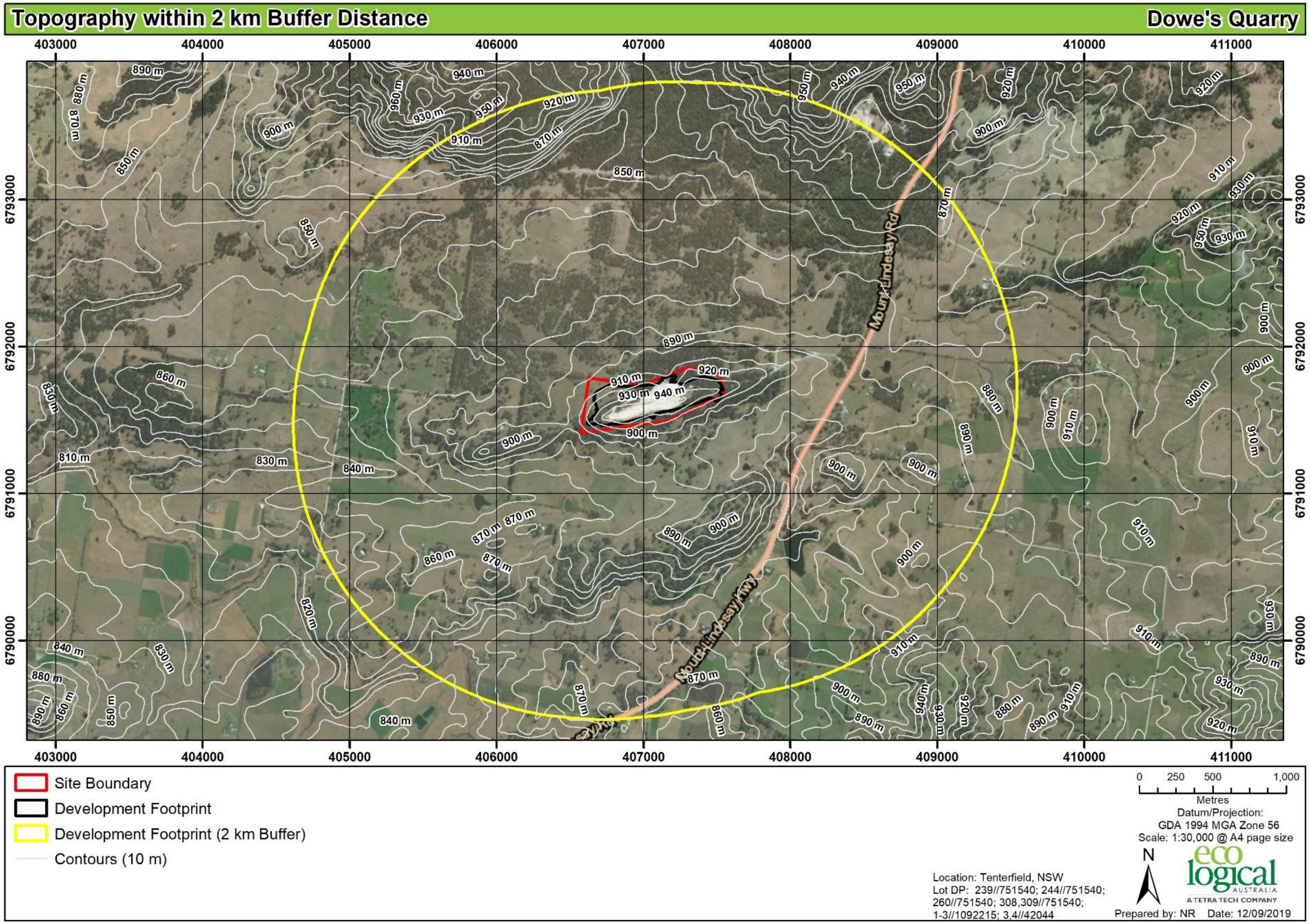

Figure 11: Topography within 2km of the development site

2.3 Risk assessment

A risk assessment for project ecological impact has been undertaken. Likelihood criteria, consequence criteria and the risk matrix are provided in Table 24, Table 25 and Table 26 respectively. The risk assessment for the project is provided in Table 27.

Table 24: Likelihood criteria

Likelihood criteria	Description
Almost certain (Common)	Will occur, or is of a continuous nature, or the likelihood is unknown. There is likely to be an event at least once a year or greater (up to ten times per year). It often occurs in similar environments. The event is expected to occur in most circumstances.
Likely (Has occurred in recent history)	There is likely to be an event on average every one to five years. Likely to have been a similar incident occurring in similar environments. The event will probably occur in most circumstances.
Possible (Could happen, has occurred in the past, but not common)	The event could occur. There is likely to be an event on average every five to twenty years.
Unlikely (Not likely or uncommon)	The event could occur but is not expected. A rare occurrence (once per one hundred years).
Remote (Rare or practically impossible)	The event may occur only in exceptional circumstances. Very rare occurrence (once per one thousand years). Unlikely that it has occurred elsewhere; and, if it has occurred, it is regarded as unique.

Table 25: Consequence criteria

Consequence category	Description
Critical (Severe, widespread long-term effect)	Destruction of sensitive environmental features. Severe impact on ecosystem. Impacts are irreversible and/or widespread. Regulatory and high-level government intervention/action. Community outrage expected. Prosecution likely.
Major (Wider spread, moderate to long term effect)	Long-term impact of regional significance on sensitive environmental features (e.g. wetlands). Likely to result in regulatory intervention/action. Environmental harm either temporary or permanent, requiring immediate attention. Community outrage possible. Prosecution possible.
Moderate (Localised, short-term to moderate effect)	Short term impact on sensitive environmental features. Triggers regulatory investigation. Significant changes that may be rehabilitated with difficulty. Repeated public concern.
Minor (Localised short-term effect)	Impact on fauna, flora and/or habitat but no negative effects on ecosystem. Easily rehabilitated. Requires immediate regulator notification.
Negligible (Minimal impact or no lasting effect)	Negligible impact on fauna/flora, habitat, aquatic ecosystem or water resources. Impacts are local, temporary and reversible. Incident reporting according to routine protocols.

Table 26: Risk matrix

Consequence	Likelihood				
	Almost certain	Likely	Possible	Unlikely	Remote
Critical	Very High	Very High	High	High	Medium
Major	Very High	High	High	Medium	Medium
Moderate	High	Medium	Medium	Medium	Low
Minor	Medium	Medium	Low	Low	Very Low
Negligible	Medium	Low	Low	Very Low	Very Low

Table 27: Risk assessment

Potential impact	Project phase	Risk (pre-mitigation)	Risk (post mitigation)
Vegetation clearing outside clearing footprint	Construction / operation	Medium	Low
Sedimentation and contaminated and/or nutrient rich run-off offsite	Construction	Medium	Low
Noise, dust or light spill	Construction	Low	Low
Rubbish dumping	Construction / operation	Low	Very low
Wood collection	Construction / operation	Low	Very low
Bush rock removal and disturbance	Construction / operation	Low	Very low
Increase in predatory species populations	Construction / operation	Low	Very low
Increase in pest animal populations	Construction / operation	Low	Very low

Potential impact	Project phase	Risk (pre-mitigation)	Risk (post mitigation)
Disturbance to specialist breeding and foraging habitat, e.g. hollow-bearing trees impacting on fauna	Construction	Medium	Low
Risk of anthropogenic fire (and associate impact on adjacent vegetation)	Construction / operation	Low	Low

2.4 Impact summary

Following implementation of the BAM and the BAMC, the following impacts have been determined.

2.4.1 Serious and Irreversible Impacts

The development does not have any SAII.

2.4.2 Impacts requiring offsets

The impacts of the development requiring offset for native vegetation are outlined in Table 28 and shown on Figure 12. The impacts of the development requiring offset for threatened species and threatened species habitat are outlined in Table 29 and on Figure 12.

Table 28: Impacts to native vegetation that require offsets

PCT ID	PCT Name	Vegetation Class	Vegetation Formation	Direct impact (ha)
568	Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion	New England Dry Sclerophyll Forest	Dry Sclerophyll Forest (Shrub/grass sub-formation)	4.63

Table 29: Impacts on threatened species and threatened species habitat that require offsets

Species	Common Name	Direct impact habitat (ha)	Relevant Veg Zone	NSW listing status	EPBC Listing status
Vespadelus troughtoni	Eastern Cave Bat	4.63	Zone 2 (good)	Vulnerable	Not Listed

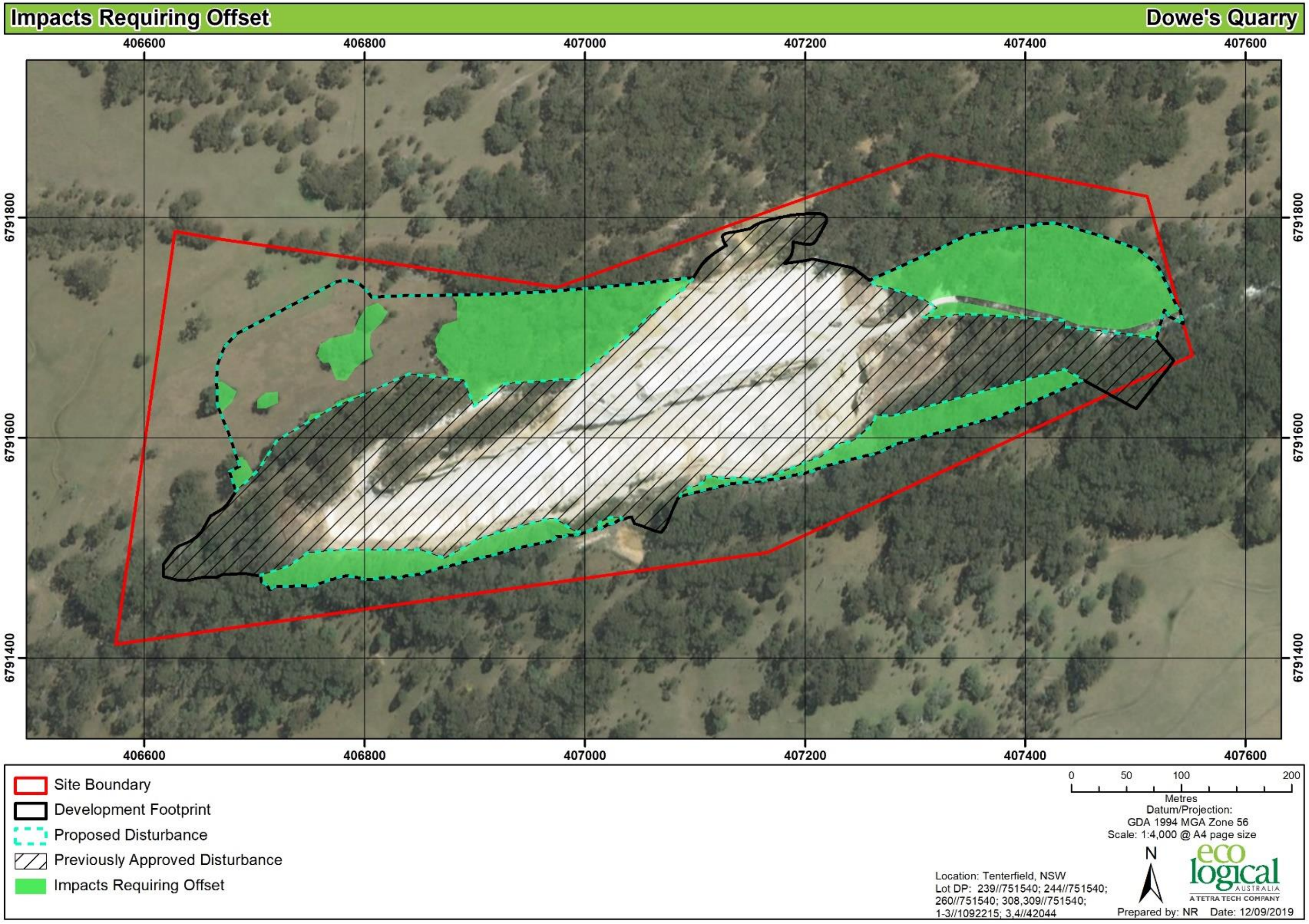

Figure 12: Impacts Requiring Offset

2.4.3 Impacts not requiring offsets

The impacts of the development not requiring offset for native vegetation are outlined in Table 30 and shown on Figure 13.

Table 30: Impacts to native vegetation that do not require offsets

PCT ID	PCT Name	Vegetation Class	Direct impact (ha)	Rationale
568	Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion	Poor	1.78	Vegetation integrity score of 3. This is below the offset threshold.

2.4.4 Areas not requiring assessment

Areas not requiring assessment are shown on Figure 14. These are cleared areas which are part of the existing quarry and areas of previously approved disturbance associated with a previously approved extension of the quarry.

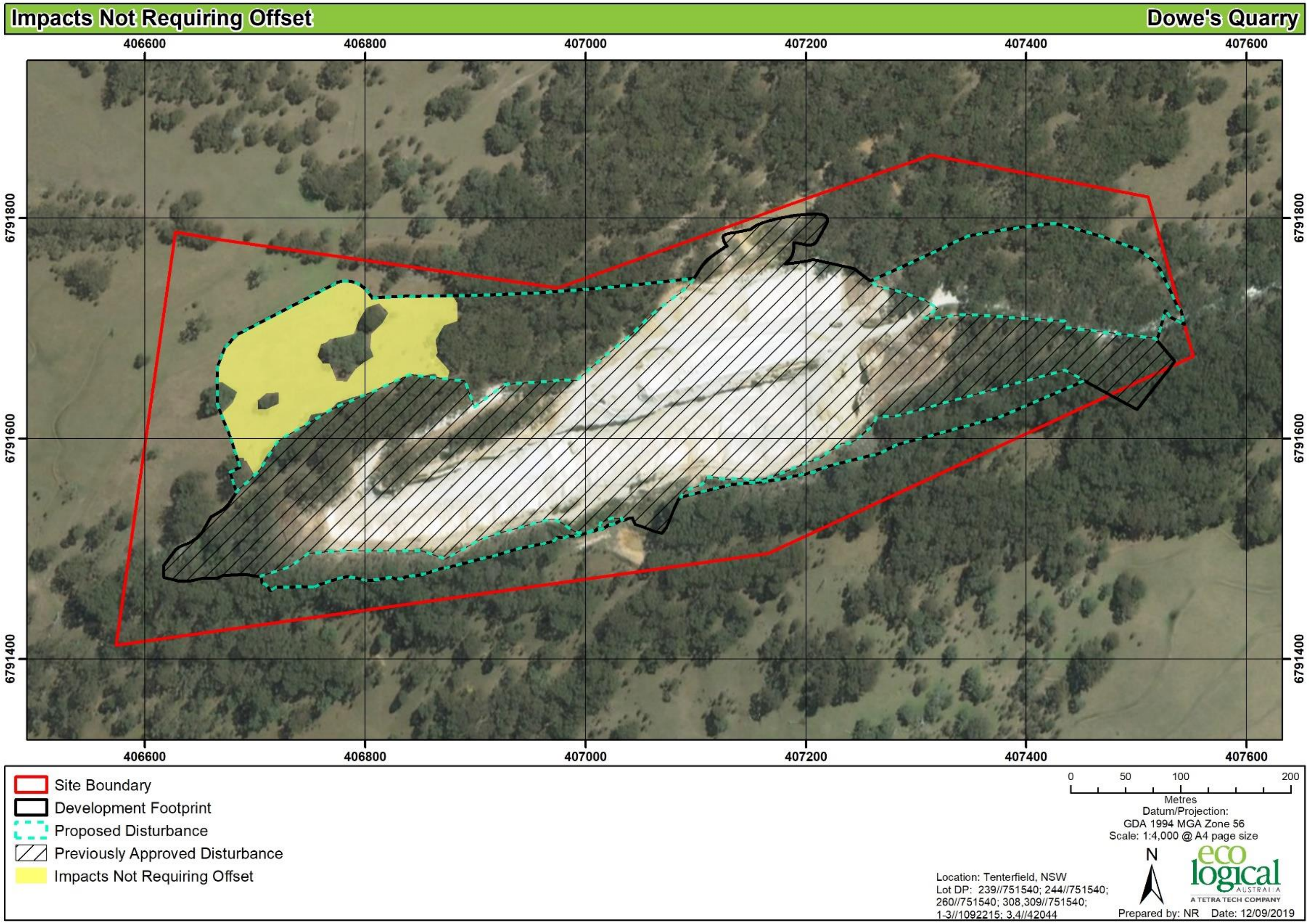

Figure 13: Impacts not requiring offset

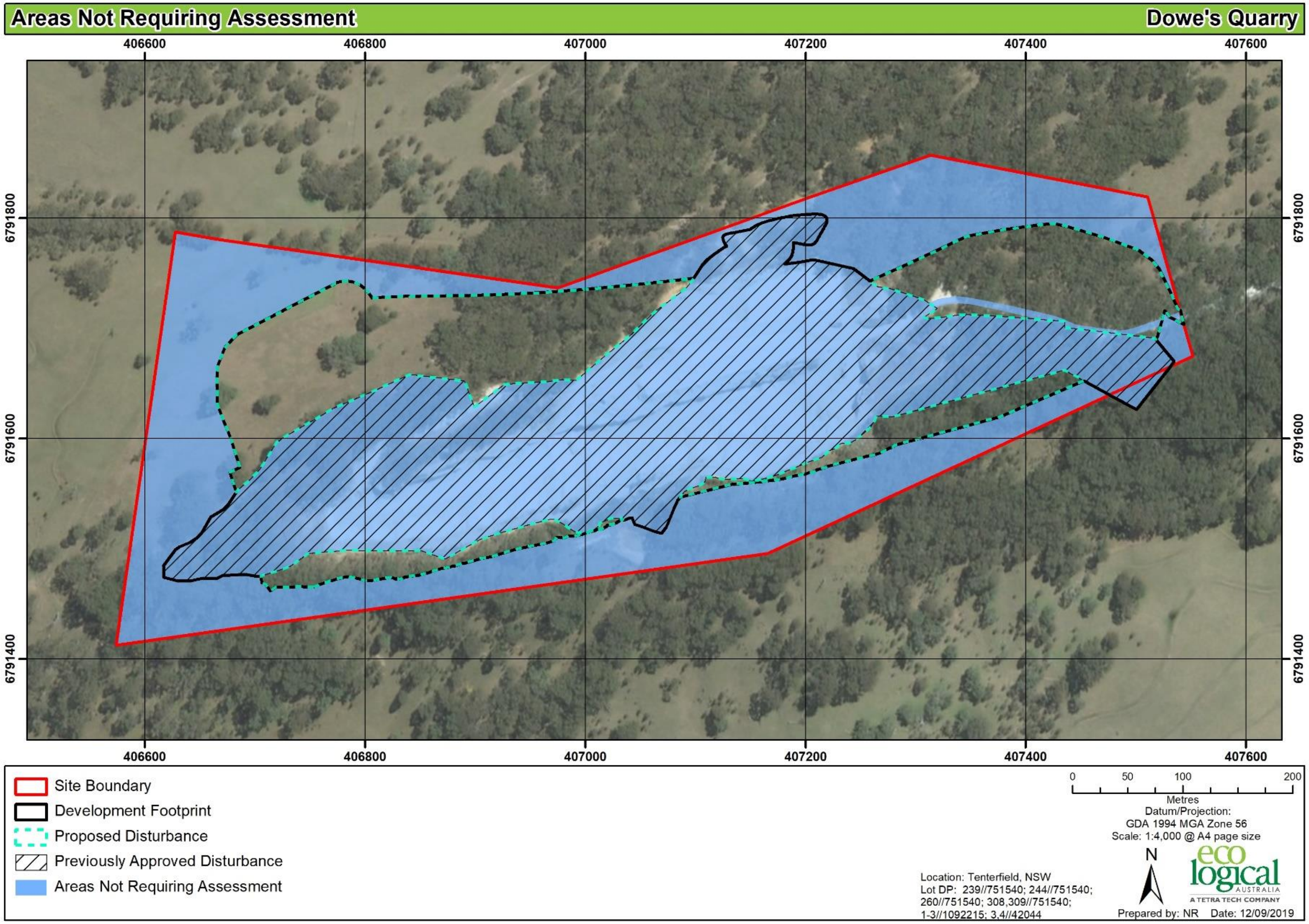

Figure 14: Areas not requiring assessment

2.4.5 Credit summary

The number of ecosystem credits required for the development are outlined in Table 31. The number of species credits required for the development are outlined in Table 32. A biodiversity credit report is included in Appendix C.

