APPENDIX P AIR QUALITY AND GREENHOUSE GAS ASSESSMENT

Verden Road Quarry

Air Quality and Greenhouse Gas Assessment

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Hills of Gold Wind Farm Pty Limited

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Verden Road Quarry

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Acronyms and definitions

Abbreviation	Definition
BoM	Bureau of Meteorology
CALMET	Meteorological model for the CALPUFF air dispersion model
CALPUFF	Computer-based air dispersion model
CO	Carbon monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEC	Department of Environment and Conservation
DPE	Department of Planning and Environment
EPA	NSW Environment Protection Authority
ERF	Emissions Reduction Fund
EPL	Environment Protection Licence
GHG	Greenhouse gas
HOGWF	Hills of Gold Wind Farm
NGER	National Greenhouse Gas and Energy Reporting
NEPM	National Environment Protection Measure
NEPC	National Environment Protection Council of Australia
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
NPI	National Pollutant Inventory
OEH	Office of Environment and Heritage, now part of the Department of Planning and Environment as Environment, Energy and Science
$PM_{2.5}$	Particulate matter with equivalent aerodynamic diameters less than 2.5 microns
PM_{10}	Particulate matter with equivalent aerodynamic diameters less than 10 microns
POEO Act	*Protection of the Environment Operations (POEO) Act 1997*
SO_2	Sulphur dioxide
TAPM	The Air Pollution Model – a meteorological and air dispersion model developed by CSIRO
TSP	Total suspended particulate matter

Executive Summary

Hills of Gold Wind Farm Pty Ltd (the Proponent) is seeking approval to construct and operate the Hills of Gold Wind Farm (HOGWF), located on the ridge line between Hanging Rock and Crawney Pass in the Northern Tablelands of New South Wales (NSW). Construction materials will be required to support the development of the wind farm and the Proponent is proposing the development of a quarry near Hanging Rock for this purpose. The quarry, referred to as the Verden Road Quarry, is proposed as an ancillary activity to the HOGWF (the Project). Extraction, processing, stockpiling and transport of up to 500,000 tonnes of material per annum is proposed.

This report represents an air quality and greenhouse gas (GHG) assessment of the Verden Road Quarry to support the HOGWF Amendment Report. The assessment involved identifying the key air quality issues, characterising the existing environment, quantifying emissions to air and modelling the potential impact of the Project on local air quality. The key air quality issues were identified as operational dust, post-blast fume and diesel exhaust. These issues were the focus of the assessment. GHG emissions were also estimated in accordance with recognised methodologies.

A detailed review of the existing environment was carried out including an analysis of historically measured concentrations of key quality indicators from regional monitoring stations. The review showed that air quality in many parts of New South Wales (NSW), including the Northern Tablelands, is heavily influenced by climatic conditions such as drought. However, due to the absence of any significant sources of air pollution, the concentrations of key air quality indicators near the Project are expected to be well below acceptable levels.

The key outcomes of the modelling and subsequent assessment were as follows:

- The Project would not cause adverse impacts with respect to dust concentrations or deposition levels, based on modelling which showed compliance with air quality criteria at all sensitive receptors.
- Post blast fume emissions are not expected to result in any adverse air quality impacts, based on modelling which showed compliance with air quality criteria.
- Emissions from diesel exhausts associated with off-road vehicles and equipment are not expected to result in any adverse air quality impacts, based on modelling which showed compliance with air quality criteria.
- The estimated annual Scope 1 and 2 emissions due to the Project is 1,525 tonnes of carbon dioxide equivalent (CO_2-e), which represents less than 0.0003% of Australia's 2019 emissions. The operation of the wind farm is expected to reduce CO_2-e emissions by 654,400 tonnes per annum.

Based on this assessment, it has been concluded that the Project is a relatively small, temporary, and remote operation that is unlikely to cause any adverse air quality impacts at sensitive locations.

1. Introduction

1.1 Background

Hills of Gold Wind Farm Pty Ltd (the Proponent) is seeking approval to construct and operate the Hills of Gold Wind Farm (HOGWF), located on the ridge line between Hanging Rock and Crawney Pass in the Northern Tablelands of New South Wales (NSW). Construction materials will be required to support the development of the wind farm and the Proponent is proposing the development of a quarry near Hanging Rock for this purpose. The quarry, referred to as the Verden Road Quarry, is proposed as an ancillary activity to the HOGWF (the Project). This report represents an air quality and greenhouse gas (GHG) assessment of the Verden Road Quarry to support the HOGWF Amendment Report.

1.2 Project Description

The Project proposes the construction and operation of a quarry with an extraction limit of up to 500,000 tonnes per annum (tpa). It is estimated that the HOGWF Project may need approximately 700,000 to 800,000 tonnes of quarry materials. Key features of the Project are summarised as follows:

- Quarry operations would be confined to the Project areas within the Forest Materials Licence Area.
- Two areas for quarrying activities are identified as follows:
  - The 'Western Operations Area', which is focussed on the existing Forestry Corporation of NSW (FCNSW) quarry operations area. This site has an area of approximately 13.2 hectares (ha), which includes the extraction pit, processing and stockpiling areas, overburden / topsoil emplacement areas and surface water management structures. This would be the primary area for the production of quarry materials.
  - The 'Eastern Operations Area', located on the hill immediately to the east of the Western Operations Area. This site has an area of approximately 9.9 ha, which includes the extraction pit, processing and stockpiling areas, overburden / topsoil emplacement areas and surface water management structures. This area would only be used should the quarry materials demand from the HOGWF Project exceed anticipated extraction from the Western Operations Area (either in total demand quantity and / or rate of demand). To summarise, it would provide a back-up option for the production of quarry materials if required. The two extraction areas would not operate concurrently.
- Development of a processing and stockpiling area adjacent to each extraction pit (as required).
- Development of a main extraction pit in the Western Operations Area, during the construction period of the HOGWF.
- Development of a satellite extraction pit in the Eastern Operations Area, during the construction period of the HOGWF. Development of this site only if / as required to meet construction tonnage demands.
- Crushing and processing of extracted rock using mobile equipment.
- Extraction, processing, stockpiling and transport of up to 500,000 tonnes of material per annum from the Project area.
- Construction and operation would be undertaken during daytime hours, being Monday to Saturday 7 am to 6 pm, with minor non-audible works to be undertaken outside of these hours (e.g. maintenance activities).
- Erection of temporary administration (mobile crib room / toilet facilities) and construction of surface water management infrastructure.
- Transport of processed quarry material would be managed by the appointed civil contractor for the HOGWF on an 'as needs' basis during quarry operations.

Figure 1 shows the proposed location of the Verden Road Quarry, surrounding features and nearest properties. Figure 2 shows the proposed site layout. Operations in the Eastern Operations Area, if required, will not operate concurrently with those in the Western Operations Area.

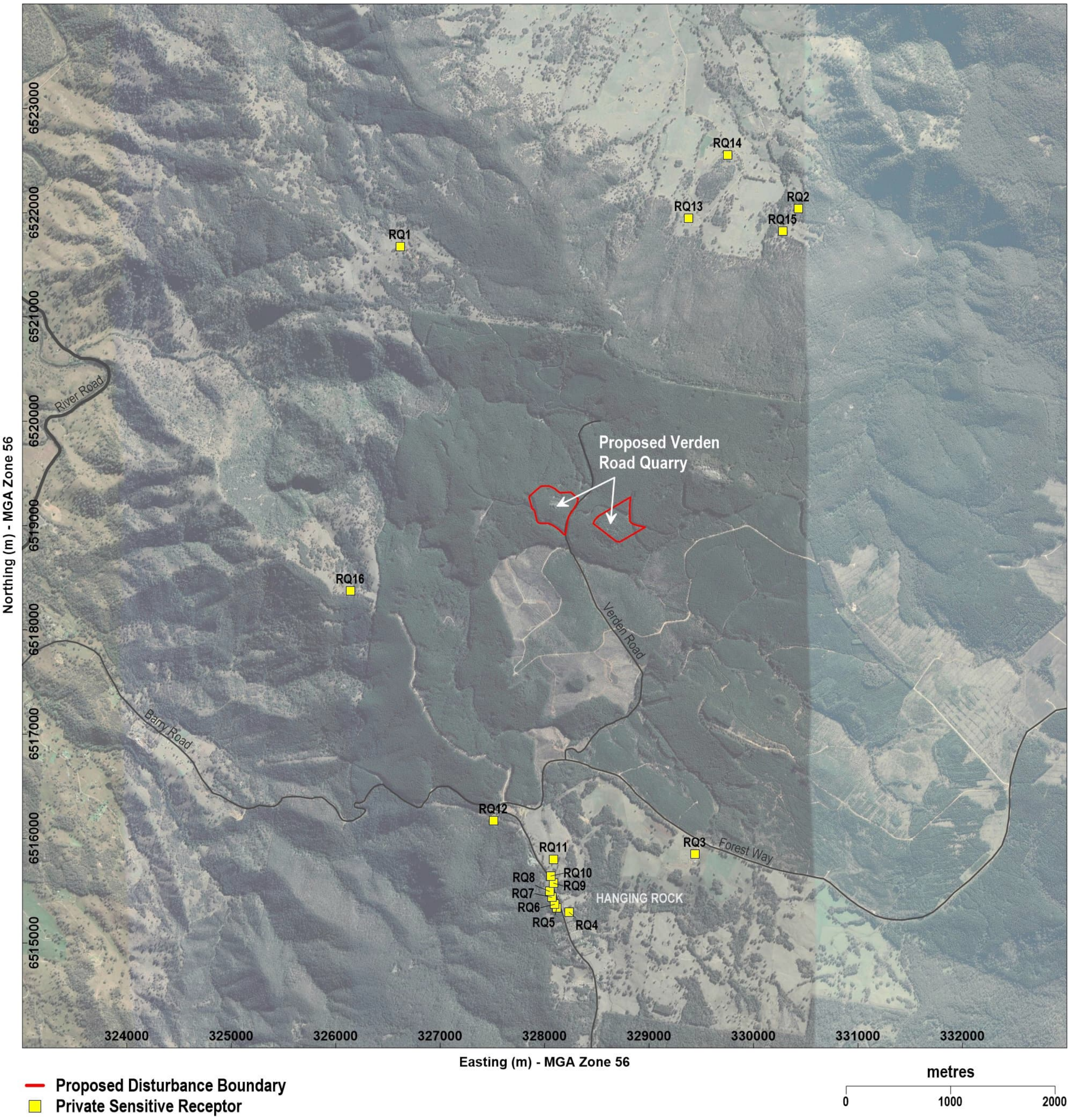

Figure 1 Location of the proposed Verden Road Quarry

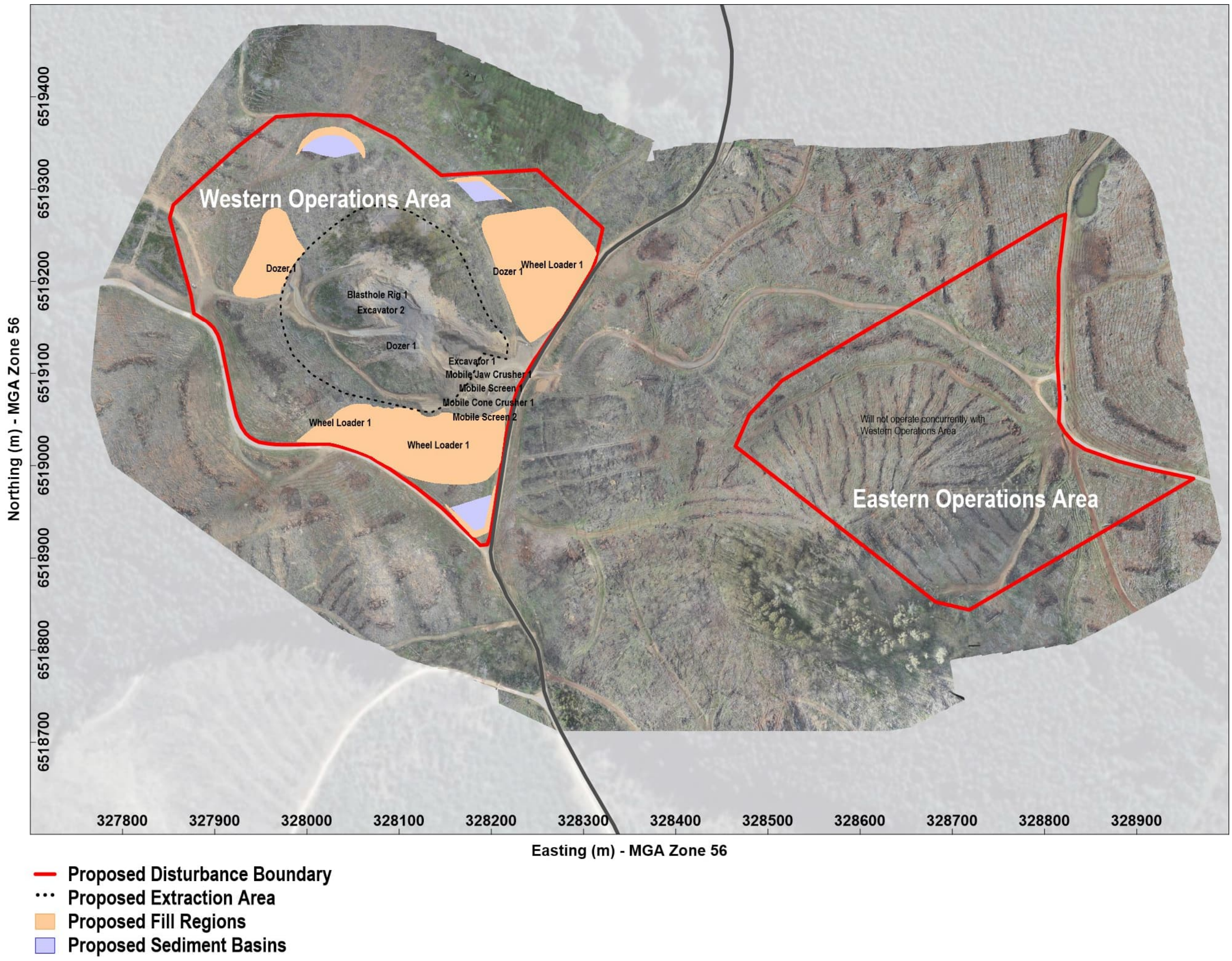

Figure 2 Proposed site layout

1.3 Report Structure

The report is structured as follows:

- Section 1 – Introduces the project with a summary of the background and description.
- Section 2 – Identifies the key air quality and GHG issues to be addressed.
- Section 3 – Outlines the key legislative and policy assessment requirements for air quality and greenhouse gas.
- Section 4 – Discusses key features of the existing environment including surrounding land uses, sensitive receptors, and local meteorological and air quality conditions.
- Section 5 – Provides an overview of the methods used to assess the potential for air quality and greenhouse gas impacts.
- Section 6 – Provides an assessment of the potential construction and operational air quality impacts including potential cumulative impacts.
- Section 7 – Provides an assessment of the potential GHG emissions.
- Section 8 – Outlines the measures to mitigate or otherwise effectively manage and monitor potential impacts.
- Section 9 – Provides the conclusions of the assessment.

2. Key Issues

Air quality issues can arise when emissions from an industry or activity lead to a deterioration in the ambient air quality. Potential air quality issues have been identified from a review of the Project and associated activities. This identification process has considered the types of emissions to air and proximity of these emission sources to sensitive receptors.

Emissions to air from the Project could occur from a variety of activities including material handling, material transport, processing, and wind erosion from exposed areas. These emissions will primarily occur during the operational phase, as limited construction works will be required.

The main emission to air from quarry activities is dust, also referred to as particulate matter. Key classifications of particulate matter include:

- Total suspended particulates (TSP)
- Particulate matter with equivalent aerodynamic diameter of 10 microns or less (PM_{10})
- Particulate matter with equivalent aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$)
- Deposited dust

Plant and equipment engine exhausts also have the potential to generate emissions that include carbon monoxide (CO), oxides of nitrogen (NO_x) and particulate matter, and to a lesser extent sulphur dioxide (SO_2). Post-blast fume has the potential to generate nitric oxide (NO) emissions which, in turn, can oxidise to the more harmful nitrogen dioxide (NO_2).

The key issues which were identified for the Project for consideration in this assessment included:

- Quarry dust i.e. particulate matter in the form of TSP, PM_{10}, $PM_{2.5}$ and deposited dust
- Post-blast fume (NO_2)
- Diesel exhaust (PM_{10}, $PM_{2.5}$ and NO_2)
- Greenhouse gas emissions e.g. carbon dioxide equivalent gases (CO_2-e).

3. Policy Setting

3.1 Air Quality Criteria

Air quality is typically quantified by the concentrations of substances in the ambient air. Air pollution occurs when the concentration (or some other measure of intensity) of one or more substances known to cause health, nuisance and/or environmental effects, exceeds a certain level. With regard to human health and nuisance effects, the substances most relevant to the Project have been identified, from Section 2, as particulate matter and NO_2.

The Environment Protection Authority (EPA) has developed assessment criteria for a range of air quality indicators including particulate matter and NO_2. These criteria are outlined in the "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" (EPA, 2022), hereafter referred to as the Approved Methods. Most of the EPA criteria referred to in this report have been drawn from national standards for air quality set by the National Environmental Protection Council of Australia (NEPC) as part of the National Environment Protection Measures (NEPMs) (NEPC, 1998).

The Project has been assessed in terms of its ability to comply with the relevant air quality criteria set by the EPA as part of the Approved Methods. These criteria are outlined in Table 1 and apply to existing and potentially sensitive receptors, where the Approved Methods defines a sensitive receptor as including *"a location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area"*.

Table 1 EPA air quality assessment criteria

Air quality indicator	Averaging time	Criterion*
Particulate matter (PM_{10})	24-hour	50 µg/m^3
	Annual	25 µg/m^3
Particulate matter ($PM_{2.5}$)	24-hour	25 µg/m^3
	Annual	8 µg/m^3
Particulate matter (TSP)	Annual	90 µg/m^3
Deposited dust	Annual (maximum increase)	2 g/m^2/month
	Annual (maximum total)	4 g/m^2/month
Nitrogen dioxide (NO_2)	1-hour	164 µg/m^3
	Annual	31 µg/m^3

**Source: Table 11 of the Approved Methods.*

The EPA air quality assessment criteria relate to the total concentration of pollutants in the air (that is, cumulative) and not just the contribution from project-specific sources. Therefore, some consideration of background levels needs to be made when using these criteria to assess the potential impacts. In situations where background levels are elevated the proponent must "*demonstrate that no additional exceedances of the impact assessment criteria will occur as a result of the proposed activity and that best management practices will be implemented to minimise emissions of air pollutants as far as is practical*" (EPA, 2022). Section 4 provides further discussion on background levels.

3.2 Greenhouse Gas

3.2.1 Overview

GHG is a collective term for a range of gases that are known to trap radiation in the upper atmosphere, where they have the potential to contribute to the greenhouse effect (global warming). GHGs include:

- Carbon dioxide (CO_2); by far the most abundant GHG, primarily released during fuel combustion.
- Methane (CH_4); generated from the anaerobic decomposition of carbon-based material (including enteric fermentation and waste disposal in landfills).

- Nitrous oxide (N_2O); generated from industrial activity, fertiliser use and production.
- Hydrofluorocarbons (HFCs); commonly used as refrigerant gases in cooling systems.
- Perfluorocarbons (PFCs); used in a range of applications including solvents, medical treatments and insulators.
- Sulphur hexafluoride (SF6); used as a cover gas in magnesium smelting and as an insulator in heavy duty switch gear.

It is common practice to aggregate the emissions of these gases to the equivalent emission of carbon dioxide. This provides a simple figure for comparison of emissions against targets. Aggregation is based on the potential of each gas to contribute to global warming relative to carbon dioxide and is known as the global warming potential (GWP). The resulting number is expressed as carbon dioxide equivalents (or CO_2-e).

GHG emissions that form an inventory can be split into three categories known as 'Scopes'. Scopes 1, 2 and 3 are defined by the Greenhouse Gas Protocol (WRI, 2004) and can be summarised as follows:

- Scope 1 – Direct emissions from sources that are owned or operated by the organisation (examples include combustion of diesel in company owned vehicles or used in on-site generators).
- Scope 2 – Indirect emissions associated with the import of energy from another source (examples include importation of electricity or heat).
- Scope 3 – Other indirect emissions (other than Scope 2 energy imports) which are a direct result of the operations of the organisation but from sources not owned or operated by them (examples include business travel (by air or rail) and product usage).

The purpose of differentiating between the scopes of emissions is to avoid the potential for double counting, where two or more organisations assume responsibility for the same emissions.

3.2.2 Federal Greenhouse Gas Policy

Paris Climate Conference COP 21

During the 21st yearly session of the Conference of Parties (COP 21) held in Paris in 2015, an agreement was reached 'to achieve a balance between anthropogenic (human induced) emissions by sources and removals by sinks of greenhouse in the second half of this century'. Following COP21, international agreements were made to:

- Keep global warming well below 2.0 degrees Celsius, with an aspirational goal of 1.5 degrees Celsius (based on temperature pre-industrial levels).
- From 2018, countries are to submit revised emission reduction targets every five years, with the first being effective from 2020, and goals set to 2050.
- Define a pathway to improve transparency and disclosure of emissions.
- Make provisions for financing the commitments beyond 2020.