Table 31: Ecosystem credits required

PCT ID	PCT Name	Vegetation Formation	Direct impact (ha)	Credits required
568	Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion	New England Dry Sclerophyll Forest	4.63	134

Table 32: Species credit summary

Species	Common Name	Direct impact habitat (ha)	Relevant Veg Zone	Credits required
Vespadelus troughtoni	Eastern Cave Bat	4.63	Zone 2 (good)	230

2.5 Consistency with legislation and policy

Additional matters relating to impacts on flora and fauna which are not covered by the BC Act must also be addressed for the proposed development. Potential impacts on MNES in accordance with the EPBC Act have been addressed below, along with SEPP 44 requirements.

2.5.1 Environment Protection and Biodiversity Conservation Act (EPBC Act) 1999.

The EPBC Act is the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places, which are known under the Act as MNES. The Act requires that if an action has, will have, or is likely to have a significant impact on MNES, it must be referred to the Australian Government Minister for the Environment for consideration. The Minister may require further assessment and approval of an action, which in this instance is deemed a 'controlled action'.

Eleven MNES threatened species and fifteen migratory species are considered as having a likelihood of occuring onsite based on desktop review, including PMST search, NSW BioNet Records, Atlas of Living Australia records, aerial imagery and the BAMC.

Following habitat assessments and survey onsite as part of this report, the list of MNES that are known or have the potential to occur on site has been reduced to three threatened species and two migratory species. An assessment of impacts for these species is presented below and has been undertaken in accordance with *EPBC Act Significant impact guidelines 1.1* and other relevant policy advice.

The results of the detailed assessments for species known or with the potential to occur on site are presented in the tables below. The overall conclusion is that the project is unlikely to have a significant impact on MNES.

The full suite of EPBC Act listed threatened species considered include:

- Spotted-tailed Quoll – potential foraging habitat occurs on site, further assessment provided
- Koala – potential foraging habitat occurs on site, further assessment provided
- Grey-headed Flying-fox – potential foraging habitat occurs on site, further assessment provided
- Swift Parrot – no habitat identified on site, no further assessment
- Brush-tailed Rock-wallaby – no habitat identified on site, no further assessment
- Mac Nutt’s Wattle – not recorded on site during surveys, no further assessment
- Beadle’s Grevillea – site is outside this species’ geographic range, no further assessment
- Narrow-leaved Black Peppermint – not recorded on site during surveys, no further assessment
- Bolivia Wattle – not recorded on site during surveys, no further assessment
- Hairy Jointgrass – not recorded on site during surveys, no further assessment
- Austral Toadflax – not recorded on site during surveys, no further assessment

The full suite of EPBC Act listed migratory species considered include:

- Fork-tailed Swift - potential foraging habitat occurs on site, further assessment provided
- Satin Flycatcher - potential foraging habitat occurs on site, further assessment provided
- Black-faced Monarch - unlikely to occur on site based on available habitat, no further assessment
- Rufous Fantail - unlikely to occur on site based on available habitat and previous records, no further assessment
- Oriental Cuckoo/Horsfield's Cuckoo – unlikely to occur on site based on available habitat and previous records, no further assessment
- White-throated Needletail – unlikely to occur on site based on available habitat and previous records, no further assessment
- Spectacled Monarch – unlikely to occur on site based on available habitat and previous records, no further assessment
- Yellow Wagtail – unlikely to occur on site based on available habitat and previous records, no further assessment
- Common Sandpiper – unlikely to occur on site based on available habitat and previous records, no further assessment
- Sharp-tailed Sandpiper – unlikely to occur on site based on available habitat and previous records, no further assessment
- Curlew Sandpiper – unlikely to occur on site based on available habitat and previous records, no further assessment
- Pectoral Sandpiper – unlikely to occur on site based on available habitat and previous records, no further assessment, no further assessment
- Latham's Snipe/Japanese Snipe – unlikely to occur on site based on available habitat and previous records, no further assessment
- Osprey – unlikely to occur on site based on available habitat and previous records, no further assessment

Table 33: Assessment of Significance: Spotted-tailed Quoll (endangered)

Criterion	Question	Response
An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility of the following:		
1)	will the action lead to a long-term decrease in the size of a population	No. This species was not identified on site during surveys. The project area provides potential foraging habitat for the species and a limited number of fallen logs and hollow-bearing trees that may be used as dens. The habitat within the project area is fragmented due to the location of the existing quarry, however is connected to a large area of contiguous vegetation of ~340 ha. This connectivity is important, as the species is known to require suitable denning sites, an abundance of small prey items and large areas of relatively intact vegetation through which to forage (DoELWP 2016). The Tenterfield population of this species is listed as an important stronghold population, i.e. an area of high abundance in the region (DoELWP 2016). In the context of the local population size and the availability of a large area of contiguous vegetation, the removal of 4.63 ha of potential foraging habitat is unlikely to lead to a long-term decrease in the size of a population of this species. This is especially so, given there is no evidence of current site use by the species.
2)	will the action reduce the area of occupancy of the species	No. There is currently no evidence that the species is occupying the project area. The proposal will result in the removal of 4.63 hectares of native vegetation which is considered potential foraging habitat. Given the position of this vegetation in the landscape i.e surrounding an existing quarry and on the edge of a large contiguous patch of vegetation, it is not considered that its removal will reduce the overall area of occupancy of this species.
3)	will the action fragment an existing population into two or more populations	No. The project is located such that connectivity to adjacent habitat is maintained by: • retaining a corridor of vegetation along the southern boundary of the site, which retains the connection between habitat to the east and west of the project, and • retaining a strip of vegetation along the eastern boundary which connects it to a large area of vegetation to the north. The vegetation remaining in the project area is part of a contiguous vegetation patch of approximately 340ha.
4)	will the action adversely affect habitat critical to the survival of a species	No. Habitat critical to the survival of the species is defined for the Spotted-tailed Quoll as large patches of forest with adequate denning resources and relatively high densities of medium-sized mammalian prey (DoELWP 2016). Given there is no evidence to suggest potential habitat within the project is currently utilised by quolls, and that the denning resources are few, it is concluded that the project area does not support habitat critical to the survival of this species.
5)	will the action disrupt the breeding cycle of a population	No. The project areas contains limited denning resources such as hollow bearing trees and fallen logs, but it does not contain significant rock outcrops, rock shelters or caves which are denning sites known to be important for supporting breeding. Further, only a small area (4.63 ha) of vegetation will be removed, relative to that available in directly connected landscapes (i.e. ~340 ha of contiguous vegetation).

Criterion	Question	Response
6) i	will the action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	No. The proposal will result in the removal of 4.63 ha of native vegetation which is considered potential foraging habitat, as well as some limited denning resources. The species is known to require suitable denning sites, an abundance of small prey items and large areas of relatively intact vegetation through which to forage (DoELWP 2016). The removal of a small area of habitat is unlikely to alter the key habitat resources for the species in the wider landscape and therefore results in a population decline.
6) ii	will the action result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	No. This species is known to have competition from and predation by dogs, cats and foxes. However, the project area is situated in a mix of rural/ cleared and vegetated areas, and within the project area is an existing quarry. The expansion of the existing quarry footprint is not likely to exacerbate any existing threats from invasive species, which already exist within the wider area.
7)	will the action introduce disease that may cause the species to decline	No. There are no diseases that are known to threaten this species.
8)	will the action interfere with the recovery of the species	No. The overall recovery objective for this species is to reduce the rate of decline of the Spotted-tailed Quoll, and ensure that viable populations remain throughout its current range in eastern Australia (DoELWP 2016). There are 11 specific recovery objectives also identified. The proposal will result in a small reduction in potential foraging habitat in an area that is not currently known to be occupied by the species. It is therefore considered that this will not affect the rate of decline (or increase) of the species and nor will the local population's viability be affected. The proposal is not inconsistent with the 11 specific recovery objectives.

Table 34: Assessment of Significance: Grey-headed Flying-fox (vulnerable)

Criterion	Question	Response
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:		
1)	lead to a long-term decrease in the size of an important population of a species	No. There are not distinct populations of the Grey-headed Flying-fox (GHFF) across the species' geographic range. However, the national population is spatially structured into colonies. Known roosting sites are regularly monitoring on the National Flying-fox monitoring viewer (DotEE 2016) and criteria established for determining nationally important roosts.

Criterion	Question	Response
		The closest known GHFF camp as identified on the National Flying-fox monitoring viewer (DotEE 2016) is approximately 98 km east of the development site at Casino (Figure 15). The largest estimated size of this camp is in November 2012 with 10,000-16,000 individuals. It was last estimated at 500-2,500 individuals in November 2018. Given the proximity of this camp is approximately double the known foraging radius for this species and that no individuals were identified during survey, it is considered that the project area does not support an important population of GHFF.
2)	reduce the area of occupancy of an important population	No. The project area is not considered to support an important population of GHFF – see criterion 1 above.
3)	fragment an existing important population into two or more populations	No. The project area is not considered to support an important population of GHFF – see criterion 1 above.
4)	adversely affect habitat critical to the survival of a species	No. The draft recovery plan for GHFF (DECCW 2009) defines habitat critical to the survival of the species, both for foraging and breeding habitats. Habitat within the project area does not meet these definitions, primarily due to the lack of known large camps (i.e. >2,500 individuals) within 50 km of the project area and/or evidence of breeding individuals.
5)	disrupt the breeding cycle of an important population	No. The project area is not considered to support an important population of GHFF – see criterion 1 above. There is no breeding habitat within the project area.
6)	modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	No. Habitat within the project area provides foraging resources and there are no known camps in the vicinity. The proposal will result in the removal of 4.63 ha of foraging resources. Given these resources are connected to a large area of continuous vegetation and that the nearest known camp is approximately twice the nightly foraging distance from the project area, it is considered unlikely that the removal of a small area of foraging habitat will result in the decline of the species.
7)	result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	No. The most relevant invasive species in the context are weeds, that may degrade the quality of foraging resources. The project area is situated in a mix of rural/ cleared and vegetated areas, and within the project area is an existing quarry. The expansion of the existing quarry footprint is not likely to exacerbate any existing threats from weeds, which already exist within the wider landscape.
8)	introduce disease that may cause the species to decline, or	No. GHFFs are reservoirs for the Australian bat lyssavirus (ABL) and can cause clinical disease and mortality in GHFF (DECCW 2009). The proposed action is unlikely to present a significant ecological stress on any camps or on individuals that may utilise the subject site and therefore the works are unlikely to introduce or exacerbate this virus or any other disease that may cause this species to decline.

Criterion	Question	Response
9)	interfere substantially with the recovery of the species.	No. A Draft National Recovery Plan for the Grey-headed Flying-fox was developed in 2009 (DECCW 2009) and lists three overall recovery objectives including: • to reduce the impact of threatening processes on Grey-headed Flying-foxes and arrest decline throughout the species' range • to conserve the functional roles of Grey-headed Flying-foxes in seed dispersal and pollination • to improve the standard of information available to guide recovery of the Grey-headed Flying-fox, in order to increase community knowledge of the species and reduce the impact of negative public attitudes on the species. There are 13 associated specific objectives. The removal of 4.63 ha of foraging habitat far from the nearest known camp is not likely to interfere with the recovery of the species and does not contradict the desired specific outcomes listed in the recovery plan.

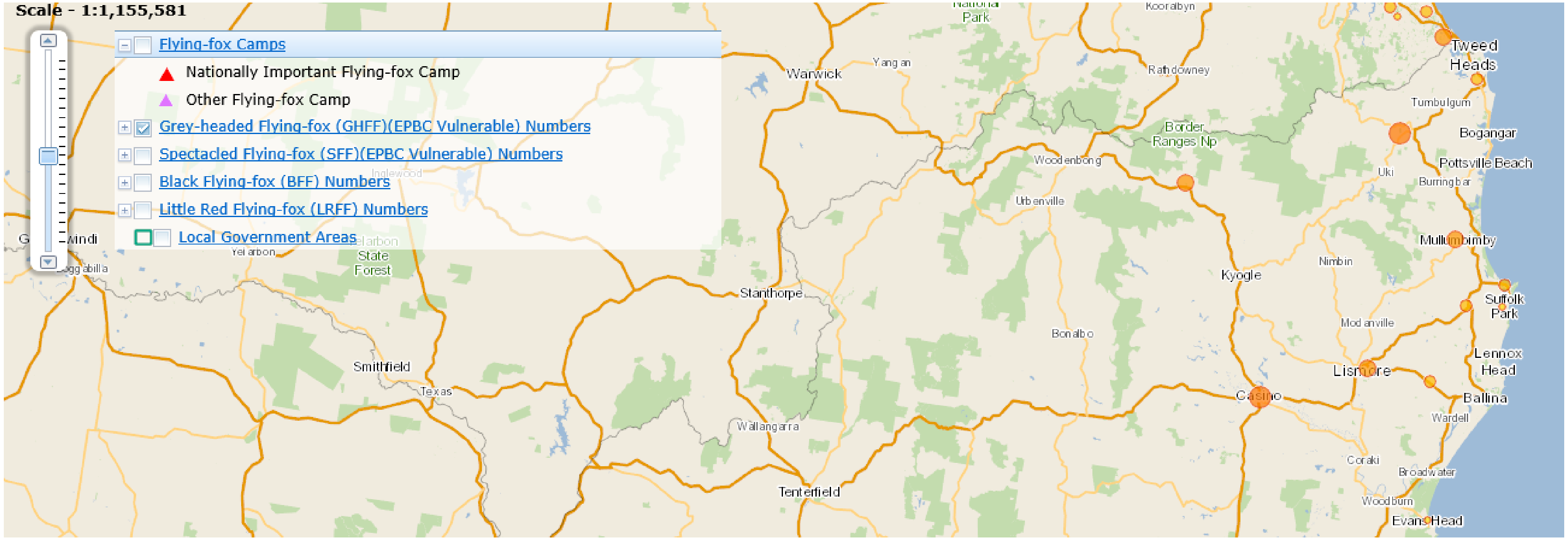

Figure 15: National Flying-fox monitoring viewer map

The EPBC Act Referral Guidelines for the vulnerable Koala (DoE, 2014) provides assessment criteria and a scoring system to assist in determining the presence of 'habitat critical to the survival of the Koala'. Under the Guidelines, impact areas that score 5 or higher are considered to contain 'habitat critical to the survival of the Koala'. These criteria have been applied to the project area, with a resulting score of 6 (see Table 36). Therefore, the following assessment has been undertaken on the basis that the project area provides habitat critical to the survival of the species.

Table 35: Assessment of Significance: Koala (vulnerable)

Criterion	Question	Response
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:		
1)	lead to a long-term decrease in the size of an important population of a species	No. There is evidence of historical use of the project area by Koala (ELA 2014), however the conclusion of this report was that there was a low density of Koala activity across the site. This is supported by the lack of recent evidence of Koala presence or site usage. Furthermore, the project area does not contain any primary food trees and only two species of secondary food tress, thereby limiting the likely value of the site to the species. It is therefore considered that there is not an important population of Koala in the project area.
2)	reduce the area of occupancy of an important population	No. The project area is not considered to support an important population of Koala – see criterion 1 above.
3)	fragment an existing important population into two or more populations	No. The project area is not considered to support an important population of Koala – see criterion 1 above.
4)	adversely affect habitat critical to the survival of a species	Unlikely. When considered against the criteria in the EPBC Act Referral Guidelines for the vulnerable Koala (DoE, 2014), the features of the project area should be considered habitat critical to the survival of the species. The proposal will result in clearing of 4.63 ha of such habitat. The Koala referral guidelines provide advice about the thresholds beyond which the clearing of habitat critical to the survival of the Koala would be considered significant, these include: • For habitat scoring 5 – 100 ha • For habitat scoring 6 or 7 – 25 ha • For habitat scoring 7 or 8 – 10 ha • For habitat scoring 9 or 10 – 5 ha The clearing for the project is under these thresholds and is therefore not considered to be a significant impact on habitat critical to the survival of the species.
5)	disrupt the breeding cycle of an important population	No. The project area is not considered to support an important population of Koala – see criterion 1 above.
6)	modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that	No. There is evidence of historical use of the project area by Koala (ELA 2014), however the conclusion of this report was that there was a low density of Koala activity across the site. This is supported by the lack of recent evidence of Koala

Criterion	Question	Response
	the species is likely to decline	presence or site usage. Furthermore, the project area does not contain any primary food trees and only two species of secondary food tress, thereby limiting the likely value of the site to the species. It is therefore considered unlikely that the removal of 4.63 ha of foraging habitat (secondary food trees) would result in the decline of this species.
7)	result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	No. Dog attack is listed as a key threat to this species. However, the project area is situated in a mix of rural/ cleared and vegetated areas, and within the project area is an existing quarry. The expansion of the existing quarry footprint is not likely to exacerbate the presence of dogs, which already exist within the wider area.
8)	introduce disease that may cause the species to decline, or	No. Chlamydia is a known threat to Koala and there is increasing evidence that other diseases may be impacting the population. However, the project is unlikely to present a significant ecological stress on any individuals that may utilise the subject site and therefore the works are unlikely to introduce or exacerbate Chlamydia or any other disease that may cause this species to decline.
9)	interfere substantially with the recovery of the species.	No. The Koala recovery plan (DECC 2008) provides a framework for localised recovery efforts throughout NSW through a number of recovery actions. The actions include: • Conserving Koalas in their existing habitat, rehabilitate and restore Koala habitat and populations • Develop a better understanding of the conservation biology of Koalas • Ensure that the community has access to factual information about the distribution, conservation and management of koalas at a national, state and local level • Manage captive, sick or injured Koalas and orphaned wild Koalas to ensure consistent and high standards of care • Manage overbrowsing to prevent both koala starvation and ecosystem damage in discrete patches of habitat • Coordinate, promote the implementation, and monitor the effectiveness of the NSW Koala Recovery Plan across New South Wales The project is not inconsistent with the above listed objectives, as there is no recent evidence of site usage and only a small area of habitat comprised of secondary food trees would be removed.

Table 36: Assessment of Koala habitat within the subject site^

Attribute	Score	Coastal context	Score	Justification
Koala occurrence	+2 (high)	Evidence of one or more Koalas within the last 2 years.	1	Scats of koala were identified during a targeted survey within the project area in 2014 (ELA, 2014)
	+1 (medium)	Evidence of one or more koalas within 2 km of the edge of the impact area within the last 5 years.		
	0 (low)	None of the above.		
Vegetation composition	+2 (high)	Has forest or woodland with 2 or more known Koala food tree species, OR 1 food tree species that alone accounts for >50% of the vegetation in the relevant strata.	2	*Eucalyptus moluccana* and *Eucalyptus caliginosa* are known secondary food tree species and occur within the site. As per the Koala referral guidelines (pp. 5), 'primary' and 'secondary' food trees are all considered to be 'food trees' for the purposes of assessment using these guidelines.
	+1 (medium)	Has forest or woodland with only 1 species of known Koala food tree present.		
	0 (low)	None of the above.		
Habitat connectivity	+2 (high)	Area is part of a contiguous landscape ≥ 500 ha.	1	Native vegetation within the site is part of contiguous vegetation patch of 380ha
	+1 (medium)	Area is part of a contiguous landscape < 500 ha, but ≥ 300 ha.		
	0 (low)	None of the above.		
Key existing threats	+2 (high)	Little or no evidence of Koala mortality from vehicle strike or dog attack at present in areas that score 1 or 2 for Koala occurrence. Areas which score 0 for Koala occurrence and have no dog or vehicle threat present	2	No records of deceased koalas within or adjacent to the area were found within the Wildlife Atlas or included the Northern Tablelands Koala Recovery Strategy 2015-2025 (Northern Tablelands Local Land Services, 2016).
	+1 (medium)	Evidence of infrequent or irregular Koala mortality from vehicle strike or dog attack at present in areas that score 1 or 2 for Koala occurrence, OR Areas which score 0 for koala occurrence and are likely to have some degree dog or vehicle threat present.		
	0 (low)	Evidence of frequent or regular Koala mortality from vehicle strike or dog attack in the study area at present, OR		

		Areas which score 0 for Koala occurrence and have a significant dog or vehicle threat present.		
Recovery value	+2 (high)	Habitat is likely to be important for achieving the interim recovery objectives for the relevant context.	0	The study area is located in between two populations which are not connected due to an existing barrier. However, a record of koala within the site was found in 2014, and the site is connected to a large area of vegetation to the north which contains the northern population. A relevant recovery objective is: conserving Koalas in their existing habitat, rehabilitate and restore Koala habitat and populations. It is unlikely that this will be an important habitat to achieve this.
	+1 (medium)	Uncertain whether the habitat is important for achieving the interim recovery objectives for the relevant context.		
	0 (low)	Habitat is unlikely to be important for achieving the interim recovery objectives for the relevant context.		
Habitat score:			6	

Conclusion:

- As per the Guidelines (DoE, 2014), Impact areas that score five or more using the habitat assessment tool for the koala contain habitat critical to the survival of the koala.
- Due to the score of six, the impact area is assessed as containing habitat critical to the survival of the Koala.

^ The subject site is categorised as a 'coastal' area as it experiences more than 800 millimetres of rainfall per annum, and as defined in Map 2 of the Guidelines (DoE, 2014).

Table 37: Assessment of Significance: Listed Migratory Species

Criterion	Question	Response
1)	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of **important habitat** for a migratory species	The area impacted contains potential important habitat for the two identified migratory species. Important habitat is defined in the guidelines (DoE, 2015) as follows: Fork-tailed Swift – Found across a range of habitats, from inland open plains to wooded areas, where it is exclusively aerial. Satin Flycatcher – Eucalypt forest and woodlands, at high elevations when breeding. They are particularly common in tall wet sclerophyll forest, often in gullies or along water courses. In woodlands they prefer open, grassy woodland types. During migration, habitat preferences expand, with the species recorded in most wooded habitats except rainforests. The area thresholds of important habitat for each species likely to result in a significant impact if affected is given bellow (DoE, 2015). Fork-tailed Swift – Not determined Satin Flycatcher – 4,400 ha[2] The area impacted does not meet the area thresholds for the Satin Flycatcher and only represents a minute proportion of the available potential habitat within the locality for the Fork-tailed Swift. Given the extensive areas of suitable habitat available nearby for the species, it is

Criterion	Question	Response
		unlikely that the proposal will result in a significant impact to these species.
2)	Result in an invasive species that is harmful to the migratory species becoming established in an area of **important habitat** for the migratory species	Although the area impacted does contain important habitat for the four species, the proposal is unlikely to introduce any new invasive species to the locality.
3)	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an **ecologically significant proportion of the population** of a migratory species	This question does not apply as the proposal will affect substantially less than the ecologically significant proportion of the population given in the guidelines (DoE, 2015): Fork-tailed Swift – 1,000 individuals Satin Flycatcher – 17,000 individuals

2.5.2 SEPP 44

The proposed development is located within a Local Government Area to which SEPP 44 applies. The identification of an area of land as Potential Koala Habitat is determined by the presence of primary koala-food tree species. These species are listed under Schedule 2 of SEPP 44: Koala Habitat Protection.

Potential Koala Habitat is defined as areas where the tree species listed under Schedule 2 constitute at least 15% of the total number of trees in the upper and lower strata of the tree component.

The Schedule 2 Primary Preferred food species occurring in the Tenterfield LGA are: *Eucalyptus punctata* (Grey Gum), *E. microcorys* (Tallowwood), *E. robusta* (Swamp Mahogany), *E. tereticornis* (Forest Red Gum) and *E. viminalis* (Manna Gum).

The subject land does not contain any koala feed trees listed on Schedule 2 of SEPP No. 44, hence is not Potential Koala Habitat. Therefore, assessment for Core Koala Habitat is not required.

No further provisions of SEPP 44 are relevant to the proposal.

3. References

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Appendix A AREA Environmental Consultants and Communications Targeted Species Search Report

Dowe's Quarry
Targeted Species Search
Tenterfield LGA
March 2020

AREA
ENVIRONMENTAL CONSULTANTS & COMMUNICATION

AREA Environmental Consultants & Communication
(a) 6 Belmore Street Dubbo NSW 2830
(b) "Thieles Gate" (Type 2 Conservation Agreement Area) 79 Huonbrook Rd Mullumbimby NSW 2482
Ph 0409 852 098
phil@areaenvironmental.com.au

- ✓ Environmental impact assessment, approvals and adulting
- ✓ Preliminary environmental assessment (PEA)
- ✓ Review of environmental factors (REF) & Minor Work REF
- ✓ Ecology assessments & biodiversity offsetting (BAM and Biobanking)
- ✓ Aboriginal & heritage assessments and community walkovers
- ✓ Community engagement
- ✓ Peer review & quote or tender preparation or advice
- ✓ Landscape design and architecture

AREA Environmental Consultants & Communication acknowledges Traditional Owners of the country on which we work

Dowe's Quarry
Targeted Species Search

March 2020

Prepared by: **AREA Environmental Consultants & Communication Pty Ltd**
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Document Controls

Proponent	Darryl McCarthy Constructions Pty Ltd
Client	RW Corkery & Co Pty Limited Geological and Environmental Consultants
AREA Job No.	QU-0220
Document Description	Dowe's Quarry Targeted species survey report
Clients Representative Managing this Document	Nick Warren Principal Environmental Consultant
AREA Person(s) Managing this Document	Phil Cameron (PJC)
Cover page image	Dowe's Quarry

Document Status	Version	Date	Action
DRAFT (Internal document)	V1.0	13/11/19	DS to PJC
	V1.1	13/11/19	Reviewed / certified
DRAFT (AREA / Client)	V2.0	13/11/19	AREA to client
FINAL	V3.0	14/11/2019	AREA to Client
	V3.1	13/1232019	AREA to Client (minor revision)
	V3.1	20/01/2020	Client to AREA
	V3.2	20/02/2020	AREA to Client (minor revision)
	V3.3	17/03/2020	AREA to Client (minor revision after BCD guidance)

Prepared For	Nick Warren Principal Environmental Consultant B.Sc., M. Bus., M. Env.Sc. Phone: 02 9985 8511 Mobile: 0437 635 975 Email: nick@rwcorkery.com RW Corkery & Co Pty Limited Geological and Environmental Consultants
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Certified by	Phillip Cameron CEnvP, NSW Biodiversity Assessment Method (BAAS17082) & Biobanking (0117) accredited The Common Seal of AREA ACN: 61605290867

Contents

1 Introduction

1.1 Background

Dowe's Quarry (subject site) is in the Tenterfield Shire approximately eight kilometres north east of Tenterfield. Access to the Quarry is via Mount Lindsay Road.

The Quarry operator/manager Darryl McCarthy Construction Pty Ltd (the Applicant) is seeking approval for the expansion of the existing Dowe's Quarry.

AREA Environmental Consultants & Communication (AREA) was engaged by R.W. Corkery to complete a targeted threatened species search for species credit species that were unable to be surveyed for during the initial surveys carried out for preparation of a Biodiversity Development Assessment Report (BDAR) (Eco Logical Australia, 2019) due to the seasonal timing / limitations of the initial assessment.

Figure 1-1:Regional Context

1.2 Previous Studies

On 22 April through to the 26 April 2019 Eco Logical Australia ecologists surveyed the development site for a Biodiversity Development Assessment Report (BDAR) to support an Environmental Impact Assessment (EIS) developed for the proposal.

Eco Logical Australia prepared the following BDAR following the Biodiversity Assessment Method (BAM) under section 6.7 of the BC Act:

- *Eco Logical Australia. 2019 Dowe's Quarry BDAR. Prepared for R.W. Corkery & Co Pty Ltd on behalf of Darryl McCarthy Constructions Pty Ltd* (Eco Logical, 2019).

AREA concurs with all the results and conclusions of the Eco Logical BDAR.

This survey found the subject site to contain one Plant Community Type (PCT) PCT568-*Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion.* This consisted of 4.63 hectares in good condition and 1.78 hectares in poor condition.

No threated species or threatened ecological communities were found within the development site. As the Eco Logical study was conducted in April 2019, the following 11 species credit species were not detectable at the time the assessment occurred and were assumed as present:

- Barking Owl (*Ninox connivens*)
- Powerful Owl (*Ninox strenua*)
- Masked Owl (*Tyto novaehollandiae*)
- Eastern Pygmy-possum *(Cercartetus nanus)*
- Eastern Cave-bat (*Vespadelus troughtoni*)
- Little Eagle (*Hieraaetus morphnoides*)
- Square-tailed Kite (*Lophoictinia isura)*
- White-bellied Sea Eagle (*Haliaeetus leucogaster*)
- Grey-headed Flying Fox (*Pteropus poliocephalus)*
- Austral Toadflax (*Thesium australe*)
- Bolivia Wattle (*Acacia pycnostachya)*

1.3 Study Area

Dowe's Quarry is located approximately eight kilometres north east of Tenterfield NSW in the Tenterfield local Government Area located on rural land. The land is privately owned and leased to the Applicant. Access is obtained via Mount Lindesay road with a 1.3-kilometre access road linking the Quarry to via Mount Lindesay Road.

The Manager/Operator of Dowe's Quarry has run the quarry since 1987 and is proposing to expand the disturbance area for the operation and increase the annual production rate from 150,000tpa to 230, 000tpa (Dowe's Quarry Environmental Impact Statement RWC, 2019).

Figure 1-3: Development Site

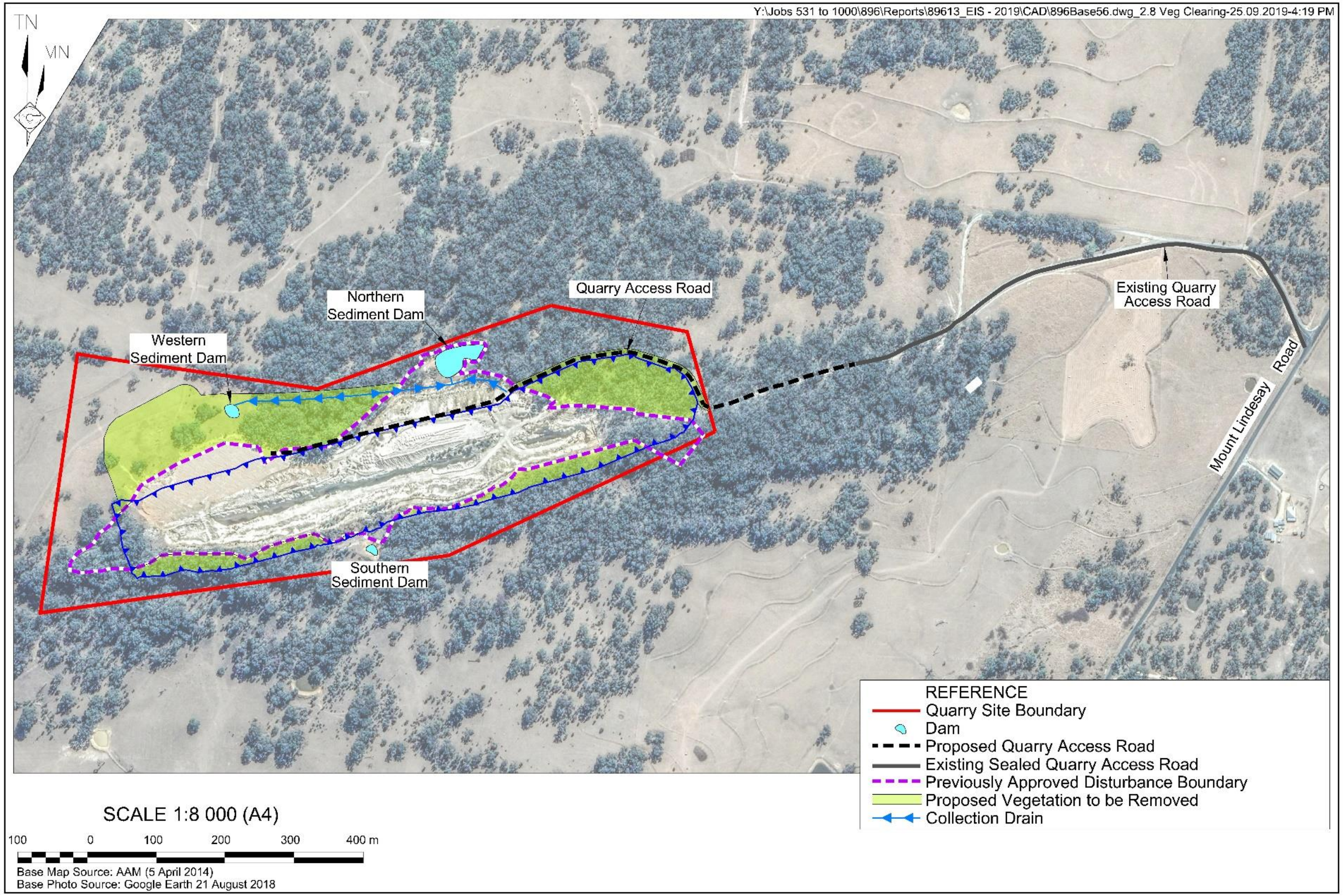


Image source: “Eco Logical Australia. 2019 Dowe’s Quarry BDAR. Prepared for R.W. Corkery & Co Pty Ltd on behalf of Darryl McCarthy Constructions Pty Ltd’

1.4 Scope

AREA was commissioned to complete targeted surveys for the species credit species identified in Section 1.2. Details of areas staff used in this project have been provided in **Table 1-1**.

Table 1-1: Contributors

Name	Position	CV Details	Relationship with this project
AREA	All staff	• NSW OEH Scientific License: 101087 • NSW DPI Ethics Approval 17/459 (3) P18/0035 Miscellaneous Blanket Permit – NSW Department of Primary Industries Fisheries	In accordance with the accredictation
Phillip Cameron	Principal consultant	• BSc. Major in Biology. Macquarie University • Ass Dip App Sci. University of Queensland • Certified Environmental Practitioner (EIANZ) • Lean Six Sigma Certificate (Sydney Uni) • NSW OEH BioBanking and Bio-certification Assessor: accreditation number 0117 • NSW OEH Scientific License: 101087 • NSW DPI Ethics Approval 11/5475 • Practicing member of the NSW Ecological Consulting Association • Practicing member of the Environment Institute of Australia and New Zealand (EIANZ) • National Railtrack Safety Induction (ARTC and John Holland Inductions) • WHS White Card and Blue Card • AHCPCM201- Recognising grasses	• Role • Project management • Report certification
Heidi Kolkert	Principal ecologist	• PhD candidate (Science) University of New England 2013 to current • BSc. (Hons) and Bachelor of Arts University of Tasmania Graduated 2005 • NSW OEH BioBanking and Bio-certification Assessor TAFE NSW • Practicing member of the NSW Ecological Consulting Association • WHS White Card and Blue Card • Apply First Aid (Medilife), Remote First Aid (St John)	• Role • Bat call analysis
Dave Sturman	Ecologist	• B. Env. Sc. Charles Sturt University • Cert III (Horticulture) • WHS White Card and Blue Card • White card – general construction induction card. • RMS-worker on foot training. • Senior First Aid • Chainsaw operator ticket • Confined Space worker and atmospheric monitoring. • Risk assessment training. • AHCPCM201- Recognising grasses	• Role • Ecology assessment, • Report writing. • Data analysis • Cartography

2 Method

2.1 Survey Requirements

The field assessment followed:

- *The Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities. Working Draft November 2004.*
- *'Species credit' threatened bats and their habitats NSW survey guide for the Biodiversity Assessment Method 2018*
- *Survey guidelines for Australia's threatened bats Guidelines for detecting bats listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999 Department of the Environment, Water, Heritage & the Arts*
- *NSW Guide to Surveying Threatened Plants 2016.*

Tables 2-1, **2-2**, **2-3** and **2-4** provide a copy of the survey requirement as well as methods employed by AREA staff in the field to meet this requirement. Rows in green fill show what relevant survey requirements for this assessment were completed for:

- Barking Owl (*Ninox connivens*)
- Powerful Owl (*Ninox strenua*)
- Masked Owl (*Tyto novaehollandiae*)
- Eastern Pygmy-possum *(Cercartetus nanus)*
- Eastern Cave-bat (*Vespadelus troughtoni*)
- Little Eagle (*Hieraaetus morphnoides*)
- Square-tailed Kite (*Lophoictinia isura)*
- White-bellied Sea Eagle (*Haliaeetus leucogaster*)
- Grey-headed Flying Fox (*Pteropus poliocephalus)*
- Austral Toadflax (*Thesium australe*)
- Bolivia Wattle (*Acacia pycnostachya).*