Australia has now legislated a Climate Change Bill. This Bill includes targets to cut emissions by 43% by 2030 from 2005 levels, and achieve net zero emissions by 2050.

National Greenhouse and Energy Reporting Act 2007

The Federal Government uses the National Greenhouse Gas and Energy Reporting (NGER) legislation for the measurement, reporting and verification of GHG emissions in Australia. This legislation is used for a range of purposes, including international GHG reporting. Corporations which meet the thresholds for reporting under NGER must register and report their GHG emissions.

Under the *National Greenhouse and Energy Reporting Act 2007* (NGER Act), constitutional corporations in Australia which exceed thresholds for GHG emissions or energy production or consumption are required to measure and report data to the Clean Energy Regulator on an annual basis. The *National Greenhouse and Energy Reporting (Measurement) Determination 2008* identifies several methodologies to account for GHGs from specific sources relevant to the proposal. This includes emissions of GHGs from direct fuel combustion (fuels for transport energy purposes), emissions associated with consumption of power from direct combustion of fuel (e.g. diesel generators used during construction), and from consumption of electricity from the grid.

Safeguard Mechanism and Emissions Reduction Fund (ERF)

The Safeguard Mechanism has been in place since 1 July 2016 and is a legislated framework that applies to all facilities that emit more than 100,000 tonnes of CO_2-e of Scope 1 emissions (emissions produced on-site) in a year. The Safeguard Mechanism places a limit on the amount of greenhouse gases Australia's largest industrial facilities can emit by assigning each facility covered by the Mechanism a 'baseline'. Each year, every large facility within the Safeguard Mechanism needs to prove that their emissions for that year are below their baseline, by reporting their emissions to the Clean Energy Regulator (CER). Any facility that emits more greenhouse gases than allowed by their baseline has to take actions to reduce their emissions. For example, through purchasing Australian Carbon Credit Units.

Emissions reduction and sequestration methodologies are available under the Emissions Reduction Fund (ERF) which could provide the opportunity to earn carbon credits as a result of emissions reduction activities.

3.2.3 State Greenhouse Gas Policy

NSW Climate Change Policy Framework

In response to national GHG reduction commitments, the NSW government has developed the NSW Climate Change Policy Framework which sets the objective of achieving net-zero emissions by 2050. The policy does not impose any specific requirements on developments undertaken by private companies but intends to achieve net-zero emissions through a combination of policy development, leading by example and advocacy. Specific directions and emission reduction initiatives from the Framework include:

- An Electricity Infrastructure Roadmap
- A Net Zero Industry and Innovation Program
- An Electric Vehicle Strategy
- A hydrogen Strategy
- A Waste and Sustainable Materials Strategy
- A Primary Industries Productivity and Abatement Program

4. Existing Environment

This section provides a description of the environmental characteristics in the area, including a review of recent and historical meteorological and ambient air quality conditions. One of the objectives for this review was to develop an understanding of any existing air quality issues and to identify the main factors that have influenced air quality conditions.

4.1 Local Setting

The Project is located in the Nundle State Forest, approximately 4 km north of Hanging Rock and 5 km east of Nundle. The closest regional centre is Tamworth, approximately 40 km to the northwest. There are several isolated rural residences to the north, south and west with the closest residence located 2 km to the west-southwest of the proposed disturbance boundary (Figure 1). The Project is located on a ridgeline at an elevation of around 1,100 m with areas of rugged terrain. Figure 3 shows a pseudo three-dimensional representation of the local terrain. This topographical environment will influence local wind conditions, discussed in Section 4.2.

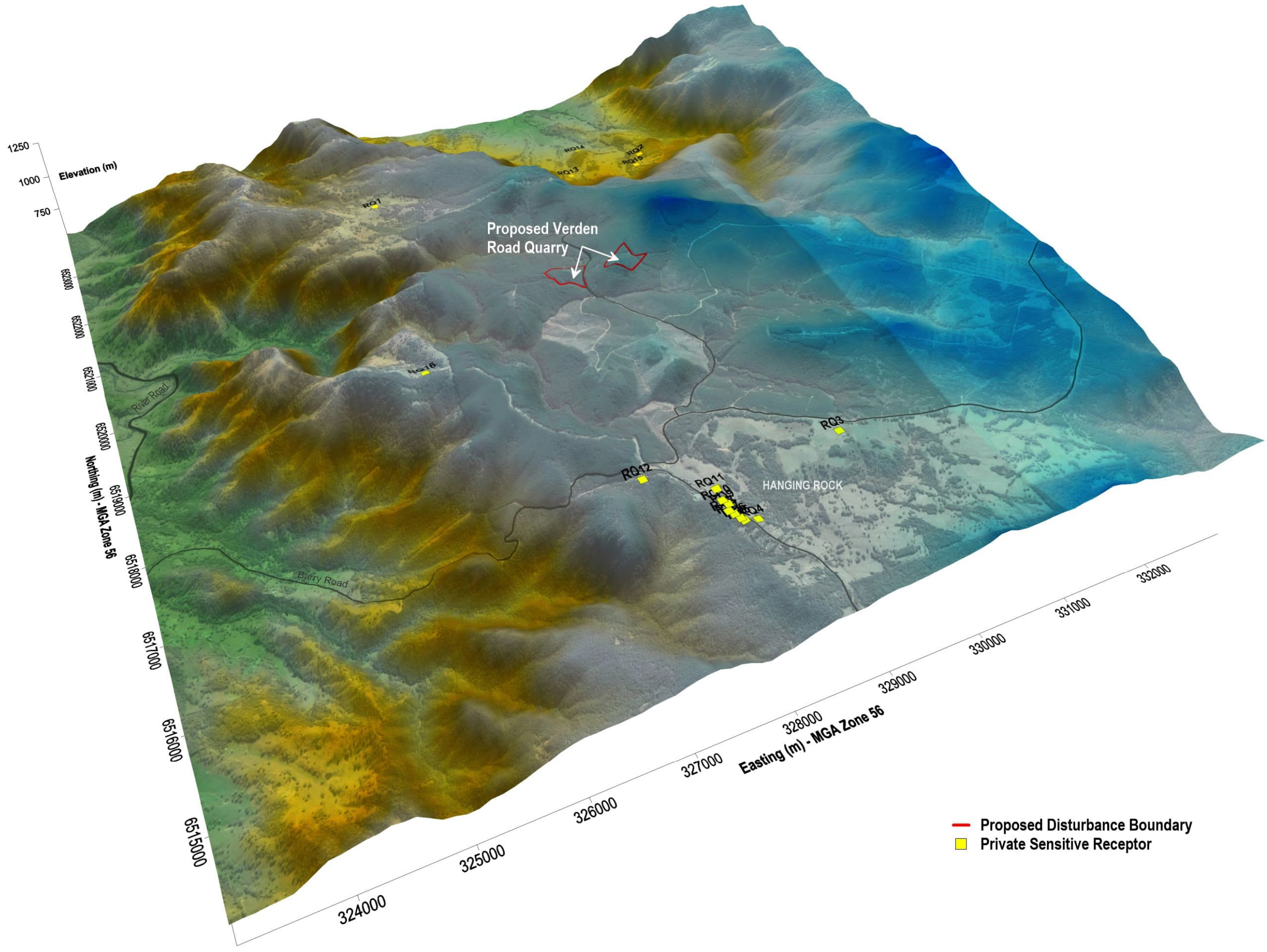

Figure 3 Pseudo three-dimensional representation of the local terrain

4.2 Meteorology

Meteorological conditions are important for determining the transport of emissions, and the potential influences on air quality. In addition, meteorological data are often used with concurrent air quality data to determine potential contributions from sources of interest. This section provides an analysis of the meteorological conditions around the Project and identifies the datasets that are representative of the long term, local conditions.

The EPA prescribes the minimum requirements for meteorological data that are to be used for air quality assessments. These requirements are outlined in the Approved Methods and include minimum data capture rates, siting and operation, and data preparation. Two types of meteorological stations are described by the EPA:

- "Site specific".
- "Site representative".

Data from site-specific meteorological stations are preferred for air quality assessments under the Approved Methods. However, site representative data are also acceptable provided that the data adequately describe the expected meteorological conditions at the site of interest.

The Proponent has operated at least four meteorological stations near the Project for the purposes of collecting data to inform the Hills of Gold Wind Farm. The DPE also operates meteorological stations across NSW with the closest to the Project located at Tamworth. Table 2 provides a summary of the stations and the available records.

Table 2 Summary of relevant meteorological records

Station	Distance from project	Elevation	Lowest monitored wind level	Data availability
M1	13 km S	1,305 m	Not available	Not available
M2	21 km S	1,416 m	40 m	Sep 2018 to Jun 2021
M3	18 km S	1,387 m	60 m	Jul 2019 to Jun 2021
M4	21 km SSW	1,419 m	60 m	Jul 2019 to Sep 2022
Tamworth	45 km NW	407 m	10 m	Oct 2000 to Sep 2022

Data from M4 were selected as the primary data source for the Project. This selection was based on the data availability, proximity to the Project, and similar elevation. The elevated and exposed location of the Project means that wind speeds will be higher than at lower elevations.

The available data from M4 have been analysed to characterise the local conditions and to identify representative datasets. This station can be regarded as "site-representative", so comparisons have also been made to the longer-term records from Tamworth. The analysis involved comparing statistics from the data collected at M4 for each calendar year to determine a year-long dataset that most closely reflects the longer term, local conditions. Wind data have been used for this purpose.

Wind-roses have been prepared from the data collected at M4 in 2020 and 2021. The wind-roses (Figure 4) show the frequency of wind speeds and wind directions based on hourly records. The most common winds in the area are from the north and south. This pattern of winds is evident in both years of data, to various degrees, and reflects to influence of the local, elevated topography. The low frequency of the calm conditions 60 m is a result of the elevated location (1,419 m above mean sea level) and monitors position above ground (60 m).