Table 2-1: Suggested survey methods and efforts for non-flying mammals

Page 1 of 2

Method	Effort per stratification unit up to 50 hectares, plus an additional effort for every additional 100 hectares	Animal sampled	Method used
Small Elliott traps	100 trap nights over 3-4 consecutive nights	small mammals	14 terrestrial traps of five nights totaling 70 trap nights. Less than required.
Large Elliott traps	100 trap nights over 3-4 consecutive nights	Medium to large mammals	N/A
Arboreal Elliott traps	24 trap nights over 3-4 consecutive nights	Arboreal mammals	11 Arboreal traps over five nights totalling 55 trap nights (collectively 125 trap nights for eastern pygmy possum including ground traps)
Wire cage traps	24 trap nights over 3-4 consecutive nights	Medium to large mammals	N/A
Pitfall traps with drift nets	24 trap nights over 3-4 consecutive nights	small mammals	N/A
Hair tubes	10 large and 10 small tubes in pairs for at least 4 days and 4 nights	small and medium mammals	N/A
Arboreal hair tubes	3 tubes in each of 10 habitat trees up to 100 hectares of stratification unit, for at least 4 days and 4 nights	arboreal mammals	N/A
Spotlighting on foot	2 x 1 hour and 1km up to 200 hectares of stratification unit, walking at approximately 1km per hour on 2 separate nights.	arboreal and terrestrial mammals	Completed five nights

Method	Effort per stratification unit up to 50 hectares, plus an additional effort for every additional 100 hectares	Animal sampled	Method used
Spotlighting from vehicle	2 x 1 km of track at maximum speed of 5km per hour up to 200 hectares of stratification. unit, on 2 separate nights	arboreal and terrestrial mammals	Completed one night
Sand plots	6 soil plots for 4 nights	mostly medium to large terrestrial mammals	N/A
Call playback	2 sites per stratification unit up to 200 hectares, plus an additional site per 100 hectares above 200 hectares. Each playback site must have the session conducted twice, on separate nights.	gliders, koalas	N/A

Table 2-1: Suggested survey methods and efforts for non-flying mammals (Cont'd)

Page 2 of 2

Method	Effort per stratification unit up to 50 hectares, plus an additional effort for every additional 100 hectares	Animal sampled	Method used
Stag-watching	Observing potential roost hollows for 30 minutes prior to sunset and 60 minutes following sunset	gliders and possums	Completed five nights.
Search for scats and signs	30 minutes searching each relevant habitat, including trees for scratch marks	all mammals	Opportunistically for five days
Track search	1km of track search with emphasis on where substrate is soft	mostly medium to large terrestrial mammals	N/A
Collection of predator scats	Opportunistic collection of predator scats for hair analysis	all mammals	N/A

Table 2-2: Suggested survey methods and effort for birds

Method	Effort per stratification unit up to 50 hectares, plus an additional effort for every additional 100 hectares or stratification unit up to 50 hectares, plus an additional effort for every additional 100 hectares	Time of assessment	Method used
Call playback	Sites should be separated by 800 metres – 1km, and each site must have the playback session repeated as follows: • at least 5 visits per site, on different nights are required for the Powerful Owl, Barking Owl and the Grass Owl; • at least 6 visits per site for the Sooty Owl, and 8 visits per site for the Masked Owl are required. Sites for Bush Stone-curlew surveys should be 2-4km apart and conducted during the breeding season.	All year	Completed five days / fiver nights
Day habitat search	Search habitat for pellets, and likely hollows. Flushing of Bush Stone-curlews by walking through potential habitat.	All year	Completed five days / four nights
Stag-watching	Observing potential roost hollows for 30mins prior to sunset and 60mins following sunset.	All year	Completed five days / five nights
Spotlighting	Spotlighting for Plains Wanderer and Bush Stone-curlew by foot or from a vehicle driven in first gear.	All year	Completed five days / five nights
Nesting observations	Observed characteristics of nesting construction. i.e.	All year	Completed

Method	Effort per stratification unit up to 50 hectares, plus an additional effort for every additional 100 hectares or stratification unit up to 50 hectares, plus an additional effort for every additional 100 hectares	Time of assessment	Method used
	Zero large stick nests were observed amongst the emergent canopy and the study area was not close to waterways.		five days / five nights

Table 2-3: Appropriate Survey Methods for Threatened Bat Species

Common name	Scientific Name	Roosts	Traps	Call Survey	Additional Methods
Eastern Cave Bat	*Vespadelus troughtoni*	S	□		Search rocks, overhangs and caves/mines
Grey-headed Flying Fox	*Pteropus poliocephalus*	Trees			Observed tree Canopies & spotlighting
Inland Forest Bat	*Vespadelus baverstocki*	H	□		
Large Pied Bat	*Chalinolobus dwyeri*	S	□	□	Search rocks, overhangs and caves/mines
Hoary Bat	*Chalinolobus nigrogriseus*	H	□	□	
Little Pied Bat	*Chalinolobus picatus*	H	□	□	
Greater Long-eared Bat	*Nyctophilus timoriensis*	H	□		Harp traps within vegetation
Northern Long-eared Bat	*Nyctophilus bifax*	H/V	□		
Greater Broad-nosed Bat	*Scoteanax rueppellii*	H		□	
Great Falsistrelle	*Falsistrellus tasmaniensis*	H	□		
Large-footed Myotis	*Myotis adversus* (also known as *Myotis macropus*)	S/H	□		Detector and spotlight around water bodies, trapping along riparian flyways
Golden-tipped Bat	*Kerivoula papuensis*	H/V	□		
Large Bentwing Bat	*Miniopterus schreibersii*	S	□		Search rocks, overhangs and caves/mines

Common name	Scientific Name	Roosts	Traps	Call Survey	Additional Methods
Little Bentwing Bat	*Miniopterus australis*	S/H	□	□	Search rocks, overhangs and caves/mines
Little Eastern Mastiff Bat	*Mormopterus norfolkensis*	H	□	□	

Table 2-4: Suggested Survey Method for Bats

Method	Effort per 100 hectares (or portion thereof) of stratification unit targeting preferred habitat	Survey Period
Harp trapping	Four trap nights over two consecutive nights (with one trap placed outside the flyways for one night)	October to March
Ultrasonic call recording	Two sound activated recording devices utilised ***for the entire night (a minimum of four hours)***, starting at dusk for two nights	October to March
Mist netting	For targeted survey: one trap set for at least two hours duration starting at dusk, for two nights	October to March
Trip line	For targeted survey of water bodies: at least two hours duration starting at dusk, for two nights	October to March
Spotlighting and transect walking	For targeted survey near likely food resources: 2 x 1 hour spotlighting on two separate nights	All year
Day habitat search	Search for bat excreta at or near potential habitats	All year

2.2 Field Survey Effort Summary

Field Surveys were conducted by AREA Ecologist Dave Sturman from 4/11/2019 to 9/11/2019 (**Table 2-5**).

Table 2-5: Field survey effort summary

Survey dates	Methods	Effort
November 2019 AREA Ecologist All activities occurred over five days and five nights.	Fauna • Bird watching • Nocturnal surveys • Looking for signs of small mammal activity, i.e. diggings, scats or tracks along linear transects • Targeted bird watching and habitat mapping for all species • Nocturnal surveys (Anabat) • Opportunistic sightings	4-full, 2-half days, 5 nights • Linear transects • Dawn, dusk and midday bird surveys • Opportunistic observations • Call playback (nocturnal) three nights • Anabat assessment five nights (two machines at separate locations) • Camera Trap set up (two separate locations) • Two-hour minimum spotlighting per evening. • Transects were employed across the property.
April 2019 Eco Logical Ecologist field survey and BAM plots completed	Fauna Targeted bird watching Opportunistic sightings Flora Four BAM Plots	BAM plots undertaken as per BAM methods

2.3 Field Survey

2.3.1 Terrestrial fauna surveys

The following resources were used in determining the outcomes of the targeted species search:

- Biodiversity Assessment Methodology (OEH, 2017)
- BAM Credit Calculator
- Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities – Working Draft (DEC, 2004)
- Survey requirements (birds, bats, reptiles, frogs, fish and mammals) for species listed under the EPBC Act
- Threatened biodiversity profile search
- NSW BioNet
- Vegetation Types databases
- Online Zoological Collections of Australian Museums
- Threatened Species Assessment Guideline - The Assessment of Significance (DECCW, 2007)
- Significant Impact Guidelines 1.1 - Matters of National Environmental Significance
- Threatened Bat Survey Guide.

Field assessment was carried out over five full days and five nights between 4 to 9 November 2019. An overview of survey effort is shown in **Figures 2-1 and 2-2**.

Figure 2-1: Overview of survey methods.

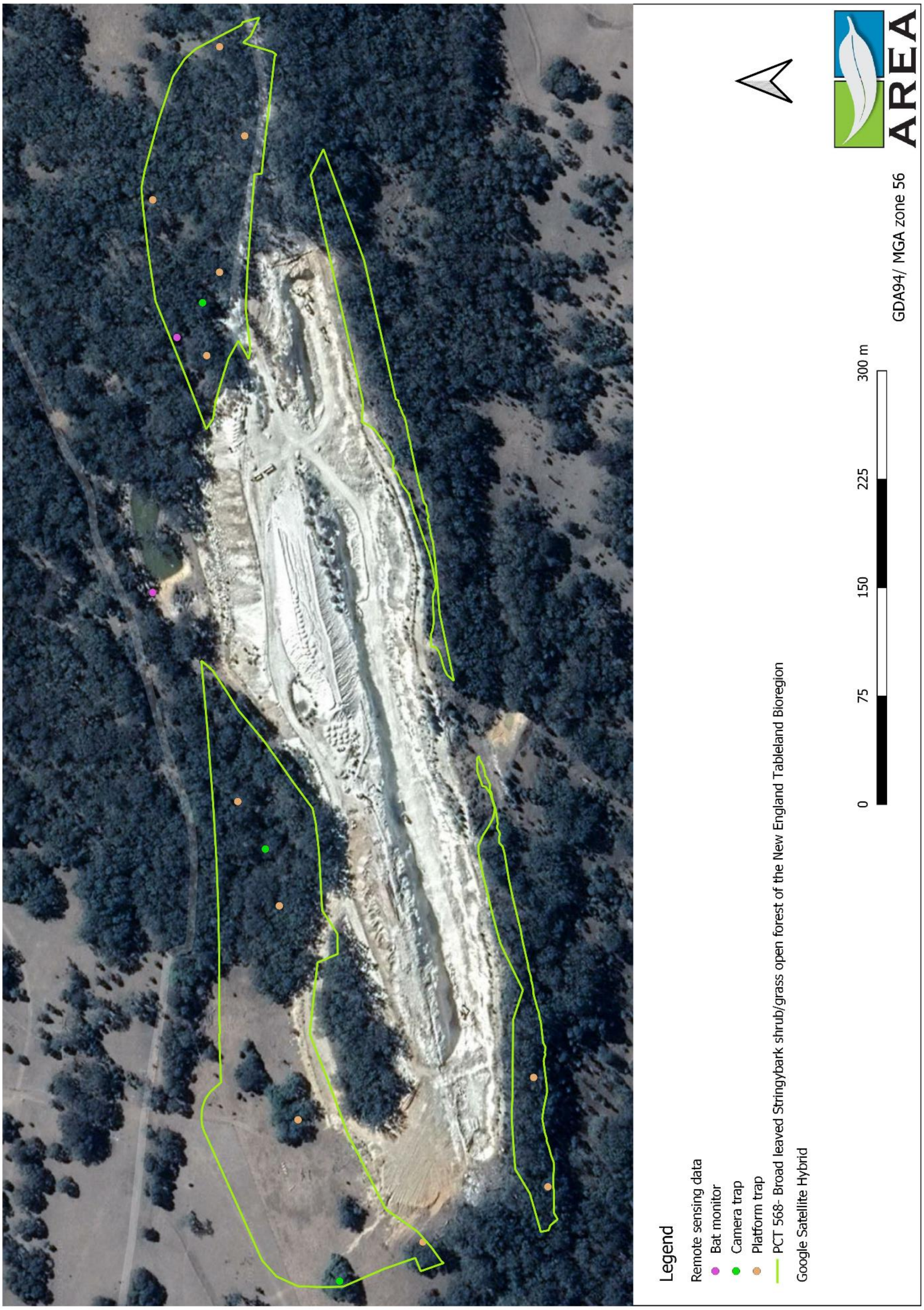
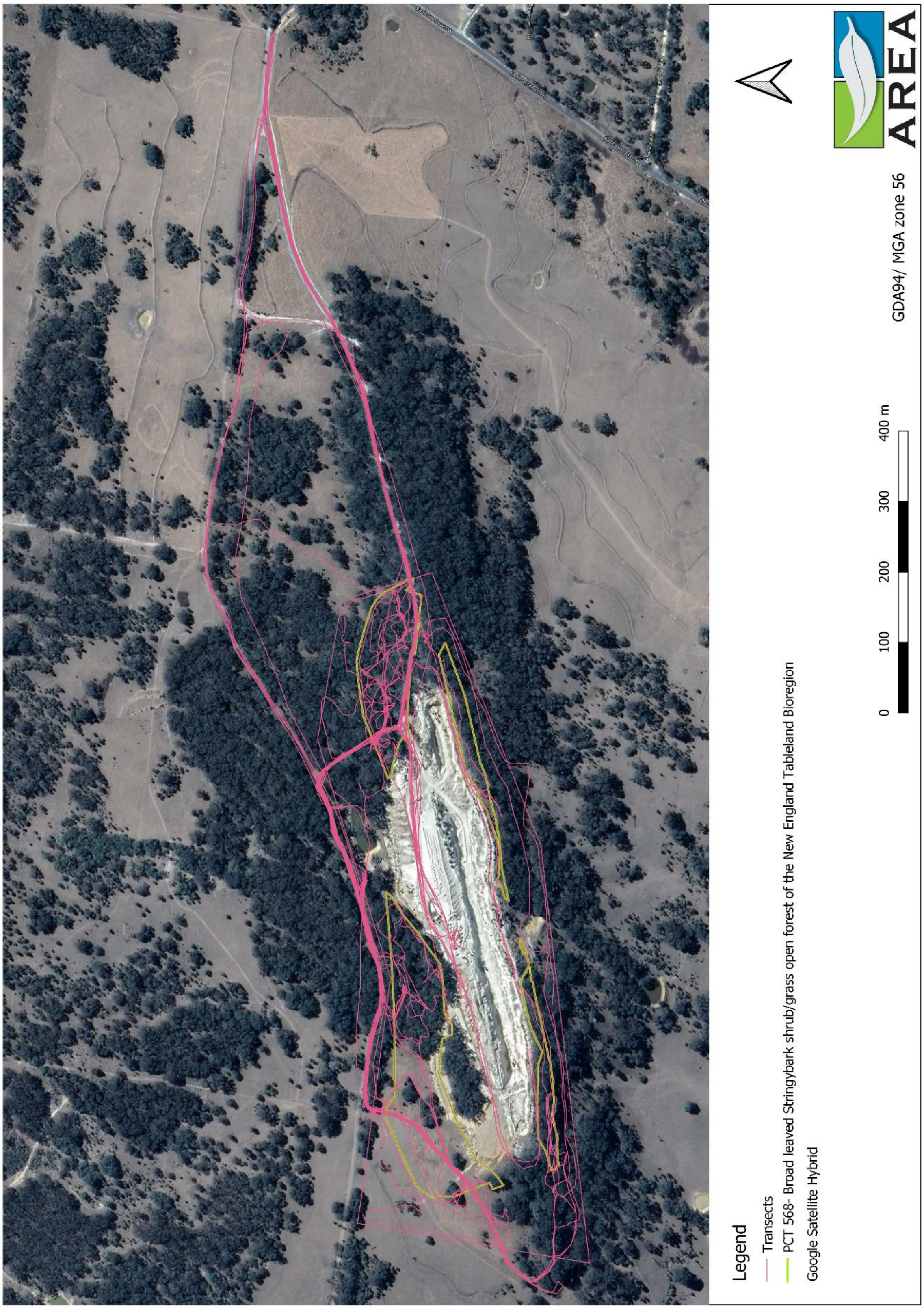


Figure 2-2: Survey Transects



2.4 Fauna

2.4.1.1 Habitat assessment

Habitat in the development site was assessed for its potential to provide resources for the targeted species. Preference of habitat for these species was determined by Department of Planning, Industry and Environment, Department of Primary Industries (DPI) Fisheries and the Australian Government Department of Environment and Energy (DoEE) Threatened online Species Profiles.

Database searches were undertaken before the assessment to inform the consultant of what species predicted or known in the 10 kilometre buffer may be recorded or should need a targeted search.

Any indirect evidence of fauna i.e. scats, tracks, calls, fur feathers, sloughed skins etc was assessed. Each mature tree in the subject site was inspected for hollows and to determine if they were used for breeding. All eucalyptus trees in the development site were also assessed for nests, feeding habitat including mistletoe or resting habitat. Where a tree with a hollow was observed it was given a score reflecting its habitat value. Where there was potential owl habitat identified (hollows >20cm) these were further assessed via stag watching- observing potential roost hollows for 30mins prior to sunset and 60mins following sunset and spotlight observations.

Specific detail on the fauna detection methods employed is found in the following sub-sections.

2.4.1.2 Echolocation

Echolocation detectors (SongMeters SM2+BAT and SM3+Bat, Wildlife Acoustics) were used to identify the possible presence of any microchiropterans (microbats) that may be present in the development site. The detectors were placed in habitats likely to be used by microchiropterans during their foraging and dispersal periods (i.e. adjacent to water bodies, and habitat ecotones) or as roosting sites (i.e. hollow-bearing trees present). Two detectors were placed for five nights respectively from the 4 November to 9 November 2019.

The detectors were set prior to dusk and left in place for the entire duration of each evening. Calls recorded were analysed by Dr Heidi Kolkert (Principal Ecologist AREA) using Anabat 6.3 computer software.

2.4.1.3 Call Playback

Nocturnal birds and marsupials were surveyed through call playback and spotlighting. Call playback followed the methods described by Kavanagh and Peake (1993) and Debus (1995). This method requires an initial listening period of ten to 15 minutes after playing the respective call, followed by a spotlight search for ten minutes to detect any animals in the immediate vicinity, followed by intermittently playing the call for another five minutes and a ten minute listening period. A general search of the immediate environs was then undertaken to see if any non-vocalising birds were present.

Use of the playback of pre-recorded sound bites (Nature Sound) for the detection of the following threatened species:

- Barking Owl (*Ninox connivens*)
- Powerful Owl (*Ninox strenua*)
- Masked Owl (*Tyto novaehollandiae*).

The sequence of the calls broadcast was as noted above, a short listening period occurring between the marsupial and owl calls.

To minimise stressing and disturbing the species targeted, if an animal responded to the call playbacks, calls of this species were not broadcast during subsequent playback sessions (unless those playbacks were proposed to be conducted beyond the limits of the documented habitat range of said target species).

2.4.1.4 Bird Survey (Diurnal and Nocturnal)

Taking into consideration the discussion in the DPIE working draft on methods to survey diurnal birds, an area-search method was used within the development site.

In addition to those dedicated bird surveys undertaken, any incidental observations or records made whilst traversing the site or conducting additional surveys (e.g. the herpetofauna searches) were noted.

All vegetation types were surveyed for bird species. Targeted bird watching was undertaken near any habitat trees to identify possible nesting or roosting areas. Birds were identified via visual observation and characteristic call.

Particular attention was paid to threatened species habitat and calls.

2.4.1.5 Spotlighting

During the nocturnal surveys, spotlighting (using a 163-lumen hand-held spotlight) was undertaken.

Spotlighting was undertaken on foot with tracks, clearings and access ways within the targeted development site. These environments were targeted to reduce the disturbance of those species present (i.e. through adverse noise generated by pushing through vegetation, stumbling over logs or crunching leaf litter and ground debris). The spotlighting sessions lasted up to 120 minutes and was undertaken:

- When traversing between the call playback sites
- As a sole operation.

Species targeted during the spotlighting session included

- Eastern Pygmy Possum (*Cercartus nanus*)
- Barking Owl (*Ninox connivens*)
- Powerful Owl (*Ninox strenua*)
- Masked Owl (*Tyto novaehollandiae*)
- Eastern Cave-bat (*Vespadelus troughtoni*).

2.4.1.6 Remote sensing cameras

Two remote sensing cameras were deployed over the duration of the assessment. One camera was placed focussed on a tree mounted Type A Elliott trap to determine if Eastern Pygmy Possum were in the area. A second remote sensing camera was set up over the duration of the assessment in a location suitable to detect Eastern Pygmy Possum. In this area a lure (roast chicken) was used to detect the species (see NSW ECA recent publication on the species success for camera trapping recording using this bait). The onsite ecologist reviewed the camera data.

2.4.1.7 Traps

Trap management followed requirements in the NSW DPI Animal Research Authority: Animal Care and Ethics Committee of the Director General of NSW.

The layout of the traps has been shown in **Figure 3-1**.

Type A Elliot traps

Eleven Type A Elliott traps were deployed over four consecutive nights for the assessment. 11 were on tree mounted platforms targeting Eastern Pygmy Possum. Each trap was baited with a standard mixture of rolled oats, peanut butter and fish oil. The Eastern Pygmy Possum traps and baits were laced with honey and misted with a honey water mix to encourage resident animals to the trap sites.

14 Type A Elliot traps were deployed on the ground over five consecutive nights for the assessment. The terrestrial Type A Elliot traps were baited in the same fashion as the arboreal Type A Elliot traps outlined above.

2.4.1.8 Threatened flora

Transects followed requirements in *NSW Guide to Surveying Threatened Plants 2016*.

The transects walked has been shown in **Figure 2-2**.

3 Results

Scientific name	Common name	Habitat constraints	BC Act listing	EPBC Act listing	Survey timing	Survey effort
Cercartetus nanus	Eastern Pygmy-possum	• Patch size less than <5ha • Percentage of Native cover between 11 and 30% • Found in a broad range of habitats from rainforest through sclerophyll (including Box-Ironbark) forest and woodland to heath, but in most areas woodlands and heath appear to be preferred, except in north-eastern NSW where they are most frequently encountered in rainforest.	Vulnerable	Not Listed	November Day and Night	The surveyed followed the NSW publication *Threatened Biodiversity Survey and Assessment Guidelines for Development Activities (Draft) 2004.* The entire development footprint was surveyed on foot by an ecologist over five days and nights. Spotlighting over all nights and 25 Type A Elliot Traps were also used with no result (Trapping exceeded the minimum required survey effort by 31 trap nights **Table 1-1**). All trees in the development footprint were surveyed and no individuals were observed. This species was not detected.
Vespadelus troughtoni	Eastern Cave Bat	• Patch size 5-24ha • Percentage of Native cover between 11 and 30% • A cave-roosting species that is usually found in dry open forest and woodland, near cliffs or rocky overhangs; has been recorded roosting in disused mine workings, occasionally in colonies of up to	Vulnerable	Not Listed	November Day and Night	The surveyed followed the *Threatened Bat Survey Guide and Survey requirements bats, for species listed under the EPBC Act.* Two Echolocation detectors (SongMeters SM2+BAT and SM3+Bat, Wildlife Acoustics) were used for a combined total of nine entire nights from dawn until dusk (exceeding the minimum of two nights by seven whole nights). Bat calls were interpreted by a suitably qualified professional who identified the presence of *Vespadelus troughtoni* on

Scientific name	Common name	Habitat constraints	BC Act listing	EPBC Act listing	Survey timing	Survey effort
		500 individuals.				three separate trap nights.
Ninox connivens	Barking Owl (breeding)	• Patch size 25-100ha • Percentage of Native cover between 11 and 30% • Living or dead trees with hollows greater than 20 cm diameter and greater than 4 m above the ground (breeding) • Inhabits woodland and open forest, including fragmented remnants and partly cleared farmland. It is flexible in its habitat use, and hunting can extend in to closed forest and more open areas. Sometimes able to successfully breed along timbered watercourses in heavily cleared habitats (e.g. western NSW) due to the higher density of prey on these fertile riparian soils	Vulnerable	Not Listed	November Day and Night	The surveyed followed the *NSW publication Threatened Biodiversity Survey and Assessment Guidelines for Development Activities (Draft) 2004.* The entire development footprint was surveyed on foot by an ecologist over five days. Spotlighting over five nights and camera traps were also used with no result. All trees in the development footprint were surveyed for suitable breeding hollows and no individuals were observed. This species nor its breeding habitat was not detected.
Ninox strenua	Powerful Owl (Breeding)	• Patch size less than <5ha • Percentage of Native cover between 11 and 30% • Living or dead trees with hollow greater than 20cm diameter	Vulnerable	Not Listed	November Day and Night	The surveyed followed the *NSW publication Threatened Biodiversity Survey and Assessment Guidelines for Development Activities (Draft) 2004.* The entire development footprint was surveyed on foot by an ecologist over five days. Spotlighting over five nights and camera traps were also used with no

Scientific name	Common name	Habitat constraints	BC Act listing	EPBC Act listing	Survey timing	Survey effort
		• The Powerful Owl inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest. • The Powerful Owl requires large tracts of forest or woodland habitat but can occur in fragmented landscapes as well. The species breeds and hunts in open or closed sclerophyll forest or woodlands and occasionally hunts in open habitats. It roosts by day in dense vegetation comprising species such as Turpentine *Syncarpia glomulifera*, Black She-oak *Allocasuarina littoralis*, Blackwood *Acacia melanoxylon*, Rough-barked Apple *Angophora floribunda*, Cherry Ballart *Exocarpus cupressiformis* and a number of eucalypt species.				result. All trees in the development footprint were surveyed and no individuals were observed. This species nor its breeding habitat was not detected.
Tito novaehollandiae	Masked Owl (Breeding)	• Patch size less than <5ha • Percentage of Native	Vulnerable	Not Listed	November Day and Night	The surveyed followed the *NSW publication Threatened Biodiversity Survey and Assessment Guidelines for Development Activities (Draft) 2014.*

Scientific name	Common name	Habitat constraints	BC Act listing	EPBC Act listing	Survey timing	Survey effort
		cover between 11 and 30% • Living or dead trees with hollow greater than 20cm diameter • Lives in dry eucalypt forests and woodlands from sea level to 1100 m. • Roosts and breeds in moist eucalypt forested gullies, using large tree hollows or sometimes caves for nesting.				The entire development footprint was surveyed on foot by an ecologist over five days. Spotlighting over five nights and camera traps were also used with no result. All trees in the development footprint were surveyed and no individuals were observed. This species nor its breeding habitat was not detected.
Thesium australe	*Austral Toadflax*	• Occurs in grassland on coastal headlands or grassland and grassy woodland away from the coast. • Often found in association with Kangaroo Grass (Themeda australis). • A root parasite that takes water and some nutrient from other plants, especially Kangaroo Grass.	Vulnerable	Vulnerable	November	The entire development footprint was surveyed on foot by an ecologist over five days.
Acacia pycnostachya	*Bolivia Wattle*	• Acacia pycnostachya typically grows in dry sclerophyll forest amongst granite outcrops, on hillsides at altitudes of 700 to 900 m. Soil types range from acid volcanics to sandy	Vulnerable	Vulnerable	November	The entire development footprint was surveyed on foot by an ecologist over five days.

Scientific name	Common name	Habitat constraints	BC Act listing	EPBC Act listing	Survey timing	Survey effort
		and skeletal on exposed outcrops, to shallow sandy loams in less exposed sites. It often grows in stands in areas sheltered from fire.				

Key- Species identified in development site.

4 Eastern Cave Bat *(Vespadelus troughtoni)*

Two Echolocation detectors (SongMeters SM2+BAT and SM3+Bat, Wildlife Acoustics) were used for a combined total of nine entire nights from dawn until dusk (exceeding the minimum of two nights by seven complete nights).

Analysis of the data collected was conducted by bat expert Heidi Kolkert using Analook V4.1 bat call analysis software.

A review of the data produced 14 positively recorded species and an additional two species which may be present in the development site **(Appendix 1).** Bat call analysis identified the presence of Eastern Cave Bat *Vespadelus troughtoni* on three separate trap nights (Table 4-1).

Table 4-1 Eastern Cave Bat record nights

Scientific name	Common Name	11/4/2019	11/5/2019	11/6/2019	11/8/2019	11/4/2019	11/5/2019	11/6/2019	11/7/2019	11/8/2019
Bats species identified										
Vedpadelus troughtoni	Eastern cave bat	x		x	x					

Heidi Kolkert (PhD candidate) a bat subject matter expert analysed the calls and noted there were calls from the Eastern Cave Bat as well as a few other species of cave dependant species indicating likely roosting habitat is locally available. She noted there is good woodland and water locally available which is probably why on the last night in particular of recording there was a lot of bat activity showing up as feeding and socialising type calls.

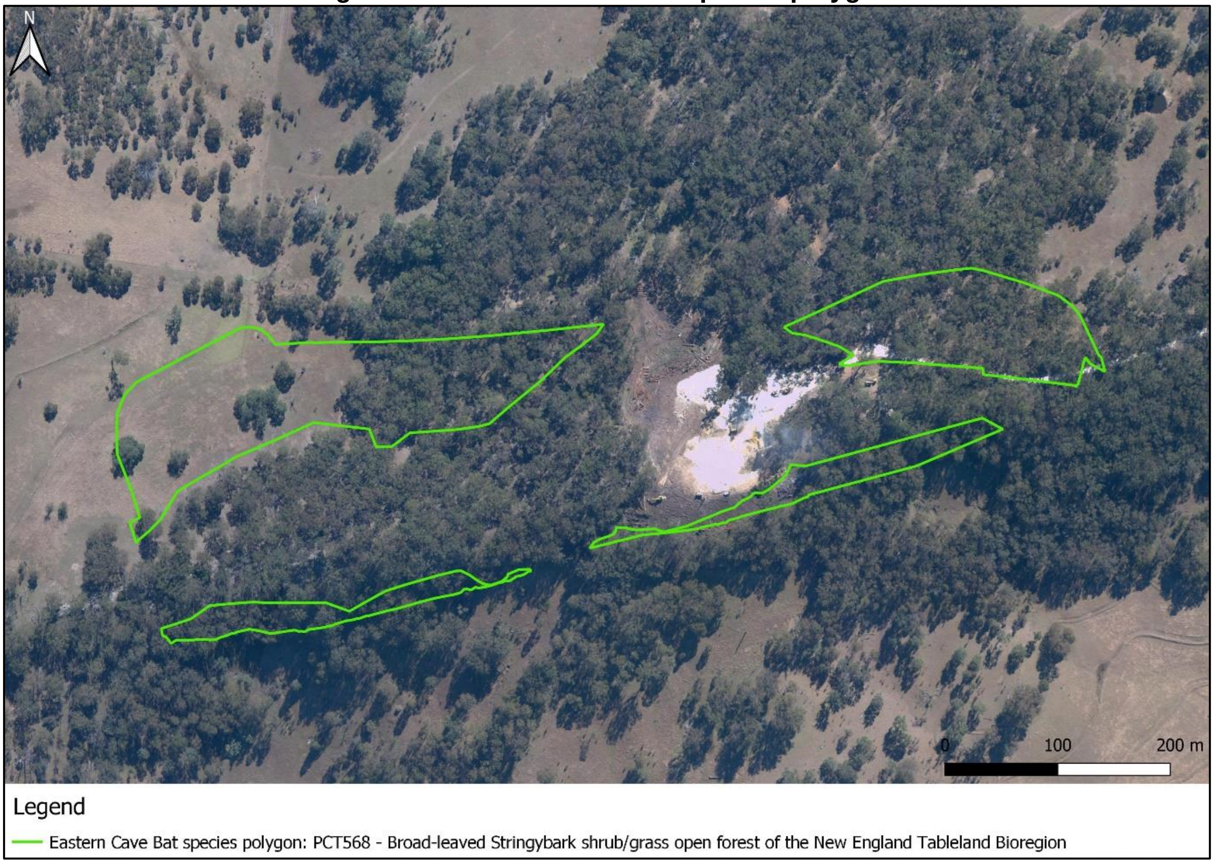
A study area based search by Eco Logical Australia April 2019 and AREA in November 2019 combined with desktop searches following 'Species credit' threatened bats and their habitats NSW survey guide for the Biodiversity Assessment Method 2018 did not identify any shafts, adits, rock formations, bridges or rock overhangs in or immediacy next to the development site.

As calls from the species was recorded on the study area but breeding habitat was not present guidance from Biodiversity and Conservation | Department of Planning, Industry and Environment - Planning, North East Branch was sought. As a result of this consultation the Eastern cave bat will be managed as a species credit species, where the species polygon is all plant community types affected by the proposal (Table 4-2. Figure 4-1).

Table 4-2 Eastern Cave Bat species polygon and offsetting obligation details

Credits Required	**Area**	**Credits Required**
Ecosystem Credits		
568 - Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion	4.63ha	134
Species Credits		
Eastern Cave Bat (*Vespadelus troughtoni*)	4.63ha	230
Source: Modified after ELA (2020) – Table 31 and Table 32		

Figure 4-1: Eastern Cave Bat Species polygon



5 Limitations of the survey effort

Not all animals and plants can be fully accounted for within any given development site. The presence of threatened species is not static. It changes over time, often in response to longer term natural forces which can, at any time, be dramatically influenced by man-made disturbance or weather. In order to overcome some of these limitations, database searches were conducted for threatened species, populations and ecological communities known to occur within the region. A 'precautionary approach' for species occurrence has been adopted where required.

This report is based upon data acquired from recent and current surveys; however, it should be recognised that data gathered is indicative of the environmental conditions of the site at the time the report was prepared.

6 Conclusion

The Biodiversity Development Assessment Report prepared by Eco Logical Australia identified five species credit species requiring further survey at the correct time of year (*"Eco Logical Australia. 2019 Dowe's Quarry BDAR. Prepared for R.W. Corkery & Co Pty Ltd on behalf of Darryl McCarthy Constructions Pty Ltd").*
These species are;

- Barking Owl (*Ninox connivens*)
- Powerful Owl (*Ninox strenua*)
- Masked Owl *(Tyto novaehollandiae*)

- Eastern Pygmy-possum *(Cercartetus nanus)*
- Eastern Cave-bat (*Vespadelus troughtoni*)

AREA followed the guidelines for survey set out in *Threatened Biodiversity Survey and Assessment Guidelines for Development Activities (Draft) 2004* to survey for these species credit species. Using the methods outlined in this document AREA did not detect the presence of the following species within the development site.

- Barking Owl (*Ninox connivens*)
- Powerful Owl (*Ninox strenua*)
- Masked Owl (*Tyto novaehollandiae*)
- Eastern Pygmy-possum (*Cercartetus nanus*)
- Little Eagle (*Hieraaetus morphnoides*)
- Square-tailed Kite (*Lophoictinia isura*)
- White-bellied Sea Eagle (*Haliaeetus leucogaster*)
- Grey-headed Flying Fox (*Pteropus poliocephalus*)
- Austral Toadflax (*Thesium australe*)
- Bolivia Wattle (*Acacia pycnostachya*).

The Biodiversity Assessment Method Calculator can be updated to reflect the findings of the study to reflect that **the above species credit species are not present in** the development site**.**

Following the guidelines for survey set out in *Threatened Biodiversity Survey and Assessment Guidelines for Development Activities (Draft) 2004* using two Echolocation detectors (SongMeters SM2+BAT and SM3+Bat, Wildlife Acoustics) recorded the presence of the Eastern Cave-bat (*Vespadelus troughtoni*).