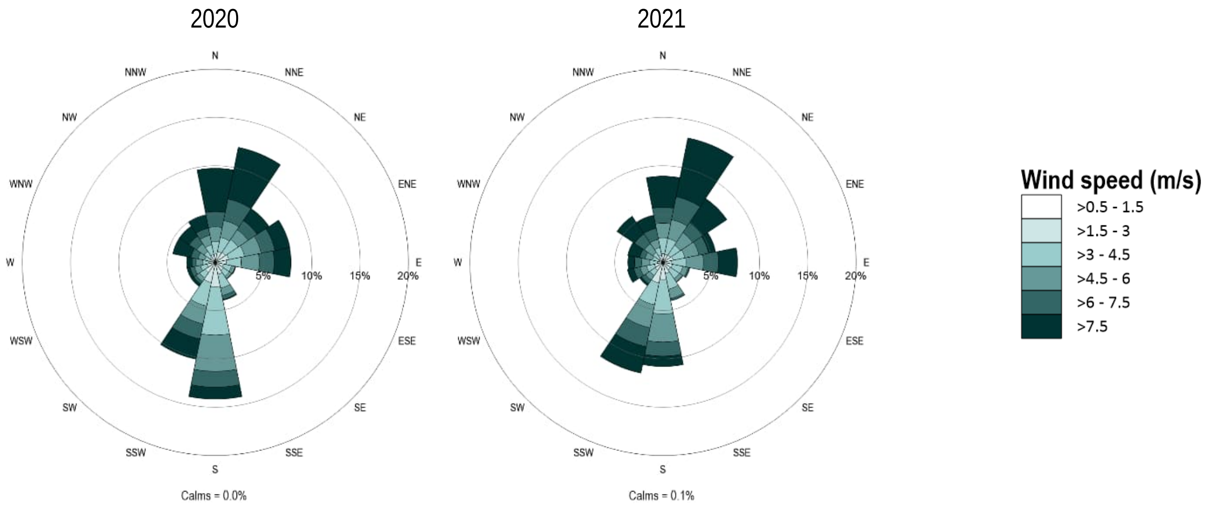

Figure 4 Annual wind-roses for data collected at M4

Figure 5 shows the annual wind-roses from data collected at Tamworth between 2017 and 2021. The most common winds were from the south-southeast and northwest. This pattern exhibits some similarities to the M4 data, albeit with a slight rotation in the wind directions. The differences in wind directions between Tamworth and M4 are most likely due to the different influences of topography at each location. As expected, the wind speeds are generally lower at Tamworth than at M4, due to the differences in elevation. Both Figure 4 and Figure 5 generally indicate that wind patterns do not vary significantly from year to year, and potentially the data from any of the years presented could be considered as representative of the longer-term conditions.

Figure 5 Annual wind-roses for data collected at Tamworth

Figure 6 shows the hourly wind speed data from M4 and Tamworth. These data illustrate the differences in wind speeds between M4 and Tamworth. Maximum wind speeds typically reach around 20 metres per second (m/s) at M4 (measured at 60 m above ground) and 10 m/s at Tamworth (measured at 10 m above ground).

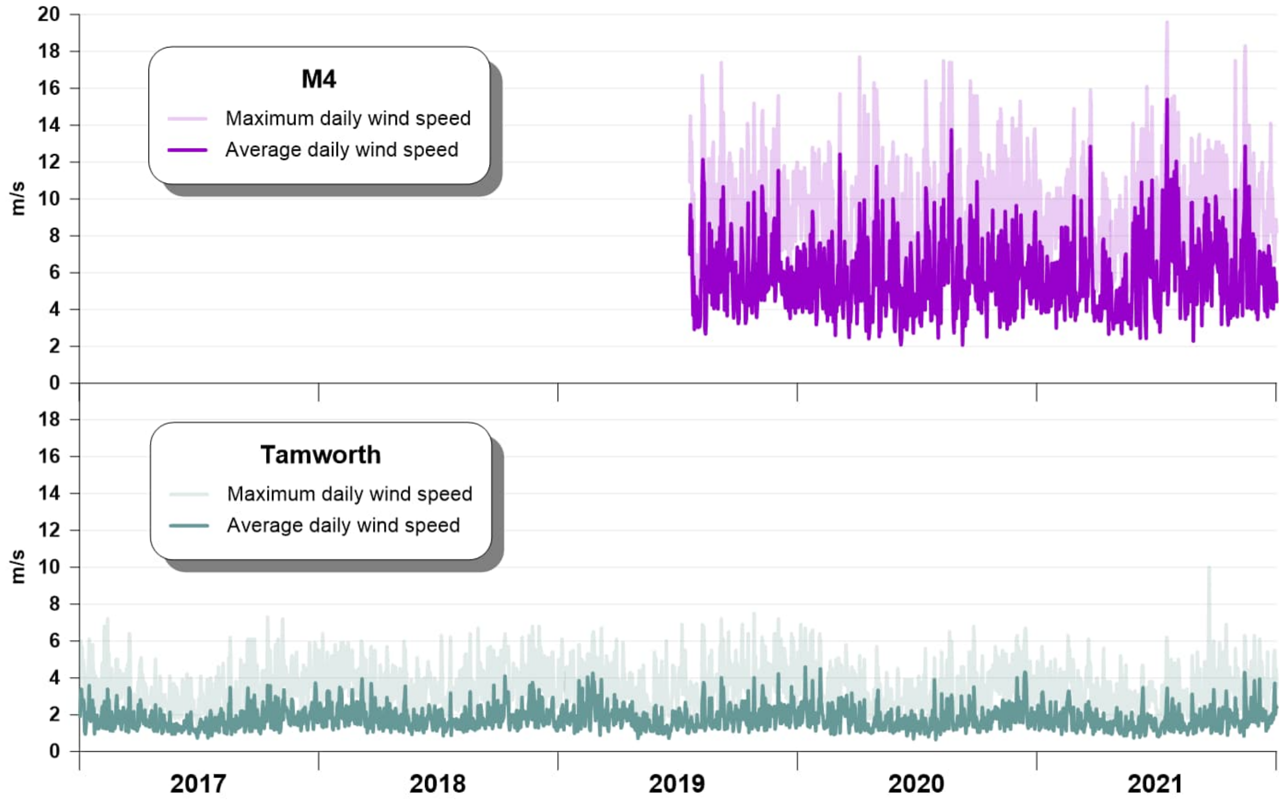

Figure 6 Wind speed and rainfall data collected between 2015 and 2020

Table 3 provides annual wind statistics for the 2017 to 2021 calendar years. These statistics support the earlier observation that conditions do not vary significantly from year to year.

Table 3 Statistics from meteorological data collected between 2017 and 2021

Statistic	Location	2017	2018	2019	2020	2021
Percentage complete (%)	M4	-	-	45	100	100
	Tamworth	100	100	100	100	100
Percentage of calms (<= 0.5 m/s) (%)	M4	-	-	0.0	0.0	0.1
	Tamworth	8.2	7.8	8.4	8.3	9.0
Mean wind speed (m/s)	M4	-	-	5.9	5.7	5.9
	Tamworth	1.7	1.9	1.9	1.8	1.7
99th percentile wind speed (m/s)	M4	-	-	13.5	14.0	13.8
	Tamworth	5.1	5.4	5.7	5.4	5.1

Data from the 2021 calendar year have been identified as being representative of the long term, local conditions around the quarry site and suitable for informing the air quality impacts of the Project. This determination was based on:

- High data capture rate, meeting the EPA's requirement for a minimum 90% complete dataset.
- Similar wind patterns to other years.

Methods used for incorporating the 2021 data into modelling for the Project are discussed in detail in Section 5. Annual and seasonal wind-roses from data collected at M4 in 2021 are provided in Appendix A.

4.3 Air Quality

The DPE monitors air quality at various locations across NSW including at Tamworth and Gunnedah. This section examines the historical air quality conditions of the region and establishes the appropriate background levels to be considered for assessment of the Project.

It should be noted that air quality monitoring data represent the contributions from all sources that have at some stage been upwind of each monitor. In the case of particulate matter (as PM_{10}) for example, a measurement may contain contributions from many sources such as from construction works, bushfires and 'burning off', agricultural activities, industry, vehicles, roads, wind-blown dust from nearby and remote areas, fragments of pollens, moulds, and so on.

4.3.1 Extraordinary Events

Air quality in many parts of NSW, including the Northern Tablelands, was adversely influenced by drought conditions between 2017 to 2019 and lower than average rainfall. A deterioration in air quality conditions over these years was not unique to the Northern Tablelands and extraordinary events, beyond normal conditions, have been identified as part of annual reviews of monitoring data.

In its "Annual Air Quality Statement 2018", DPE (formerly OEH) concluded that particle levels increased across NSW due to dust from the widespread, intense drought and smoke from bushfires and hazard reduction burning (OEH, 2019). The DPE subsequently concluded, from their "Annual Air Quality Statement 2019", that air quality in NSW was greatly affected by the continuing intense drought conditions and unprecedented extensive bushfires during 2019. In addition, the continued "intense drought has led to an increase in widespread dust events throughout the year" (DPE, 2020).

The influence of drought conditions on air quality is evident in the DPE's monitoring data. Figure 7 shows the rolling annual average PM_{10} concentrations from data collected at various rural and urban air quality monitoring sites since 2011. These data clearly show an increase in PM_{10} concentrations at all rural and urban locations from 2017 onwards, reflecting the onset of drought conditions, and increased bushfire activity in 2019. The rolling annual average PM_{10} concentrations decreased rapidly from 2020 to 2022 as rainfall increased.

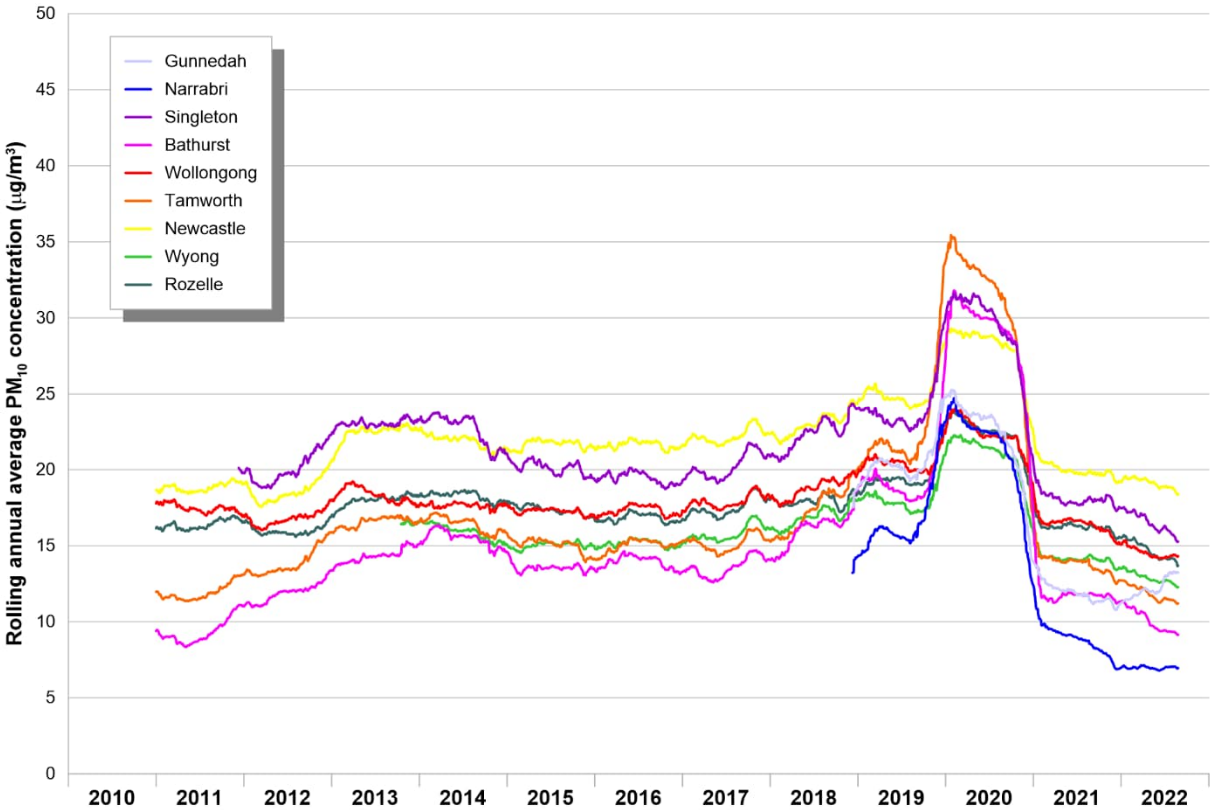

Figure 7 Rolling annual average PM_{10} concentrations at various NSW air quality monitoring sites

The use of years with elevated air quality levels, largely driven by extraordinary events or extreme climatic conditions (or both) are avoided in modelling studies primarily because they do not address the definition of representative. In addition, extraordinary events cannot be reliably simulated in air dispersion models as it is not possible to identify all possible factors that led to these events, for example, the factors that influence the time, location, and intensity of bushfires. This context has been considered in the analysis below.