The Biodiversity Assessment Method Calculator can be updated to reflect the findings of the study to reflect that **the above species credit species is present** in the development site, but breeding habitat is not present**.**

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8 Appendix 1-Insectivorous Bat Data

Table 1: Insectivorous bats recorded in the study area via echolocation

			Machine 1				Machine 2				
	Scientific name	Common Name	11/4/2019	11/5/2019	11/6/2019	11/8/2019	11/4/2019	11/5/2019	11/6/2019	11/7/2019	11/8/2019
No.	Bats species identified										
1	*Austronomus australis*	White-striped freetail bat	x	x	x	x	x	x	x	x	x
2	*Chalinolobus gouldii*	Gould's wattled bat	x	x	x	x	x	x	x	x	x
3	*Chalinolobus morio*	Chocolate wattled bat	x	x	x	x	x	x	x	x	x
4	*Falsistrellus tasmaniensis #*	Eastern falsistrelle	x		x	x		x		x	x
5	*Miniopterus schreibersii oceanensis #*	Eastern bentwing bat	x		x		x	x	x	x	x
6	*Mormopterus ridei*	Ride's free-tailed bat		x	x		x		x	x	x
7	*Scotorepens balstoni*	Inland broad-nosed bat					x	x			x
8	*Scotorepens orion*	Eastern broad-nosed bat	x	x	x	x	x	x	x	x	x
9	*Scoteanax rueppellii #*	Large broad-nosed bat			x	x	x	x		x	x
10	*Vespadelus darlingtoni*	Large forest bat	x	x	x	x	x		x	x	x
11	*Vespadelus regulus*	Southern forest bat	x	x	x			x	x	x	x
12	*Vespadelus troughtoni #*	Eastern cave bat	x		x	x					
13	*Vespadelus vulturnus*	Little forest bat	x		x		x	x	x	x	x
	Unidentified bat species										
	V. troughtoni or V. pumilus								x	x	x
	S. orion or S. rueppellii # or F. tasmaniensis #		x				x		x		
	V. darlingtoni or M. s. oceanensis			x			x	x	x		
14	*Nyctophilus gouldi or geoffroyi*		x		x		x				x
	Myotis macropus #	Large-footed myotis					1P		1P		1P
	Total files		158	23	188	364	153	93	459	717	1392

x Species identified in the study
P Potential record of species and number of passes.
\# species listed under the Biodiversity Conservation Act 2016
* species listed under the Environmental Protection and Biodiversity Act

Appendix B Vegetation plot data

Plot Location Data							
Plot no	PCT	Vegetation zone	Condition	Zone	Easting	Northing	Bearing
Plot 1	568	2	good	56	406995	6791680	350
Plot 2	568	1	poor	56	406677	6791606	30
Plot 3	568	2	good	56	407323	6791866	50
Plot 4	568	2	good	56	407501	6791720	60

Composition (number of species)						
Plot no.	Tree	Shrub	Grass	Forb	Fern	Other
1	3	2	7	7	1	3
2	1	0	4	6	1	1
3	3	2	7	5	0	3
4	4	1	10	13	0	2

Structure (Total cover)						
Plot no	Tree	Shrub	Grass	Forb	Fern	Other
1	25	8	21.5	1.1	0.3	0.3
2	0.1	0	0.4	0.7	0.1	0.1
3	45.2	1.1	4.2	0.7	0	0.5
4	62.2	0.3	67.7	1.6	0	0.5

Function											
Plot no.	Large Trees	Hollow trees	Litter Cover	Length Fallen Logs	Tree Stem 5- 9 cm	Tree Stem 10-19 cm	Tree Stem 20-29 cm	Tree Stem 30-49 cm	Tree Stem 50-79 cm	Tree Regen	High Threat Weed Cover
1	2	5	58	76	present	present	present	present	present	present	0.1
2	0	0	64	5	present	absent	absent	absent	absent	present	90.2
3	2	1	36	72	present	absent	present	present	present	present	1
4	3	1	80	55	present	absent	present	present	present	present	0.2

Plot no	Photo
Plot 1	
Plot 2	

Plot no	Photo
Plot 3	
Plot 4	

Plot Flora list

Species	Common Name	Exotic	High Threat Weed	Growth Form Group	plot 1		Plot 2		Plot 3		Plot 4	
					Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance
Acacia brownii	Heath Wattle			Shrub (SG)	0	0	0	0	0.1	1	0	0
Acacia irrorata	Green Wattle			Shrub (SG)	5	1	0	0	0	0	0	0
Acacia melanoxylon	Blackwood			Tree (TG)	0	0	0	0	0.2	1	0	0
Acetosella vulgaris	Sheep Sorrel	yes	Yes		0	0	0.1	10	0	0	0	0
Allocasuarina torulosa	Forest Oak			Tree (TG)	5	2	0	0	0	0	0	0
Angophora subvelutina	Broad-leaved Apple			Tree (TG)	0	0	0.1	1	0	0	0	0
Aristida vagans	Three-awn Speargrass			Grass & grasslike (GG)	2	10	0	0	0	0	0	0
Brachychiton populneus	Kurrajong			Tree (TG)	0	0	0	0	0	0	0.2	2
Calotis cuneifolia	Purple Burr-Daisy			Forb (FG)	0.3	20	0.2	5	0	0	0.1	5
Cheilanthes sieberi	Rock Fern			Fern (EG)	0.3	20	0.1	20	0	0	0	0
Commelina cyanea	Native Wandering Jew			Forb (FG)	0.1	5	0.1	5	0.2	5	0.1	5
Crassula sieberiana	Australian Stonecrop			Forb (FG)	0	0	0	0	0	0	0.1	1
Cymbopogon refractus	Barbed Wire Grass			Grass & grasslike (GG)	2	10	0	0	0.3	8	1	10
Cyperus aggregatus		yes			0	0	0.1	3	0	0	0	0
Cyperus gracilis	Slender Flat-sedge			Grass & grasslike (GG)	0.2	10	0.1	10	0	0	1	100
Desmodium gunnii	Slender Tick-trefoil			Forb (FG)	0	0	0	0	0	0	0.1	3
Desmodium varians	Slender Tick-trefoil			Other (OG)	0.1	5	0	0	0	0	0	0

Plot Flora list												
Desmodium varians	Slender Tick-trefoil			Other (OG)	0	0	0.1	3	0	0	0	0
Dianella revoluta	Blueberry Lily			Forb (FG)	0	0	0	0	0.1	1	0	0
Dichondra repens	Kidney Weed			Forb (FG)	0.3	15	0.1	20	0.2	10	0.2	10
Echinopogon ovatus	Forest Hedgehog Grass			Grass & grasslike (GG)	15	100	0	0	0.2	5	2	6
Einadia trigonos	Fishweed			Forb (FG)	0.1	5	0.1	5	0	0	0.2	10
Epilobium spp.				Forb (FG)	0	0	0	0	0	0	0.1	5
Eragrostis brownii	Brown's Lovegrass			Grass & grasslike (GG)	0	0	0	0	0	0	0.5	15
Eragrostis curvula	African Lovegrass	yes	Yes		0	0	90	1000	0.2	8	0.1	0.2
Eragrostis leptostachya	Paddock Lovegrass			Grass & grasslike (GG)	2	50	0	0	2	20	60	500
Eragrostis leptostachya	Paddock Lovegrass			Grass & grasslike (GG)	0	0	0	0	0.2	3	0	0
Eucalyptus biturbinata	Grey Gum			Tree (TG)	5	2	0	0	0	0	20	2
Eucalyptus caliginosa	Broad-leaved Stringybark			Tree (TG)	15	20	0	0	20	9	2	1
Eucalyptus moluccana	Grey Box			Tree (TG)	0	0	0	0	25	3	40	2
Gahnia aspera	Rough Saw-sedge			Grass & grasslike (GG)	0.1	1	0	0	0	0	0.3	2
Geitonoplesium cymosum	Scrambling Lily			Other (OG)	0.1	1	0	0	0.03	3	0	0
Glycine spp.				Other (OG)	0.1	5	0	0	0	0	0	0
Glycine tabacina	Variable Glycine			Other (OG)	0	0	0	0	0.1	5	0.3	8
Goodenia spp.				Forb (FG)	0	0	0	0	0.1	5	0.2	10
Hardenbergia violacea	False Sarsaparilla			Other (OG)	0	0	0	0	0.1	1	0.2	2
Hypochaeris radicata	Catsear	yes			0	0	0.1	10	0	0	0	0

Plot Flora list												
Juncus spp.	A Rush			Grass & grasslike (GG)	0	0	0.1	2	0	0	0	0
Lagenophora stipitata	Common Lagenophora			Forb (FG)	0	0	0	0	0	0	0.1	3
Ligustrum lucidum	Large-leaved Privet	yes	yes		0	0	0	0	0.5	1	0	0
Ligustrum sinense	Small-leaved Privet	yes	yes		0	0	0	0	0.3	2	0	0
Lobelia spp.				Forb (FG)	0.1	5	0	0	0	0	0.1	6
Lomandra filiformis	Wattle Matt-rush			Grass & grasslike (GG)	0	0	0	0	0.2	5	0	0
Lomandra glauca	Pale Mat-rush			Grass & grasslike (GG)	0	0	0	0	0	0	0.2	3
Lomandra longifolia	Spiny-headed Mat-rush			Grass & grasslike (GG)	0	0	0.1	2	0.2	5	0.2	6
Lomandra multiflora subsp. multiflora	Many-flowered Mat-rush			Grass & grasslike (GG)	0.2	2	0	0	0	0	0	0
Mentha spp.				Forb (FG)	0	0	0	0	0	0	0.1	3
Microlaena stipoides	Weeping Grass			Grass & grasslike (GG)	0	0	0.1	5	0	0	0.5	25
Olearia viscidula	Wallaby Weed			Shrub (SG)	0	0	0	0	1	1	0	0
Opercularia hispida	Hairy Stinkweed			Forb (FG)	0	0	0	0	0	0	0.1	1
Oxalis spp.				Forb (FG)	0.1	5	0.1	1	0.1	5	0	0
Ozothamnus spp.				Shrub (SG)	3	2	0	0	0	0	0.3	2
Paronychia brasiliana	Chilean Whitlow Wort, Brazilian Whitlow	yes			0	0	0.1	3	0	0	0	0
Plantago debilis	Shade Plantain			Forb (FG)	0	0	0	0	0	0	0.1	3
Rumex spp.	Dock			Forb (FG)	0	0	0.1	2	0	0	0	0

Plot Flora list												
Rytidosperma spp.				Grass & grasslike (GG)	0	0	0	0	0.1	3	2	10
Senecio madagascariensis	Fireweed	yes	yes		0.1	1	0.1	1	0	0	0.1	2
Solanum spp.				Forb (FG)	0.1	3	0	0	0	0	0	0

Appendix C Biodiversity credit report

BAM Biodiversity Credit Report (Like for like)

Proposal Details

Assessment Id	Proposal Name	BAM data last updated *
00017495/BAAS18018/19/00017496	Dowes Quarry updated 18 March 2020	26/11/2019
Assessor Name	Assessor Number	BAM Data version *
Steven Jarman	BAAS18018	22
Proponent Names	Report Created	BAM Case Status
Rodney Dowe	18/03/2020	Open
Assessment Revision	Assessment Type	Date Finalised
2	Part 4 Developments (General)	To be finalised

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Potential Serious and Irreversible Impacts

Nil

Species
Vespadelus troughtoni / Eastern Cave Bat

Additional Information for Approval

PCTs With Customized Benchmarks

No Changes

BAM Biodiversity Credit Report (Like for like)

Predicted Threatened Species Not On Site

No Changes

Ecosystem Credit Summary (Number and class of biodiversity credits to be retired)

Name of Plant Community Type/ID	Name of threatened ecological community	Area of impact	Number of credits to be retired
568-Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion	Not a TEC	6.4	134.00

568-Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion	**Like-for-like credit retirement options**			
	Class	Trading group	HBT	IBRA region
	New England Dry Sclerophyll Forests This includes PCT's: 524, 526, 540, 541, 542, 559, 568, 608, 632, 738, 740, 949, 965, 970, 996, 997, 1164, 1394, 1396	New England Dry Sclerophyll Forests >=50% and <70%	Yes	Tenterfield Plateau, Binghi Plateau, Deepwater Downs, Nandewar Northern Complex, Northeast Forest Lands, Rocky River Gorge and Stanthorpe Plateau. or Any IBRA subregion that is within 100 kilometers of the outer edge of the impacted site.

BAM Biodiversity Credit Report (Like for like)

Species Credit Summary

Species	Area	Credits
Vespadelus troughtoni / Eastern Cave Bat	4.6	230.00

Vespadelus troughtoni/ Eastern Cave Bat	568_Good	**Like-for-like credit retirement options**	
		Spp	IBRA region
		Vespadelus troughtoni/Eastern Cave Bat	Any in NSW

Assessment Id	Proposal Name	Page 3 of 3
00017495/BAAS18018/19/00017496	Dowes Quarry updated 18 March 2020	

Appendix D Vegetation Clearing Protocol

Darryl McCarthy Constructions Pty Ltd

Vegetation Clearing Protocol for Operations at the Dowe's Quarry, Tenterfield

This protocol has been compiled in recognition of the need to avoid, wherever possible, any direct impacts on fauna species inhabiting the hollow-bearing trees within the approved extraction area or Koalas present in any trees to be cleared.

Aspect and Associated Management	Action Taken/Comments
Weed Management	
• All new machinery to arrive on site free of caked mud and dirt (which can potentially carry weed seed).	
• Weed controls, such as inspection of the undercarriage of any equipment brought onto the quarry site prior to each campaign of vegetation clearing.	
• Management and removal of weed species should occur immediately prior to clearing of mature trees.	
Clearing Mature Trees (including hollow-bearing trees)	
• Ensure that all areas of proposed disturbance are clearly marked prior to the commencement of clearing campaigns.	
• Engage a qualified or suitably experienced spotter-catcher to undertake an initial assessment of the mature trees to be cleared for threatened species and to guide and inspect the felling of hollow-bearing trees.	
• Check all trees for the presence of nesting or roosting fauna before felling or pushing, then start tree removal immediately after the visual inspection.	
• When a tree with hollows requires removal, the tree is to be gradually nudged at intermittent intervals so that any fauna has the chance of vacating the area after the initial disturbance. There should be a pause of at least one minute between intervals and at the end of the process.	
• If no fauna appears, the tree is to be pushed over as slowly or gently as possible (known as 'soft felled').	
• After the felled tree has settled, the spotter-catcher is to inspect the hollows and any other part of the tree for the presence of fauna.	
• Where breeding threatened species are identified, works shall cease until the species is confirmed and necessary approvals are obtained. The breeding place will be fenced	

Aspect and Associated Management	Action Taken/Comments
off and excluded from works. Works shall not continue until the breeding place is no longer active.	
• Where possible avoid impact on trees that have hollows: ○ >20cm (potential breeding habitat for Masked, Barking and Powerful Owl) between May-Dec; ○ up to 10cm (potential breeding habitat for Eastern Pygmy Possum) between Sep-March.	
• Avoid leaving trees on ground unmanaged for more than two weeks as these would quickly become habitat for hollow-dependent species.	
• Salvage tree trunks, major limbs and, if practicable, minor branches for use in rehabilitation of disturbed areas within the Quarry.	
Observations for Koalas	
For each clearing campaign, the following should occur.	
• An initial site assessment is undertaken by a spotter-catcher to identify if any Koalas are present in the trees to be removed.	
• If Koalas are observed within the area to be cleared, only the surrounding vegetation should be cleared (this must not include any tree with a crown overlapping a tree where a Koala is present).	
• Clearing of the remaining area where Koalas are present will not recommence until the Koala has moved without human intervention.	
Other	
• Allow any other fauna that has become displaced from vegetation clearing to find its way to remnant vegetation and give suitable assistance to any injured fauna including capture and transfer to a local veterinarian or WIRES representative where necessary.	

A TETRA TECH COMPANY

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Appendix 7

Indicative Site Office Plans

(Total No. of pages including blank pages = 6)

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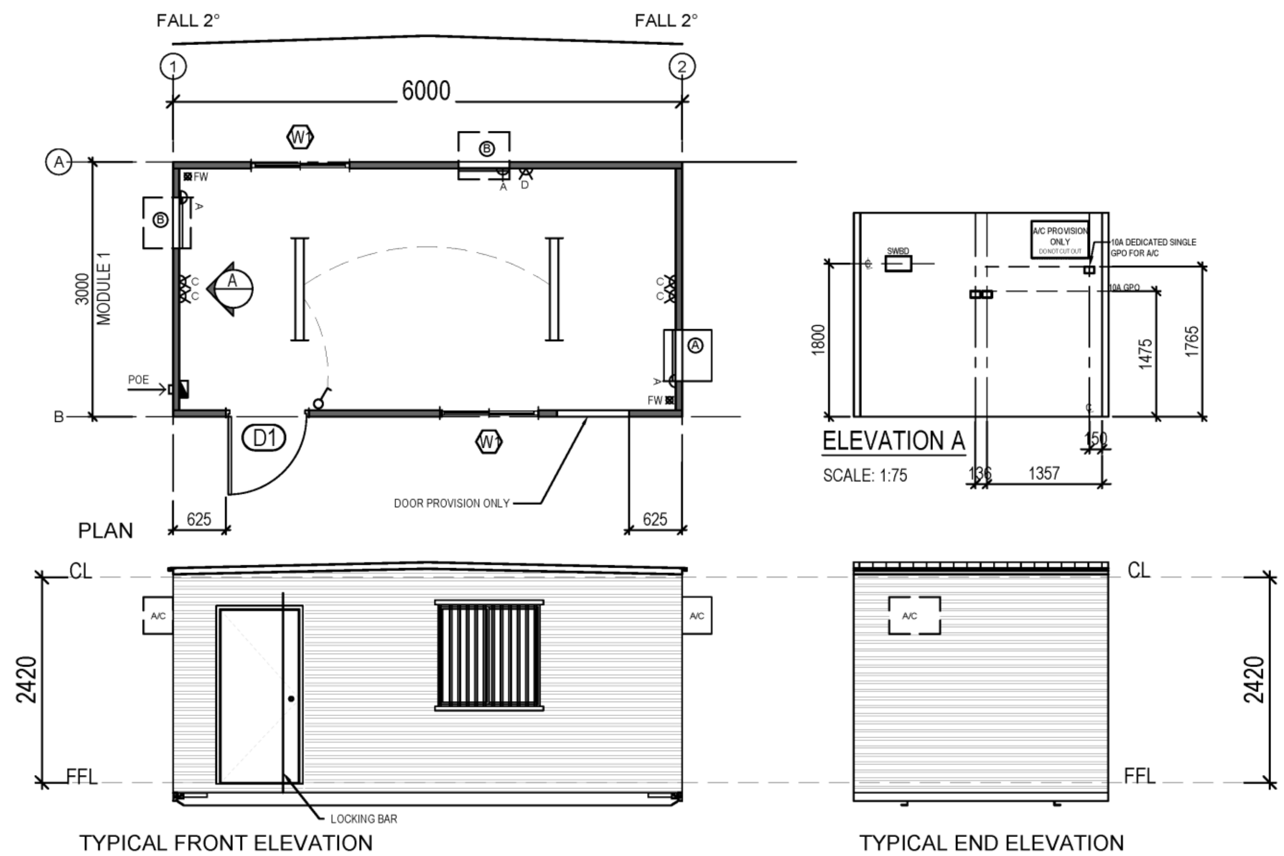
DESIGN SPECIFICATION

BASEFRAME / REFER BASEFRAME LAYOUTS FOR DETAILS	
BEARER	150 x 75mm PFC, TOES OUT
OUTRIGGER/SPREADER	100 x 50mm PFC
BRACING ANGLE	50 x 50 x 5mm EQUAL ANGLE
END MEMBER	100 x 50mm PFC
LIFTING MECHANISMS	EXTENDABLE OUTRIGGERS
TOW LUG	8mm PLATE / Ø30mm HOLE
STEELWORK TREATMENT	FINISHED WITH ANTI CORROSIVE BLACK ENAMEL / TOW LUGS = CLARKE GREEN / LIFTING POINTS = SAFETY YELLOW
FLOOR FRAME / REFER BASEFRAME LAYOUTS FOR DETAILS	
JOISTS	C10015 @ 480 CENTRES
CAPPER	C10415
END JOIST	100 x 100 x 4mm SHS
FLOORING	
FLOOR SHEET	17mm TONGUE AND GROOVE PLYWOOD F11
FLOOR COVERING	2.0mm VINYL - (SEALED) ARMSTRONG ARMATRANS NEUTRAL GREY
SKIRTING	PVC D MOULD - GREY
COMPLEXING	-
WATERPROOFING	-
OTHER	DRY FLOOR WASTES WITH PLUGS
WALLS	
INTERNAL HEIGHT	2400mm
INTERNAL LINING	4mm POLYPLY PRE-FINISHED EMBOSSED PLYWOOD - GREY
INTERNAL TRIM	PVC D MOULD - GREY (GREY WAFER HD SCREWS)
WALL INSULATION	R1.8 (75mm)
EXTERNAL CLADDING	COLORBOND PANELRIB, LAID HORIZONTALLY - SURFMIST
EXTERNAL CORNER	HD 40x40x2.5mm D'GAL ANGLE, SILICONE SEAL WALL TO FLOOR
WALL FRAMES	
FRAMING	75 x 41 x 0.75mm G550 STEEL STUDS
STUD SPACING	400mm CTS (WIND REGION N3)
STRAP BRACING	WALLS TO FLOOR & WALLS TO CEILING STRAP BRACED EVERY 1200mm WITH 125 x 30 x 1.2mm BUILDERS STRAP - 8/18x20mm SCREWS x 4
ROOF / CEILING	
CEILING TYPE	FLAT
CEILING LINING	4mm PRE-FINISHED PLYWOOD - MIRAGE PEARL
CEILING INSULATION	R1.8 (75MM)
ROOF PITCH	2° CENTRE PITCH
ROOF CLADDING	TRIMDECK 0.42 BMT - ZINCALUME
ROOF INSULATION	-
UNDER BARGE FLASHING	ZINC
BARGE	WOODLAND GREY
GUTTER	NIL
DOWNPIPE	NIL
STEPDOWN FLASHING	30 x 60 STEP DOWNS - WOODLAND GREY
ROOF / CEILING FRAMES	
FRAMING	75 x 41 x 0.75mm G550 STEEL STUDS
STUD SPACING	400mm CTS (WIND REGION N3)
ELECTRICS	
SPECIFICATION	TO AS3000, 3001, 3012
S/W BOARD	P.O.E. LOCATED BEHIND SWITCHBOARD, POLY PLASTIC INTERNALLY MOUNTED SWITCHBOARD, 1800mm AFFL(TO CTR)