4.3.2 Particulate Matter (as PM_{10})

Air quality criteria for PM_{10} are set to protect against adverse health impacts. The closest known monitoring of PM_{10} occurs at Tamworth. Figure 8 shows the measured 24-hour average PM_{10} concentrations from Tamworth for data collected between 2017 and 2022. The influence of the drought that led to bushfires and extraordinary events between 2018 and early 2020 is evident from these data.

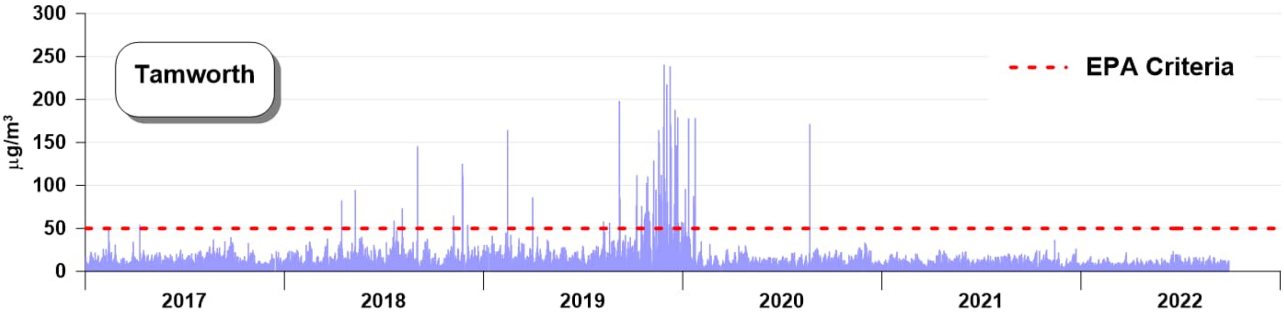

Figure 8 Measured 24-hour average PM_{10} concentrations at Tamworth

Table 4 provides a summary of the Tamworth PM_{10} data. The data show that PM_{10} concentrations increased from 2017 to 2019 coinciding with drought conditions and lower than average rainfall. These conditions led to increases in the number of days when the 24-hour average PM_{10} concentration exceeded 50 µg/m³ and increases in the annual average PM_{10} concentrations. The increases in PM_{10} concentrations were observed across many locations in NSW and were not unique to the Northern Tablelands. Concentrations decreased in 2020, coinciding with increased rainfall. Concentrations of PM_{10} near the Project would be much lower than at Tamworth due to the absence of any significant sources of particulate matter.

Table 4 Summary of measured PM_{10} concentrations at Tamworth

Statistic	2017	2018	2019	2020	2021	EPA criterion
Maximum 24-hour average (µg/m³)	54	145	240	178	36	50
Number of days above 50 µg/m³ (days)	2	9	56	4	0	-
Annual average (µg/m³)	15	20	34	17	13	25

4.3.3 Particulate Matter (as $PM_{2.5}$)

Air quality criteria for $PM_{2.5}$ are set to protect against adverse health impacts. The closest monitoring station to the Project that measures $PM_{2.5}$ is located at Tamworth. Figure 9 shows the measured 24-hour average $PM_{2.5}$ concentrations from Tamworth for data collected between 2017 and 2022. As for PM_{10}, the influence of the drought that led to bushfires and extraordinary events between 2018 and early 2020 is evident from these data.

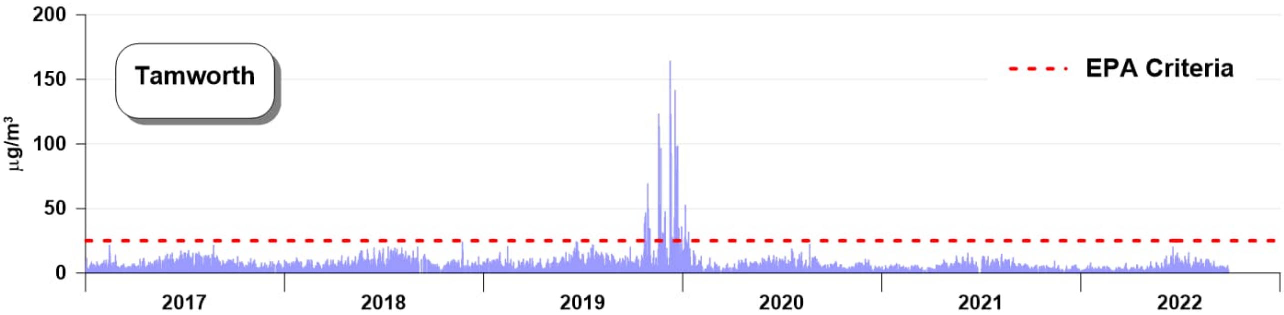

Figure 9 Measured 24-hour average $PM_{2.5}$ concentrations at Tamworth

Table 5 provides a summary of the Tamworth $PM_{2.5}$ data. These data again highlight the effect of the drought conditions and lower than average rainfall. Concentrations of $PM_{2.5}$ near the Project would, again, be much lower than at Tamworth due to the absence of any significant sources of particulate matter.

Table 5 Summary of measured $PM_{2.5}$ concentrations at Tamworth

Statistic	2017	2018	2019	2020	2021	EPA criterion
Maximum 24-hour average (µg/m^3)	22	24	164	32	16	25
Number of days above 25 µg/m^3 (days)	0	0	36	0	0	-
Annual average (µg/m^3)	7.8	8.3	14.5	6.8	5.1	8

4.3.4 Particulate Matter (as TSP)

TSP is not monitored in the vicinity of the Project. The NSW Minerals Council (2000) estimated that, for rural environments in NSW, the average PM_{10} concentrations are typically 40% of the TSP concentrations. For this assessment it has therefore been assumed that PM_{10} concentrations would be 40% of the TSP concentrations, an assumption that yields an estimated annual average TSP concentration of 32 µg/m^3 at Tamworth based on the measured annual average PM_{10} concentration of 13 µg/m^3 in 2021. Table 6 shows the estimated annual average TSP concentrations from each PM_{10} monitoring site for data collected between 2017 and 2021.

Table 6 Summary of estimated TSP concentrations at Tamworth

Statistic	2017	2018	2019	2020	2021	EPA criterion
Annual average (µg/m^3)	38	50	85	42	32	90

4.3.5 Deposited Dust

Air quality criteria for deposited dust are set to protect against nuisance amenity impacts. Deposited dust is not monitored in the vicinity of the Project, so it was necessary to estimate levels from the Tamworth data. Table 4 shows the estimated annual average deposited dust levels at Tamworth. These estimates show that deposited dust levels are unlikely to have exceeded the 4 g/m^2/month criterion in the past five years.

Table 7 Summary of estimated deposited dust at Tamworth

Statistic	2017	2018	2019	2020	2021	EPA criterion
Annual average (g/m^2/month)	1.7	2.2	3.8	1.9	1.4	4

4.3.6 Nitrogen Dioxide (NO_2)

Table 8 provides a summary of the measured NO_2 concentrations from Gunnedah, the closest known air quality monitoring site which records this air quality indicator. As expected for this rural location, these data show that the maximum NO_2 concentrations have not exceeded the EPA's (current) 1-hour average criterion of 164 µg/m^3. Annual averages have not exceeded the EPA's annual average criterion of 31 µg/m^3.

Table 8 Summary of measured NO_2 concentrations at Gunnedah

Statistic	2017	2018	2019	2020	2021	EPA criterion
Maximum 1-hour average (µg/m^3)	N/A	70	74	57	105	164
Annual average (µg/m^3)	N/A	10	10	6	6	31

4.4 Assumed Background Levels

Table 9 shows the assumed background levels that would apply to sensitive receptors near the Project. These levels have been added to project contributions to determine the potential cumulative impacts.

Table 9 Assumed background levels that apply at sensitive receptors

Air quality indicator	Averaging time	Assumed background level that applies at sensitive receptors	Notes
Particulate matter (PM_{10})	24-hour	36 µg/m^3	Measured maximum 24-hour average PM_{10} concentration at Tamworth in the representative year (2021)
	Annual	13 µg/m^3	Measured annual average PM_{10} concentration at Tamworth in the representative year (2021)
Particulate matter ($PM_{2.5}$)	24-hour	16 µg/m^3	Measured maximum 24-hour average PM_{10} concentration at Tamworth in the representative year (2021)
	Annual	5.1 µg/m^3	Measured annual average PM_{10} concentration at Tamworth in the representative year (2021)
Particulate matter (TSP)	Annual	32 µg/m^3	Estimated annual average TSP concentration in the representative year (2021), assuming PM_{10} is 40% of the TSP.
Deposited dust	Annual	1.4 g/m^2/month	Estimated annual average deposited dust in the representative year (2021).
Nitrogen dioxide (NO_2)	1-hour	105 µg/m^3	Maximum 1-hour average NO_2 concentration from data collected in 2021 from Gunnedah.
	Annual	6 µg/m^3	Annual average NO_2 concentration from data collected in 2021 from Gunnedah.

5. Assessment Methodology

This assessment has followed the procedures outlined in the Approved Methods (EPA, 2022). The Approved Methods include guidelines for the preparation of meteorological data, reporting requirements and air quality assessment criteria to assess the significance of expected impacts.

Specific methodologies for each of the identified key issues (from Section 2) are described below. A conservative approach has been taken in regards to determining background levels, estimating emissions, and application of mitigation measures.