ITEMS & EQUIPMENT SCHEDULE

TAG	QTY	DESCRIPTION
A	1	FRAME FOR A/C CUT OUT - 435h x 670w FRAME OPENING & FIT A/C SUPPLIED BY COATES HIRE
B	2	FRAMEOUT FOR A/C, DO NOT CUT
NOTES:		COATES SIGNS - 1 / PER BUILDING @ TOP RIGHT CORNERS
		COATES ASSET TAGS - FIT BESIDE ENTRY DOOR @ LOCK
		ALLOW NOGS IN CEILINGS AND EXTERNAL WALL FOR FUTURE PARTITIONS



GENERAL ARRANGEMENT

SCALE: 1:75

ELECTRICAL LEGEND

ITEM	DESCRIPTION	HEIGHT	QTY
EDB	ELECTRICAL DISTRIBUTION BOARD	-	1
POE	ELECTRICAL SUPPLY POINT OF ENTRY	1800 AFFL	1
	2xSL 9732/40cw LED LIGHTS - SURFACE MOUNT	C/MNTD	2
	SINGLE LIGHT SWITCH	1300 AFFL	1
A	SINGLE GPO - 10 AMP DOUBLE POLE	1765 AFFL	3
B	SINGLE GPO - 10 AMP DOUBLE POLE	1765 AFFL	-
C	DOUBLE GPO - 10 AMP DOUBLE POLE	1475 AFFL	4
D	DOUBLE GPO - 10 AMP DOUBLE POLE	375 AFFL	1

coateshire

THIS SPECIFICATION TO BE COMPLIANT IN CONJUNCTION WITH THE COATES HIRE PURCHASE SPECIFICATIONS (PLANT) PART 2 - EQUIPMENT TYPE AND PART 3 - COMMON REQUIREMENTS WITH MBS MARK UPS DATED 21.06.17

DOOR SCHEDULE

TAG	SIZE	QTY	LOCATION	COLOUR	FURNITURE	LOCKING	KEYING	ARCHITRAVE	GLASS	CLOSER	STOP	NOTES: "DO NOT" REBATE BOTTOM OF DOORS FOR DOOR SWING TO MISS VERANDAH DECKING
D1	2040 x 920mm	1	EXTERNAL	SURFMIST	KNOB	PASSAGE SET	-	PVC	-	NIL	YES	CABIN HOOK REBATED EDGE; SECURITY - ZINC PLATED PIVOT LOCKING BAR - BOTTOM OF BAR TO BE 5mmABOVE DOOR THRESHOLD

WINDOW SCHEDULE

TAG	SIZE H x W	QTY	LOCATION	HEIGHT	OPENING	COLOUR	KEYING	ARCHITRAVE	GLASS	BLINDS	NOTES
W1	1200 x 1180mm	2	EXTERNAL	900 AFFL	1210 x 1190mm CUT-OUT	WHITE	-	PVC	CLEAR	NIL	TAPE & SILICON SEAL TOP SIDES. GAL. SEC. BARS BOLT FIX w/NYLOC NUTS @ 4 CORNERS

FOR CONSTRUCTION

MBS modular building systems
132 WARREN RD, SMITHFIELD NSW 2164
TEL: 1800 217 131 D: (02) 8718 2500
FAX: (02) 8718 2599

PROJECT / TYPE :	PROJECT: COATES HIRE COMMONWEALTH GAMES 6.0 x 3.0m SHELL	DATE : 15.01.2018	TITLE : PLAN- GENERAL ARRANGEMENT
SIGNATURE:		DRAWN BY : TW	
NAME:		CHECKED BY : DT	DRAWING NUMBER : MS-200108-101 / BUILDING NUMBER : #0000
DATE:		SCALE : SHOWN	QUOTATION NUMBER : 200108 / REV : [1]

ISSUE	AMENDMENT	BY	DATE
1	FOR CONSTRUCTION	TW	15.01.2018

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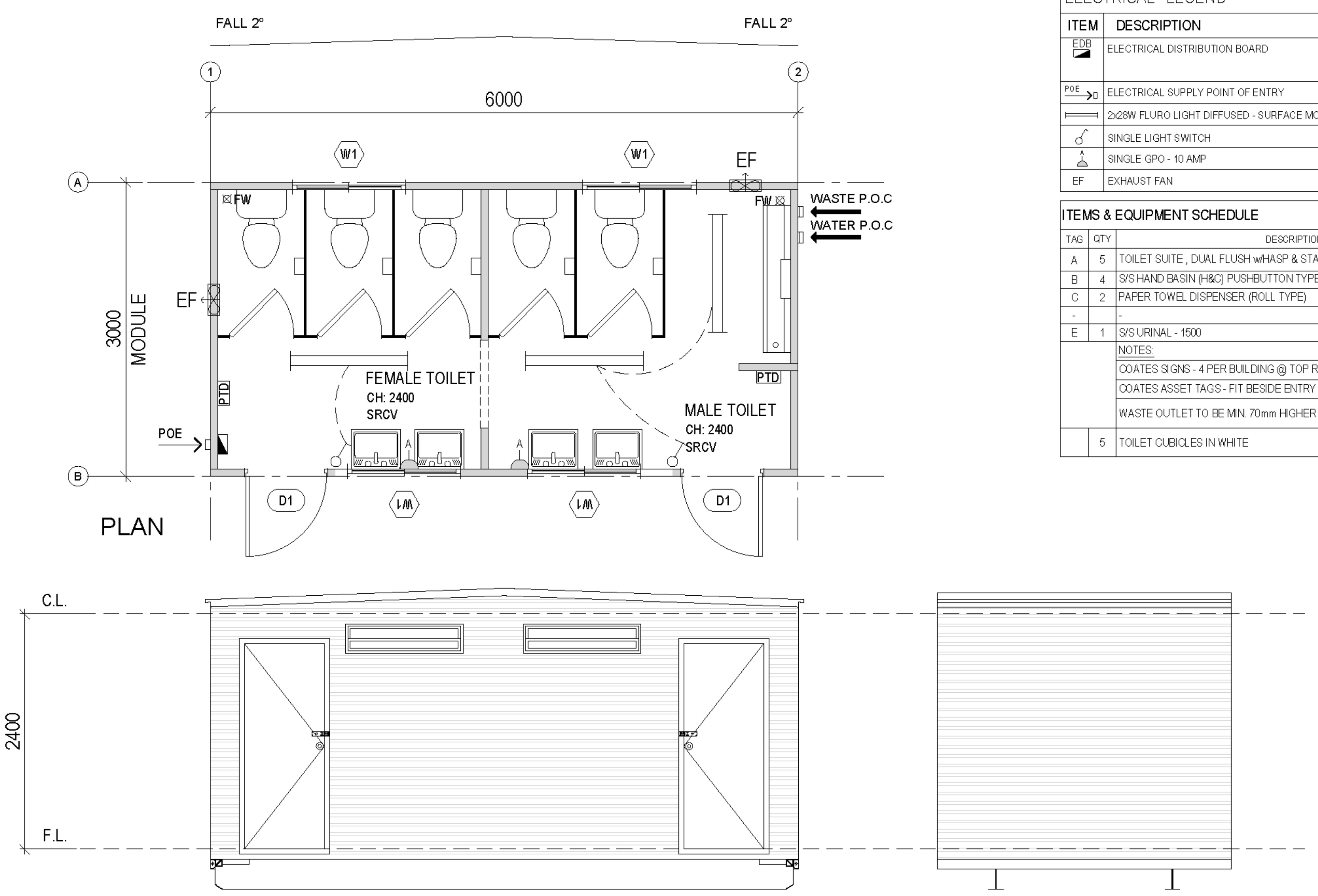
coateshire



TYPICAL FRONT ELEVATION

TYPICAL END ELEVATION

GENERAL ARRANGEMENT

SCALE: 1:50

DESIGN SPECIFICATION

BASEFRAME / REFER BASEFRAME LAYOUTS FOR DETAILS	
BEARER	310 UB
OUTRIGGER/SPREADER	100 x 50mm PFC
BRACING ANGLE	50 x 50 x 5mm EQUAL ANGLE
END MEMBER	100 x 50mm PFC
LIFTING MECHANISMS	EXTENDABLE OUTRIGGERS
TOW LUG	10mm PLATE / Ø30mm HOLE
STEELWORK TREATMENT	PRIMED WITH RED OXIDE / FINISHED WITH BLACK ENAMEL
FLOOR FRAME / REFER BASEFRAME LAYOUTS FOR DETAILS	
JOISTS	C10015 @ 480 CENTRES
CAPPER	C10415
END JOIST	100 x 100 x 4mm SHS
FLOORING	
FLOOR SHEET	15mm TONGUE AND GROOVE PLYWOOD F11
FLOOR COVERING	2.0mm NON-SLIP VINYL - POLYSAFE HYDRO EVOLVE TIGRIS #4257
SKIRTING	100mm COVED VINYL
COMPLEXING	-
WATERPROOFING	NO
OTHER	DRY FLOOR WASTES
WALLS	
INTERNAL HEIGHT	2400mm
INTERNAL LINING	4mm POLYPLY PRE-FINISHED EMBOSSED PLYWOOD - GREY
INTERNAL TRIM	PVC D MOULD - WHITE (3 ROWS OF GREY SCREWS)
WALL INSULATION	-
EXTERNAL CLADDING	COLORBOND PANELRIB, LAID HORIZONTALLY - SURFMIST
EXTERNAL CORNER	HD 40x40x2.5mm D'GAL ANGLE
WALL FRAMES	
FRAMING	75 x 41 x 0.75mm G550 STEEL STUDS
STUD SPACING	400mm CTS
ROOF / CEILING	
CEILING TYPE	FLAT
CEILING LINING	4mm PRE-FINISHED PLYWOOD - MIRAGE PEARL
CEILING INSULATION	R 1.8 (75mm)
ROOF PITCH	2° CENTRE PITCH
ROOF CLADDING	TRIMDECK 0.42 BMT - ZINCALUME
ROOF INSULATION	-
UNDER BARGE FLASHING	ZINC
BARGE	WOODLAND GREY
GUTTER	-
DOWNPIPE	-
STEPDOWN FLASHING	30 x 60 STEP DOWN - WOODLAND GREY
ROOF / CEILING FRAMES	
FRAMING	75 x 41 x 0.75mm G550 STEEL STUDS
STUD SPACING	400mm CTS
ELECTRICS	
SPECIFICATION	TO AS3000, 3001, 3012 (TO COATES HIRE PURCHASE SPECIFICATIONS)
S/W BOARD	P.O.E. LOCATED BEHIND SWITCHBOARD, POLY PLASTIC INTERNALLY MOUNTED SWITCHBOARD, 1800mm AFFL (TO CTR)

ELECTRICAL LEGEND

ITEM	DESCRIPTION	HEIGHT	QTY
EDB	ELECTRICAL DISTRIBUTION BOARD	-	1
POE	ELECTRICAL SUPPLY POINT OF ENTRY	1800 AFFL	1
	2x28W FLURO LIGHT DIFFUSED - SURFACE MOUNT	C/MNTD	3
	SINGLE LIGHT SWITCH	1300 AFFL	2
	SINGLE GPO - 10 AMP	1550 AFFL	2
EF	EXHAUST FAN	-	2

ITEMS & EQUIPMENT SCHEDULE

TAG	QTY	DESCRIPTION
A	5	TOILET SUITE , DUAL FLUSH w/HASP & STAPLE
B	4	S/S HAND BASIN (H&C) PUSHBUTTON TYPE w/ MIRROR OVER
C	2	PAPER TOWEL DISPENSER (ROLL TYPE)
-	-	-
E	1	S/S URINAL - 1500
		NOTES:
		COATES SIGNS - 4 PER BUILDING @ TOP RIGHT CORNERS
		COATES ASSET TAGS - FIT BESIDE ENTRY DOOR @ LOCK
		WASTE OUTLET TO BE MIN. 70mm HIGHER THAN BOTTOM OF SKID
	5	TOILET CUBICLES IN WHITE

DOOR SCHEDULE

TAG	SIZE	QTY	LOCATION	COLOUR	FURNITURE	LOCKING	KEYING	ARCHITRAVE	GLASS	CLOSER	STOP	NOTES
D1	2040 x 920mm	2	EXTERNAL	WHITE	KNOB	PASSAGE	-	PVC	-	STD	YES	REBATED EDGE, SECURITY - ZINC PLATED HASP & STAPLE, CABIN HOOK

WINDOW SCHEDULE

TAG	SIZE H x W	QTY	LOCATION	HEIGHT	OPENING	COLOUR	KEYING	ARCHITRAVE	GLASS	BLINDS	NOTES
W1	280 x 1175mm	4	EXTERNAL	2020 AFFL	290 x 1190mm CUT-OUT	PEARL WHITE	-	PVC	OBS& PERMANENT VENT	-	TAPE & SILICON SEAL TOP SIDES.

PRELIMINARY ISSUE

MBS modular building systems

132 WARREN RD, SMITHFIELD NSW 2164
TEL: 1800 217 131 D: (02) 8718 2500
FAX: (02) 8718 2599

CLIENT APPROVAL

SIGNATURE:
NAME: ....
DATE: ....

PROJECT:
COATES - CAPEX
3.0 x 6.0m M/F TOILET

DATE: 09.10.2015
DRAWN BY: ML
CHECKED BY: DT
SCALE: SHOWN

TITLE: PLAN- GENERAL ARRANGEMENT

DRAWING NUMBER: MS-200305-B20-101
BUILDING NUMBER: #0000
QUOTATION NUMBER: 200305
REV: E
SHEET A3

ISSUE	AMENDMENT	BY	DATE
E	AS CLOUDED	ML	04.05.18
D	AS CLOUDED	ML	06.02.18
C	REVISED SPECIFICATIONS	TW	18.08.17
B	PRELIMINARY ISSUE	SN	27.07.16
A	PRELIMINARY ISSUE	ML	09.10.15

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Appendix 8

QUT Central Analytical Research Facility (XRD Analysis) November 2019

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QUT Central Analytical Research Facility

QUT Central Analytical Research Facility
Materials Characterisation Report

CLIENT	Shannon Edmiston Groundwork Plus
REPORT DATE	28th November 2019
PREPARED BY	Henry Spratt
ANALYSIS REQUESTED	Quantitative XRD
OUR REFERENCE	X19417
YOUR REFERENCE	2303.607
QUT CONTACTS	Mr Ashley Locke, X-ray Analysis Coordinator Ph: 0400128230 | email: a.locke@qut.edu.au Dr Henry Spratt, Senior X-ray Technologist (Geoscience) Ph: 07 3138 9526 | email: henry.spratt@qut.edu.au **X-ray and Particles Laboratory enquiries: xandp@qut.edu.au**

QUT Central Analytical Research Facility | Institute for Future Environments
www.qut.edu.au/ife/carf | ABN 83 791 724 622 | CRICOS No 00213J

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RESULTS

Phase Identification / Quantification

The powder X-ray diffraction pattern shows the presence of crystalline phases. A graphic of the collected diffraction pattern along with the phases identified are included at the end of this report. Below is a table of phase concentration estimates. The estimated normalised abundance of the corundum internal standard in the sample is slightly than 20 wt%. This means amorphous content is below our limit of detection and within uncertainty of zero. A weak peak at 36.6 °2θ was modelled as akermanite but halite is possible.

There is possibly trace cristobalite in the sample as this phase could be modelled to a weak peak. The sample is essentially quartz with trace impurities.

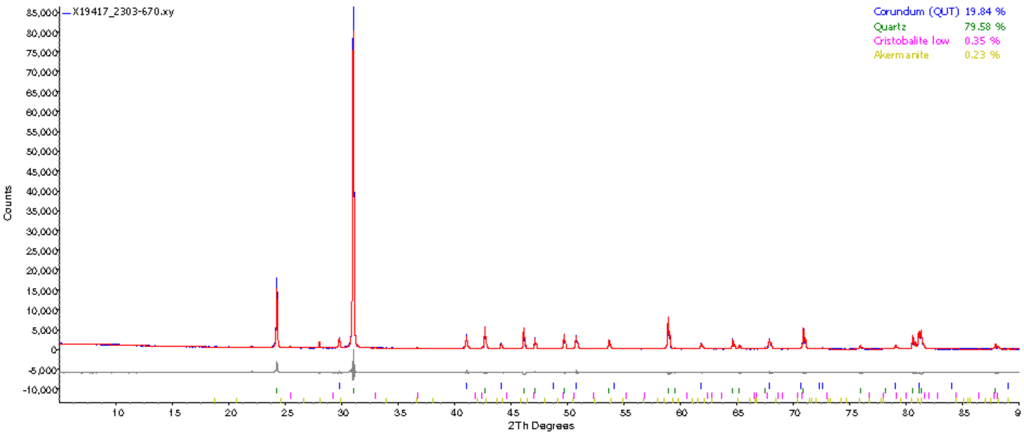
Table of phase abundances (nominal wt%, absolute)

X19417 2303-607	1
Quartz	99.1
Cristobalite	0.4
Akermanite?	0.3
Amorphous	0.2

APPENDIX 1 – X-RAY DIFFRACTION DATA AND GRAPHICS

Powder X-ray Diffraction Pattern

In the graphics below the red line is the Rietveld refinement model, the coloured line is the collected data, and the grey line is the difference. The abundances on the graphic are before taking into account the known addition of corundum. Please use the tabulated abundances which require no further manipulation.



APPENDIX 2 – ANALYTICAL TECHNIQUES

Sample preparation

The sample was dried at 40 °C, then jaw crushed to < 4 mm. The crushed material was then split to < 100 g and crushed in short bursts using a ring mill until the entirety of the sample passed a 300 µm sieve.