5.1 Operational Dust

Operational dust has been quantified by modelling. The choice of model has considered the expected transport distances for the emissions, as well as the potential for temporally and spatially varying flow fields due to influences of the locally complex terrain, non-uniform land use, and stagnation conditions characterised by calm or very low wind speeds with variable wind directions. The CALPUFF model has been selected. This model is specifically listed in the Approved Methods as a more advanced dispersion model than AUSPLUME v 6.0 and has been used to predict ground-level particulate matter concentrations and deposition levels due to the Project activities and other sources. Concentrations and deposition levels have been simulated for every hour of the representative year and results at sensitive receptors have then been compared to the relevant air quality assessment criteria.

Figure 10 shows an overview of the model and key inputs. Appendix B provides details of all model settings.

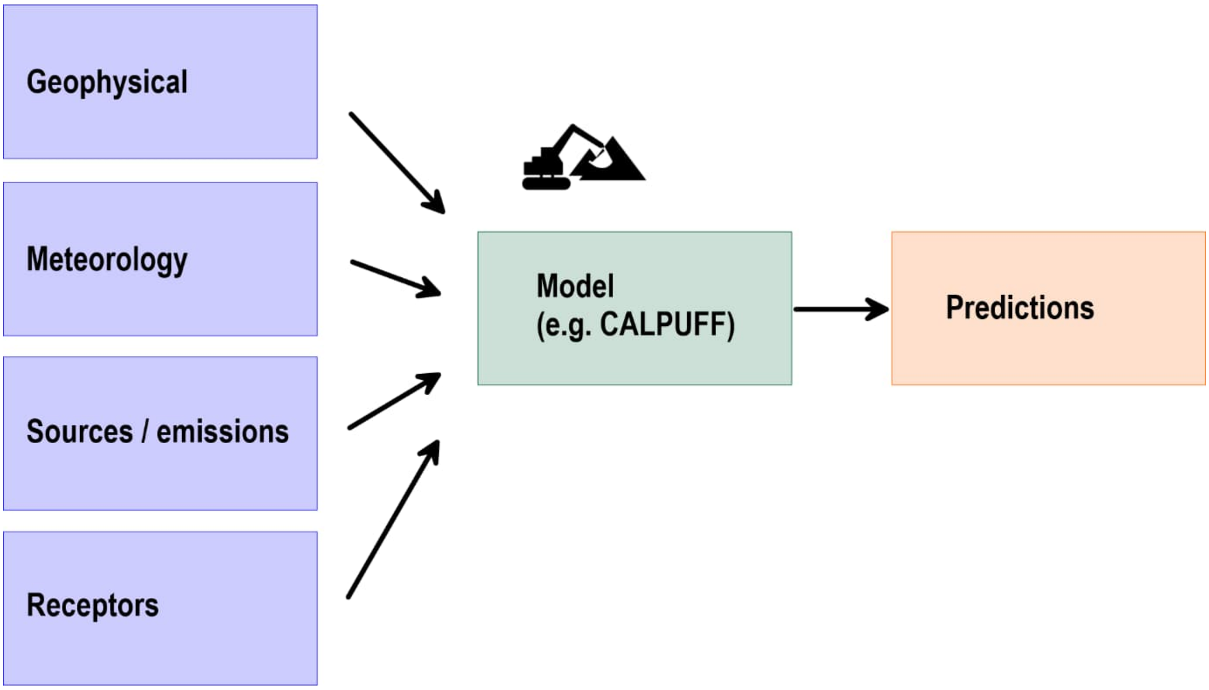

Figure 10 Overview of model inputs and outputs

Dust (particulate matter) is the most significant emission to air from the operations and estimates of these emissions are required by the dispersion model. Total dust emissions have been estimated for selected operational scenarios using the material handling schedule, equipment listing and plans relating to the Project combined with emission factors from:

- Emission Estimation Technique Manual for Mining (NPI, 2012).
- AP 42 (US EPA 1985 and updates).

Table 10 shows the estimated annual TSP, PM_{10} and $PM_{2.5}$ emissions due to the Project. It was assumed that the Project produces 2,000 tonnes per day (tpd) for every day of the year. This is a conservative assumption that will over-state impacts. Full details on the emission calculations, including assumptions, emission controls and allocation of emissions to modelled locations are provided in Appendix C.

Table 10 Estimated particulate matter emissions

Activity	Annual emissions (kg/y)		
	TSP	PM_{10}	$PM_{2.5}$
Dozer working	48,867	11,897	5,131
Excavators working	1,560	738	78
Drilling rock	331	174	17
Blasting rock	362	187	18
Loading rock to mobile crusher by FEL	1,560	738	78
Crushing (mobile jaw crusher)	4,052	1,588	203
Screening (mobile screen 1)	10,950	3,650	548
Crushing (mobile cone crusher)	4,052	1,588	203
Screening (mobile screen 2)	10,950	3,650	548
Loading product stockpiles	780	369	39
Wind erosion from exposed areas	5,256	2,628	394
Wind erosion from product stockpiles	438	219	33
Loading product to trucks	1,560	738	78
Hauling product off-site (Verden Rd)	273,750	52,143	13,036
Total	364,468	80,306	20,402

The quarry operations were represented by a series of volume sources located according to the location of activities. Emissions from the dust generating activities at each operation were assigned to one or more source location (refer to Appendix C for details of the allocations).

Dust emissions for all modelled quarry-related sources have been considered to fit in one of three categories, as follows:

- Wind insensitive sources, where emissions are relatively insensitive to wind speed (for example, dozers).
- Wind sensitive sources, where emissions vary with the hourly wind speed, raised to the power of 1.3, a generic relationship published by the US EPA (1987). This relationship has been applied to sources such as loading and unloading to/from trucks and results in increased emissions with increased wind speed.
- Wind sensitive sources, where emissions also vary with the hourly wind speed, but raised to the power of 3, a generic relationship published by Skidmore (1998). This relationship has been applied to sources including wind erosion from stockpiles, overburden dumps or active pits, and results in increased emissions with increased wind speed.

Emissions from each volume source were developed on an hourly time step, taking into account the level of activity at that location and, in some cases, the hourly wind speed. This approach ensured that light winds corresponded with lower dust generation and higher winds, with higher dust generation.

Blasting activities and associated emissions were assumed to take place only during daylight hours (9 am to 5 pm for the purposes of the modelling) while all other activities have been modelled for 24 hours per day.

Finally, the model predictions at identified sensitive receptors were then compared with the EPA air quality criteria, previously discussed in Section 3.1. Contour plots have also been created to show the spatial distribution of model predictions. Section 6.1 provides the assessment of operational dust.

5.2 Post Blast Fume

Blasting activities have the potential to result in fume and particulate matter emissions. Particulate matter emissions from blasting are produced from the modelling discussed in Section 5.1. Post-blast fume has also been quantified by modelling.

Post-blast fume can be produced in non-ideal explosive conditions of the ammonium nitrate/fuel oil (ANFO) and is visible as an orange / brown plume. The fumes comprise of NO_x including nitric oxide (NO) and NO_2. In general, at the point of emission, NO will comprise the greatest proportion of the total NO_x emission. Typically, this is 90% by volume of the NO_x. The remaining 10% will comprise mostly NO_2. Ultimately however, much of the NO emitted into the atmosphere is oxidised to NO_2. The rate at which this oxidisation takes place depends on prevailing atmospheric conditions including temperature, humidity, and the presence of other substances in the atmosphere such as ozone. It can vary from a few minutes to many hours. The rate of conversion is important because from the point of emission to the point of maximum ground-level concentration there will be an interval of time during which some oxidation will take place. If the dispersion is sufficient to have diluted the plume to the point where the concentration is very low, then the level of oxidation is unimportant. However, if the oxidation is rapid and the dispersion is slow then high concentrations of NO_2 can occur.

The NO_x monitoring data from Gunnedah (DPE data from March 2018 to November 2020) show that percentage of NO_2 in the NO_x is inversely proportional to the total NO_x concentration, and when NO_x concentrations are high, the percentage of NO_2 in the NO_x is typically of the order of 20%. This is demonstrated by Figure 11 which shows that, for high NO_x concentrations, the NO_2 to NO_x ratio reduces to 20%.

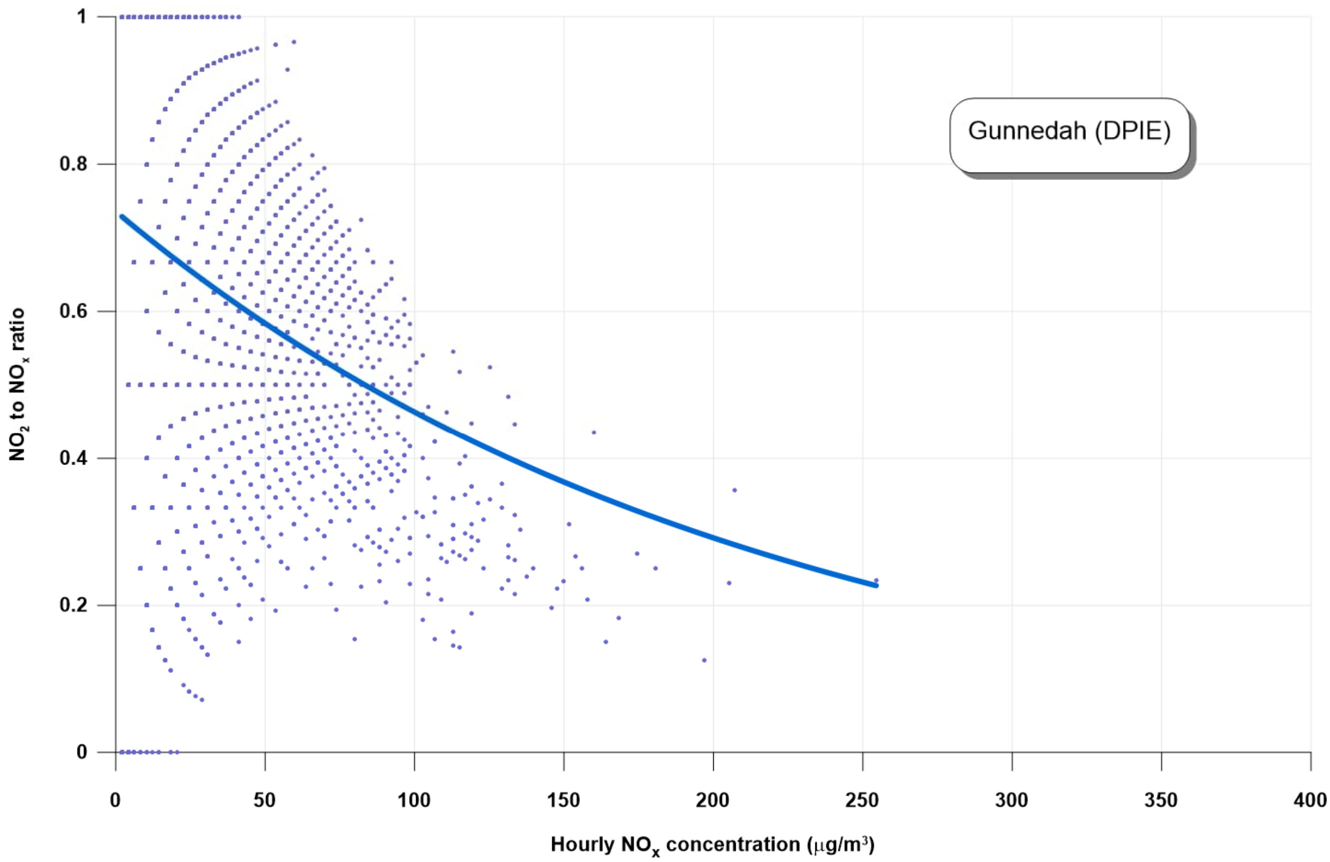

Figure 11 Measured NO_2 to NO_x ratios from hourly average data collected at Gunnedah

The methodology for the operation post-blast fume modelling is outlined below:

- Blast modelled as a single volume source in a location indicative of the centre of the quarry.
- Release height of 10 m, effective plume height of 20 m, initial horizontal spread (sigma y) of 10 m and initial vertical spread (sigma z) of 5 m.
- Emissions assumed to occur every hour between 9 am and 5 pm, and on any day of the week. These are conservative assumptions as the Project does not propose operations every day of the week.
- NO_x emissions based on data presented in the Queensland Guidance Note for the management of oxides in open cut blasting (DEEDI, 2011). It was conservatively assumed that the initial NO_2 concentration in the plume would be 17 ppm (34.9 mg/m^3) based on the Rating 3 Fume Category in the Queensland Guidance Note.

- The initial NO_2 concentration in the plume was converted to a total NO_x emission rate based on a detailed measurement program of NO_x in blast plumes in the Hunter Valley made by Attalla et al. (2008) which found that the $NO:NO_2$ ratio was typically 27:1, giving a $NO_x:NO_2$ ratio of approximately 18.6 g NOx/g NO_2.
- Calculated emission of 43.3 g/s of NO_x per blast and an emission release time of 5 minutes.
- 20% of the NO_x is NO_2 at the points of maximum 1-hour average concentrations and at sensitive receptors.

Model results for post-blast fume have been compared to the applicable EPA air quality criterion for NO_2; that is 164 $\mu g/m^3$ as a 1-hour average and taking background levels into account. Section 6.2 provides the assessment of operational post blast fume.

5.3 Diesel Exhaust

The most significant emissions from diesel exhausts are products of combustion including CO, NO_x, PM_{10} and $PM_{2.5}$. It is the NO_x, or more specifically NO_2, and PM_{10} (including $PM_{2.5}$) which have been assessed. DPE monitoring data have shown that CO concentrations have not exceeded relevant air quality criteria at rural or urban monitoring stations in NSW, indicating that this substance represents a much lower air quality risk.

The modelling for operational dust (Section 5.1) has considered emission factors that represent the contribution from both wheel generated particulates and the exhaust particulates. These emission factors, including with control factors, are based on measured emissions which included diesel particulates in the form of both PM_{10} and $PM_{2.5}$.

Table 11 provides the explicit estimates of PM_{10} and $PM_{2.5}$ emissions due only to diesel plant and equipment exhausts. Emission factors for “Industrial off-road vehicles and equipment” from the EPA’s 2008 Air Emissions Inventory (EPA, 2012) were used for the calculations and it has been assumed that there will be no reduction to emissions in the future; a conservative approach. These factors relate to diesel exhaust and evaporative emissions.

Table 11 Estimated PM_{10} and $PM_{2.5}$ emissions from diesel engines

Parameter	Value
Estimated fuel usage (kL)	509.4
PM_{10} calculations	
Diesel exhaust emission factor (kg/kL)	2.84
Diesel exhaust emissions - all equipment (kg/y)	1,447
$PM_{2.5}$ calculations	
Diesel exhaust emission factor (kg/kL)	2.75
Diesel exhaust emissions - all equipment (kg/y)	1,403

Emissions of NO_x from diesel exhausts have been estimated using fuel consumption data, provided by ARDG, and an emission factor from the EPA’s Air Emissions Inventory for 2008 (EPA, 2012). Table 12 shows the calculations. Again, it has been assumed that there will be no reduction to emissions in the future, a conservative approach.

Table 12 Estimated NO_x emissions from diesel engines

Parameter	Value
Estimated fuel usage (kL)	509.4
NO_x calculations	
Diesel exhaust emission factor (kg/kL)	40.77
Diesel exhaust emissions - all equipment (kg/y)	20,768

The NO_x emission estimates Table 12 have been explicitly modelled to provide an indication of the off-site NO_2 concentrations due to diesel exhaust emissions. Section 6.3 provides the assessment of operational diesel exhaust.

5.4 Greenhouse Gas

The GHG inventory in this document has been calculated in accordance with the principles of the GHG Protocol and the "Technical Guidelines for the Estimation of Greenhouse Gas Emissions by Facilities in Australia" (DEE, 2017). The initial actions for a GHG inventory are to determine the sources of GHG emissions, assess their likely significance and set a boundary for the assessment. Creating an inventory of the likely GHG emissions associated with the Project has the benefit of determining the scale of the emissions and providing a baseline from which to develop and deliver GHG reduction options.

The results of this assessment are presented in terms of the previously mentioned 'Scopes' to help understand the direct and indirect impacts of the project. The GHG Protocol (and similar reporting schemes) dictates that reporting Scope 1 and 2 sources is mandatory, whilst reporting Scope 3 sources is optional. Reporting significant Scope 3 sources is recommended. Scope 3 emissions are a consequence of the activities of the company, but from sources not owned or controlled by the company. Some examples of Scope 3 activities include the extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services. The inventory for this assessment includes all significant sources of GHGs (Scopes 1, 2 and 3) associated with the Project.

Future projections of fuel usage were used to determine the greenhouse gas emissions from the Project. Estimated emissions will be conservative as the calculations do not consider the likelihood of increased renewable energy usage or potential improvements to vehicle efficiency in the future (for example, through electrification or alternative fuel sources).

The *National Greenhouse and Energy Reporting (Measurement) Determination 2008* (Measurement Determination) provides methods, criteria and measurement standards for calculating and reporting greenhouse gas emissions and energy data under the NGER Act. It covers scope 1 and scope 2 emissions and energy production and consumption. The Measurement Determination is used for historical reporting of activities. However, the calculation methodologies for the Project have been based primarily on the National Greenhouse Accounts (NGA) Factors as the NGA Factors are referred to in, for example, the Secretary's Environmental Assessment Requirements (SEARs) where relevant, for the purposes of project assessment. The NGA Factors is not published for the purposes of reporting under the NGER Act.

Table 13 shows the key emission sources that have been considered in this assessment as well as the estimation methodologies.

Table 13 GHG emission sources and estimation methodologies

Activity	Description	Scope(s)	Emission estimation methodology
Diesel usage (on-site equipment)	Combustion of diesel fuel from on-site mobile and stationary plant and equipment	1, 3	Emission factors from NGA Factors (DISER, 2021a).
Diesel usage (trucks transporting product)	Combustion of diesel fuel from trucks transporting product off-site	1, 3	Emission factors from NGA Factors (DISER, 2021a).

Section 7 provides the assessment of GHG emissions.

6. Air Quality Assessment

This section provides an assessment of the identified key air quality issues from Section 2.

6.1 Operational Dust

This section provides an assessment of the Project in terms of operational dust, based on the methodology described in Section 5.1. Model results have been assessed for each of the key particulate matter classifications.

6.1.1 Particulate Matter (as PM_{10})

Figure 12 shows the modelled maximum 24-hour average PM_{10} concentrations due to the Project. These results have been assessed against the EPA's 24-hour average PM_{10} criterion of 50 $\mu g/m^3$. This criterion relates to the total concentration in the air (that is, cumulative) and not just the contribution from the Project. Therefore, the extent of 50 $\mu g/m^3$ has been represented by the 14 $\mu g/m^3$ contour which includes the estimated maximum background level of 36 $\mu g/m^3$ (from Table 9). The modelling shows that the Project would not cause exceedances of the EPA assessment criterion for 24-hour average PM_{10} at any private sensitive receptor.

Figure 13 shows the modelled annual average PM_{10} concentrations due to the Project. These results have been assessed against the EPA's annual average PM_{10} criterion of 25 $\mu g/m^3$. The extent of 25 $\mu g/m^3$ has been represented by the 12 $\mu g/m^3$ contour which includes the estimated background level of 13 $\mu g/m^3$ (from Table 9). These results indicate compliance with the EPA's assessment criterion for annual average PM_{10} (25 $\mu g/m^3$) at all private sensitive receptors.

The results indicate that the Project would not cause adverse impacts with respect to PM_{10}.