A sub-sample was accurately weighed and a specimen prepared for X-ray diffraction analysis by the addition of a corundum internal standard at 20 wt%. The specimen was micronised in a McCrone mill using zirconia beads and ethanol, then dried in an oven overnight at 40 °C. The resultant homogenous powder was back-pressed into a sample holder.

Sample analysis

A step scanned X-ray diffraction pattern was collected for an hour using a PANalytical X'Pert Pro powder diffractometer and cobalt Kα radiation operating in Bragg-Brentano geometry. The collected data was analysed using JADE (V2010, Materials Data Inc.) and X'Pert Highscore Plus (V4, PANalytical) with various reference databases (PDF4+, AMCSD, COD) for phase identification. Rietveld refinement was performed using TOPAS (V6, Bruker) for quantitative phase analysis. The known concentration of added corundum facilitates reporting of absolute phase concentrations for

QUT Central Analytical Research Facility

the modelled phases. The sum of the absolute concentrations is subtracted from 100 wt% to obtain a residual (called non-diffracting/unidentified, also known as "amorphous"). The residual represents the unexplained portion of the pattern: it may be non-diffracting content but will also contain unidentified phases or poorly modelled phases. It is not an accurate measure as its error is the sum of the errors of the modelled phases. The estimated uncertainties in the reported phase abundances are 20 wt% relative or better for every modelled phase. Due to propagation of errors the uncertainty in the amorphous (non-diffracting/unidentified) content is higher at approximately 30 wt% relative or more. The detection limit and limit of quantification using our method is approximately 1 wt% or less depending on the phase in question and sample matrix.

Powder X-ray diffraction is bulk phase analysis, it is not chemical analysis. Phase concentrations may be mis-estimated if an incorrect chemical formula is assigned to a phase. Therefore, the closest matches in the reference phase identification databases were used in the Rietveld refinement model, but other members of the identified mineral groups may be present.

Appendix 9

Petrographic Inspection Report – Dowe's Quarry

prepared by
Groundwork Plus Pty Ltd

(Total No. of pages including blank pages = 10)

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GROUNDWORK plus

Petrographic Inspection Report

Title:	Petrographic Examination – Coarse Quartzite
Prepared for:	SEE Civil
Date Sampled:	20/07/2018
Sample Description:	Coarse Quartzite
Source:	Dowe's Quarry
Sample ID:	DP18_05-10m
Date of Inspection:	13/09/2018
Report Issued:	14/09/2018
Project/ File Ref.:	P2018_095_001

Author:

Luke Ryan (BGeo)
Geologist,
Groundwork Plus

Reviewer:

Rod Huntley

Rod Huntley (BSc, M.App.Sc, M.Eng)
Principal Resource Consultant,
Groundwork Plus

Rock Identity

Name:	Quartzite
Lithology	Metamorphic Rock

Introduction

The results of this report relate to a recent geological investigation conducted at Dowe's Quarry and provides the results of a targeted petrographic assessment of rock chips retrieved on site at a depth of **10 metres** from percussion hole **DP18-05**. The thin section was prepared and analysed by Groundwork Plus by suitably qualified personnel with instructions from the client to conduct petrographic testing to ASTM C295 and recommend further testing if significant deleterious characteristics are identified pursuant to Clause 16.3 of this standard. The location and depth of reference were selected in order to broadly represent the mineralogical and textural characteristics of the target source material. Accordingly, it is accepted that the provided modal mineral percentages relate to this material specifically and that structural analysis of the site should determine the extent and nature of any variation. Assessment regarding the Alkali-Silica Reactivity (ASR) potential of the aggregate has been advised by AS1141.65-2008 and is communicated pursuant to Clause 9. Communication of findings are advised by AS 1726-1993 Geotechnical Site Investigations.

Method

The petrographic assessment of the slide was carried out using a Nikon polarising microscope equipped with a digital camera at the Groundwork Plus petrographic laboratory. A photograph of the hand specimen and thin section photomicrographs showing grain sizes and any particular aspects of the minerals were included as part of the report (**Plates 1, 2,** and **3**). Modal analysis was conducted on the sample using JMicroVision image analysis software on 200 points (**Table 2 – Modal Analysis of Minerals**).

The petrology assessment was based on:

- ASTM C 295 Standard Guide for Petrographic Examination of Aggregates for Concrete.
- AS2758.1 – 1998 Aggregates and Rock for Engineering Purposes Part 1: Concrete Aggregates (Appendix B).
- AS1141 Standard Guide for the Method for Sampling and Testing Aggregates.
- Alkali Aggregate Reaction - Guidelines on Minimising the Risk of Damage to Concrete Structure in Australia - Cement and Concrete Association of Australia and Standards Australia (HB 79-2015).
- The accepted definition of free silica is set out in the Queensland Department of Transport and Main Roads Test Method Q188, and tested pursuant to the AS1141.65-2008 Methods for sampling and testing aggregates – Alkali aggregates reactivity – Qualitative petrological screening for potential alkali-silica reaction and AS1141.26 Secondary Mineral Content.

Interpretation

- The supplied rock sample is identified as **Quartzite,** a **Metamorphic Rock.**

- The hand sample is described as fragments of coarsely grained white quartzose rock with sacharoidal to conchoidal crystal and fracture faces. The rock is composed chiefly of tightly intergrown quartz crystals of varying sizes ranging from subordinate microcrystalline material to large 4.0mm crystals which compose the bulk of the rock. The rock is exceptionally hard and expected to be of extremely high strength and offer exceptional durability. Trivial ferruginous staining is observed is association with opaque inclusions, infilled fracture planes and mica segregations. While regarded as essentially competent and composed of hard, strong, durable and chemically resistant quartz fractures propagate between large individual quartz crystals which may exploited by crushing. This determine the shape and integrity of derived aggregate pieces. The rock is not appreciably magnetic and metamorphic mica is observed as planar segregations. Trace sulfides are detected as fine pyrite.

- Petrographic analysis reveals the quartzite is comprised principally of robust recrystallised quartz crystals (97%) with muscovite (2%) and minor iron oxide, goethite and zircon (1%). The rock is essentially unweathered and is non-porous.

- The sample contains 97% free silica in the form of heavily strained quartz. Duly, material represented by this sample is regarded as presenting risk of significant Alkali-Silica Reactivity (ASR) in concrete.

- Pending material testing, the quartzite is regarded as suitable for use as Coarse Aggregate in Concrete (provided account is made in mix design for the stated potential for ASR) and Unbound Pavements. The rock may also be suitable as Cover Aggregate and Asphalt following bitumen affinity and Polished Aggregate Friction Value (PAFV) testing given potential for highly siliceous rock to polish and strip and service. Extensive crushing is expected to produce quality manufactured sand. The highly competent quartzose composition of the quartzite may result in increased wear on crushing and processing equipment.

- For engineering purposes the rock may be summarised as:

  - Quartzite, a metamorphic rock.
  - Essentially unweathered and non-porous.
  - Composed principally of robust and recrystallised quartz grains (97%) with metamorphic micas and ferruginous staining/infill (3%).
  - Displaying inter-crystalline fracture propagations which may define aggregate shape and loosen crystal cohesion with further crushing.
  - Very hard and of expected extremely high strength and durability.
  - Containing 97% free silica
  - Presenting risk of significant ASR in concrete.

Table 1 – Risk Rating for Specific Applications and Source Rock Quality

Risk Rating for Application	Low	Mod	High	Comments (Pending material testing and assuming the percussion sample is indicative of overall source rock quality)
Aggregate Unbound Pavements	✓			Suitable hardness, strength and durability
Aggregate in concrete	✓			Suitable hardness, strength and durability observing incidence of micaceous planes
Manufactured Sand	✓			May produce quality manufactured sand with attending micaceous fines. May increase water demand if used in concrete
Gabion and Revetment	✓			Suitable
Asphalt/Cover Aggregate		✓		Siliceous rock types with large quartz faces associated with stripping and polishing in service
Risk Rating Source Rock	**Low**	**Mod**	**High**	
Alkali Aggregate Reactivity			✓	High risk of ASR if used concrete due to heavy strain
Secondary Mineral Impacts	✓			Subordinate weak secondary phases (3%) including metamorphic micas and ferruginous infill/staining
Durability	✓			Suitable if incidence of micaceous planes does not significantly increase
Strength	✓			Of high predicted strength
Hardness	✓			Suitable
Free Silica Content			✓	97% free silica as quartz grains and annealed crystals
Sulfides	✓			No sulfides detected
Polishing and bitumen affinity		✓		While potentially mechanically suitable, given large quartz faces available Polished Aggregate Friction Value Testing and Bitumen Affinity are recommended prior to allocation to these roles
Fractures	✓			Weathered fractures observed parallel to bedding
Voids	✓			Non observed, tightly cohesive metamorphic fabric
Light particles		✓		Micaceous planes common

*Low risk means a low probability of causing source rock related issues in regard to material performance in any particular applications. Risk is recommended to be considered in conjunction with a sampling frequency protocol for production of any particular product.

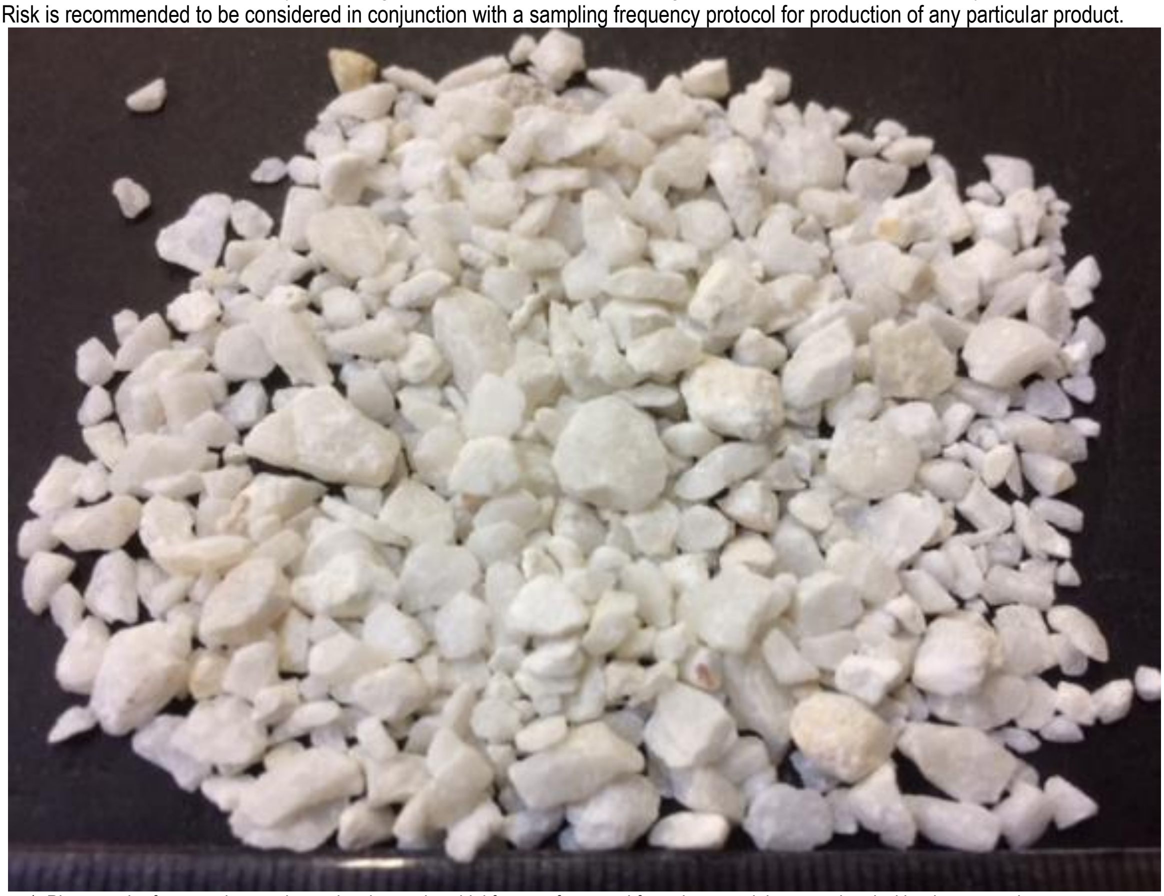

Plate 1. Photograph of a quartzite specimen showing sacharoidal fracture faces and ferruginous staining associated with micaceous planes.

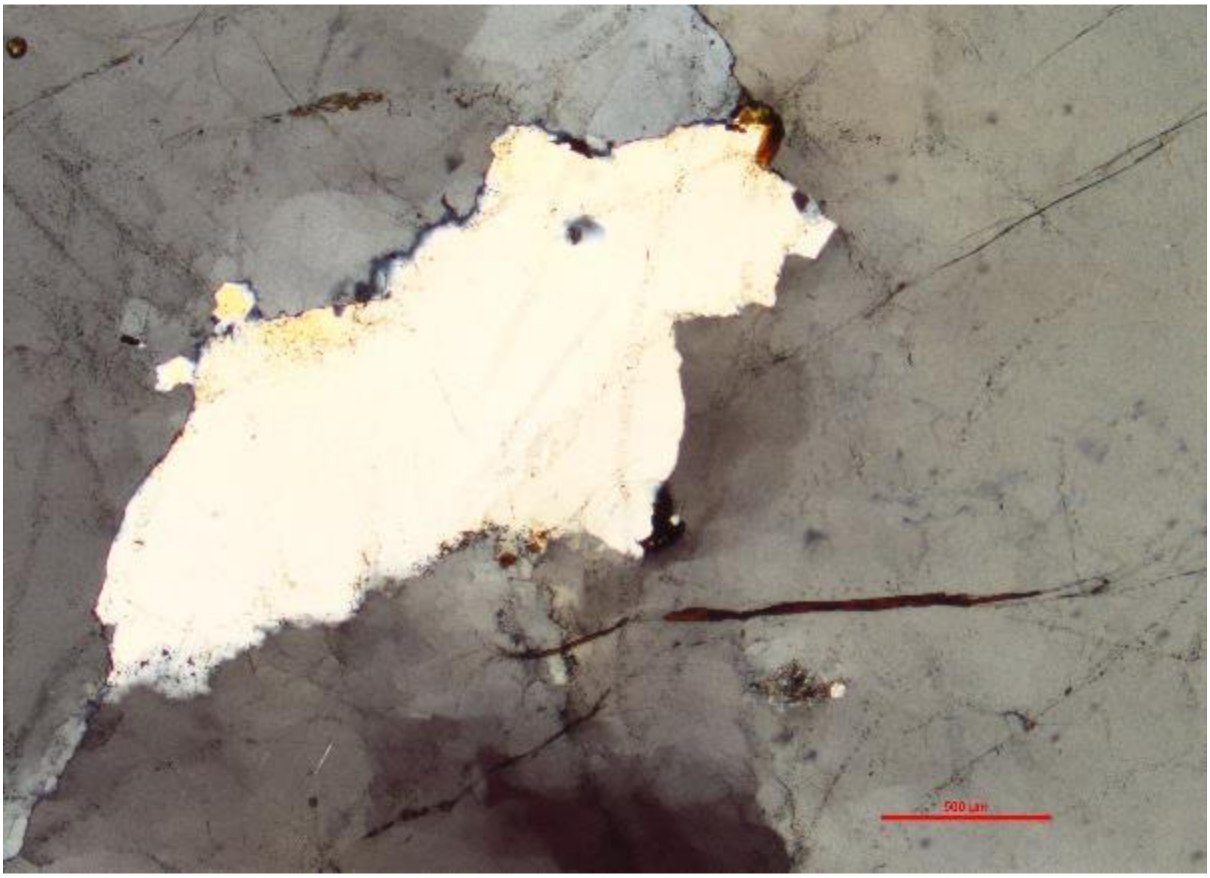

Plate 2. Microphotograph displaying sutured crystal boundaries among constituent strained quartz crystals. Fine zircon, apatite and magnetite inclusions as well as trivial ferruginous staining of internal fractures are common features throughout the observed sample. Image shown in cross polarised light.

Plate 3. Microphotograph utilising plane polarised light to illustrate isolated nature and minor incidence of ferruginous staining among white quartzite pieces.

Thin Section Description

Following petrographic analysis the source rock has been identified as a comprehensively metamorphosed quartzite composed principally of coarse 0.5 to 2.0mm, sutured quartz crystals with attending intercrystalline annealed material and rare zircon and opaque inclusions. Aluminous clay rich laminations in the arenitic source rock have metamorphosed to produce subordinate muscovite planes and rare mica inclusions throughout the sampled rock. Fracture faces often coincident with these micaceous planes and show variable associated weathering as ferruginous staining. These features are of low incidence in the observed material and are therefore unlikely to result in liberation of deleterious weak phases even with crushing or affect the mechanical performance of the derived aggregate. However, increased incidence of these muscovite lineations are likely to be accompanied by an overall reduction in the cohesion of constituent quartz crystals and facilitate disaggregation particularly after crushing with increased attending weathered argillic fines and brown staining. A network of fine fractures is detected which propagates preferentially between highly competent quartz crystals and may therefore be exploited by crushing. This effect will determine the shape of derived aggregate and depending on the distribution of micaceous phases may loosen crystals from the otherwise crystal matrix.

Collectively, the retrieved percussion drill chips represent a highly competent, hard and strong source rock likely to display durability in service provided significantly micaceous/argillic material can be avoided. Stark colour variations in the field emanate from weathered magnetite and goethite inclusions with intensity related to proximity of the quartzite to weathered rock-types and exposure to fracturing and moisture ingress. Extensive crushing may produce suitable manufactured sand as fine aggregate. A mode based on a count of 200 widely spaced points is listed in **Table 2 – Modal Analysis of Minerals**.

Table 2 – Modal Analysis of Minerals

Strong Minerals	Mode (%)	Comments
Quartz	97	Coarse heavily strained and sutured crystals with subordinate microcrystalline to annealed material at boundaries
Zircon/opaques	Trace	Fine 0.02mm accessary inclusions
Weak Minerals		
Muscovite	2	Mica flakes commonly sub-parallel to relic sedimentary laminations
Ferruginous staining	1	Including trivial iron oxide staining and goethite infill associated with mica planes
Total	**100**	***Balance accounted for by minor and trace minerals***

Summary

Pending material testing, the quartzite is regarded as suitable for use as Coarse Aggregate in Concrete (provided account is made in mix design for the stated potential for ASR) and Unbound Pavements. The rock may also be suitable as Cover Aggregate and Asphalt following bitumen affinity and Polished Aggregate Friction Value (PAFV) testing given potential for highly siliceous rock to polish and strip and service. Extensive crushing is expected to produce quality manufactured sand. The highly competent quartzose composition of the quartzite may result in increased wear on crushing and processing equipment.

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- Displaying inter-crystalline fracture propagations which may define aggregate shape and loosen crystal cohesion with further crushing.
- Very hard and of expected extremely high strength and durability.
- Containing 97% free silica.
- Presenting risk of significant ASR in concrete.

Free Silica Content

97% free silica content.

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Enquiries regarding the content of this report should be directed to Groundwork Plus 07 3871 0411

Samples are disposed of after 3 months from the date of report. Thin sections will remain on site indefinitely.

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