Concentrations in µg/m³

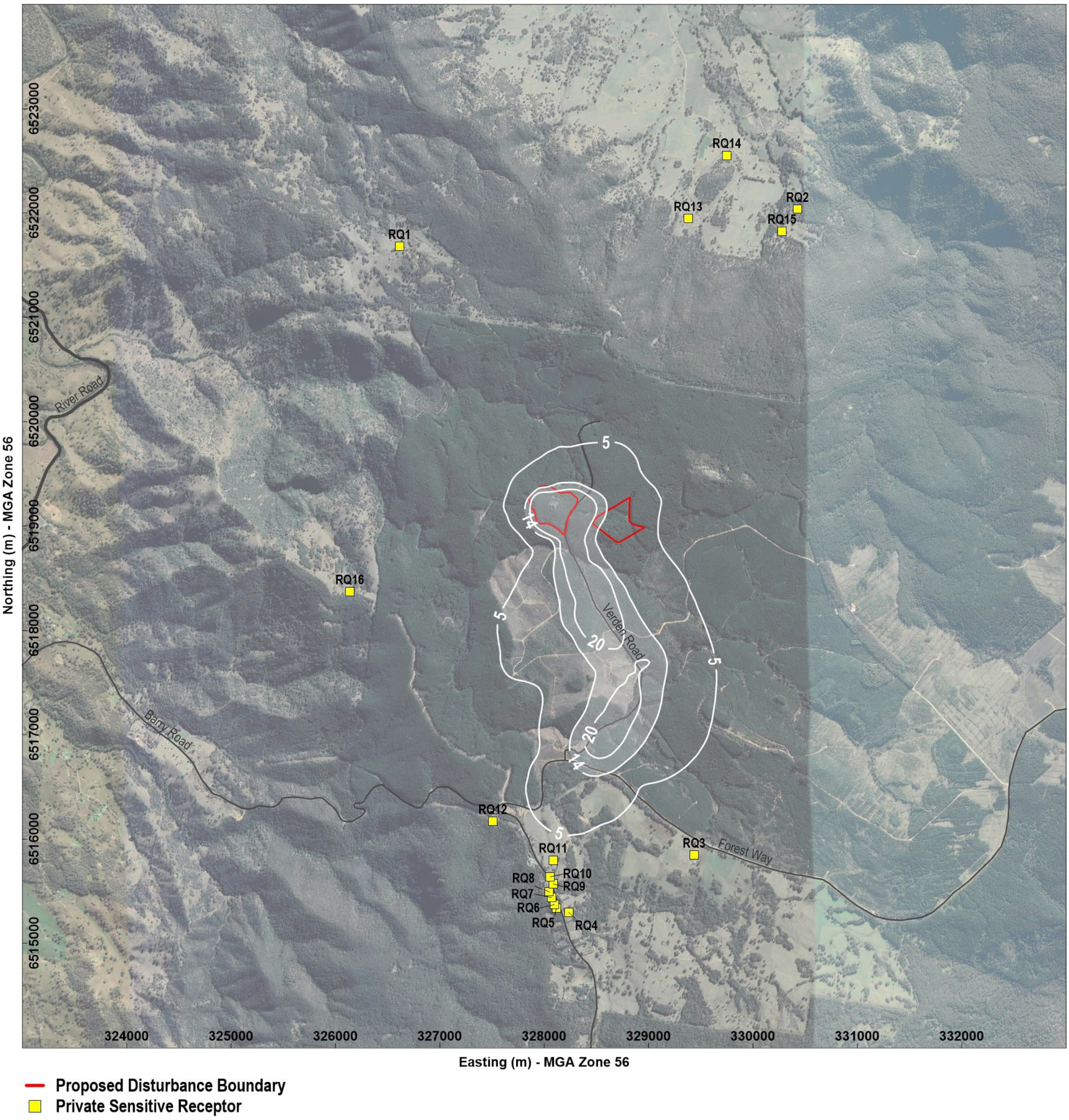

Figure 12 Predicted maximum 24-hour average PM_{10} due to the Project

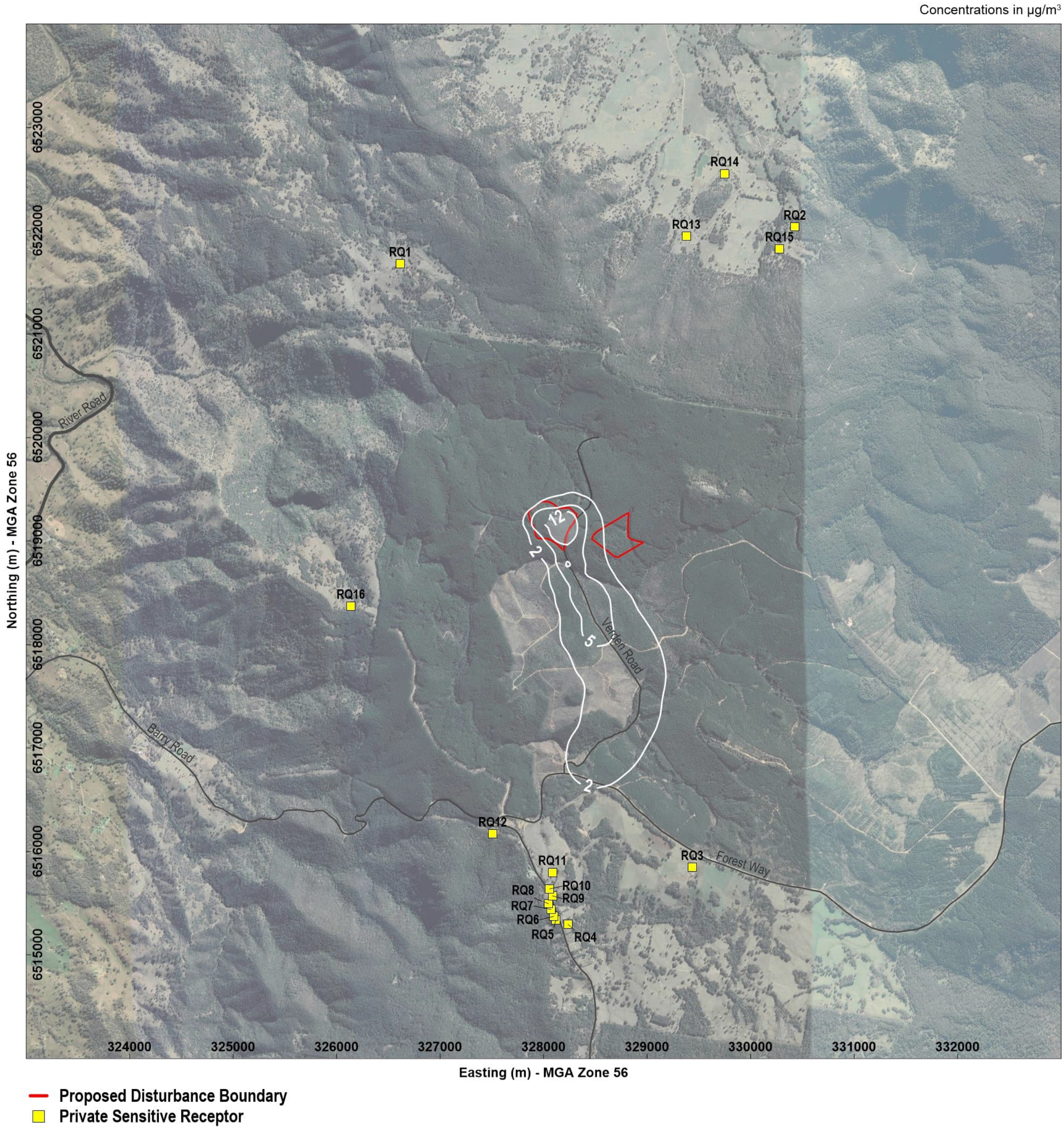

Figure 13 Predicted annual average PM_{10} due to the Project

6.1.2 Particulate Matter (as $PM_{2.5}$)

Figure 14 shows the modelled maximum 24-hour average $PM_{2.5}$ concentrations due to the Project. These results have been assessed against the EPA's 24-hour average PM_{10} criterion of 25 µg/m³. The extent of 25 µg/m³ has been represented by the 9 µg/m³ contour which includes the estimated maximum background level of 16 µg/m³ (from Table 9). The modelling shows that the Project would not cause exceedances of the EPA assessment criterion for 24-hour average $PM_{2.5}$ at any private sensitive receptor.

Figure 15 shows the modelled annual average $PM_{2.5}$ concentrations due to the Project. These results have been assessed against the EPA's annual average PM_{10} criterion of 8 µg/m³. The extent of 8 µg/m³ has been represented by the 2.9 µg/m³ contour which includes the estimated background level of 5.1 µg/m³ (from Table 9). These results indicate compliance with the EPA's assessment criterion for annual average $PM_{2.5}$ (8 µg/m³) at all private sensitive receptors.

Concentrations in µg/m³

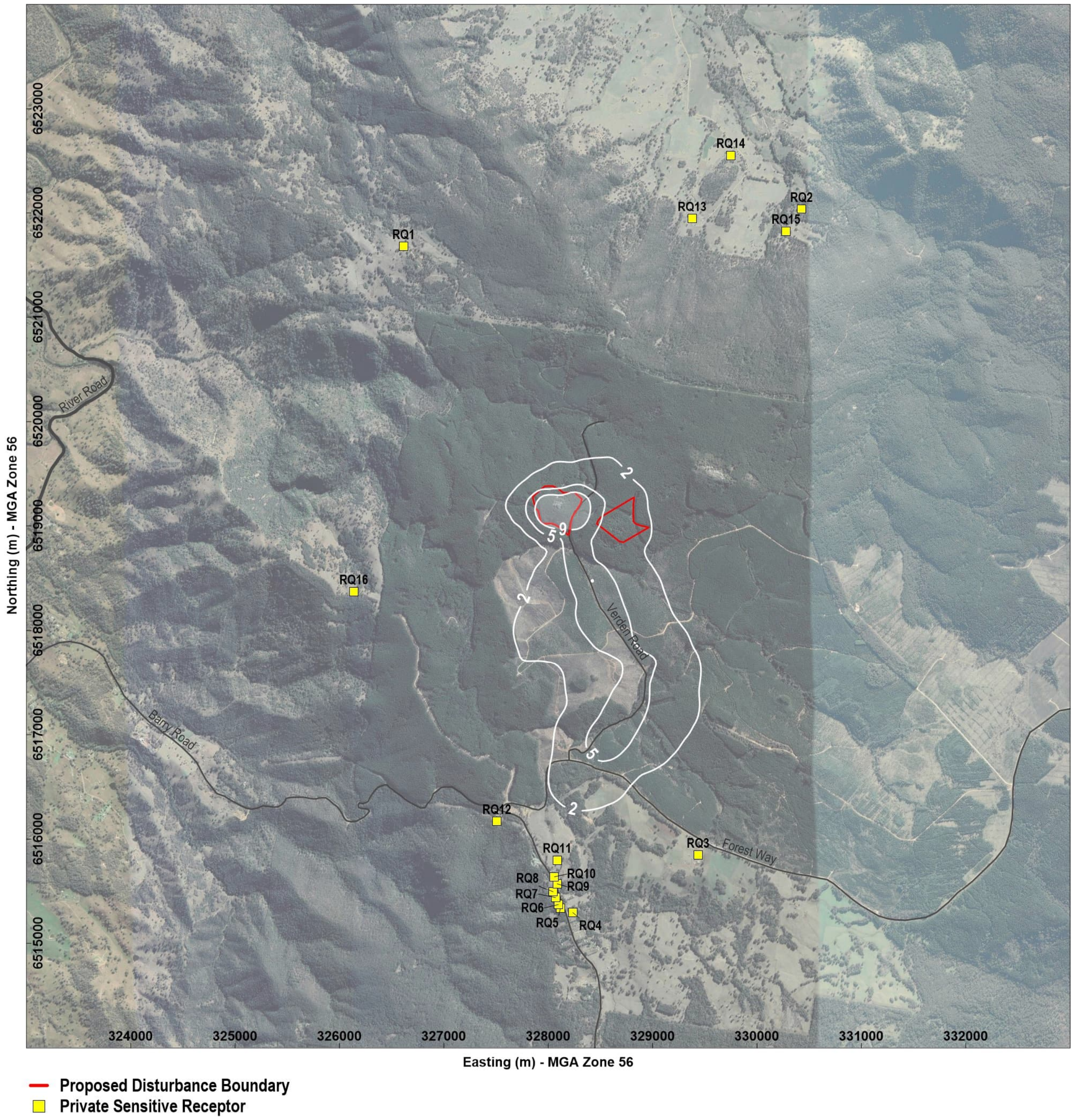

Figure 14 Predicted maximum 24-hour average $PM_{2.5}$ due to the Project

Concentrations in µg/m³

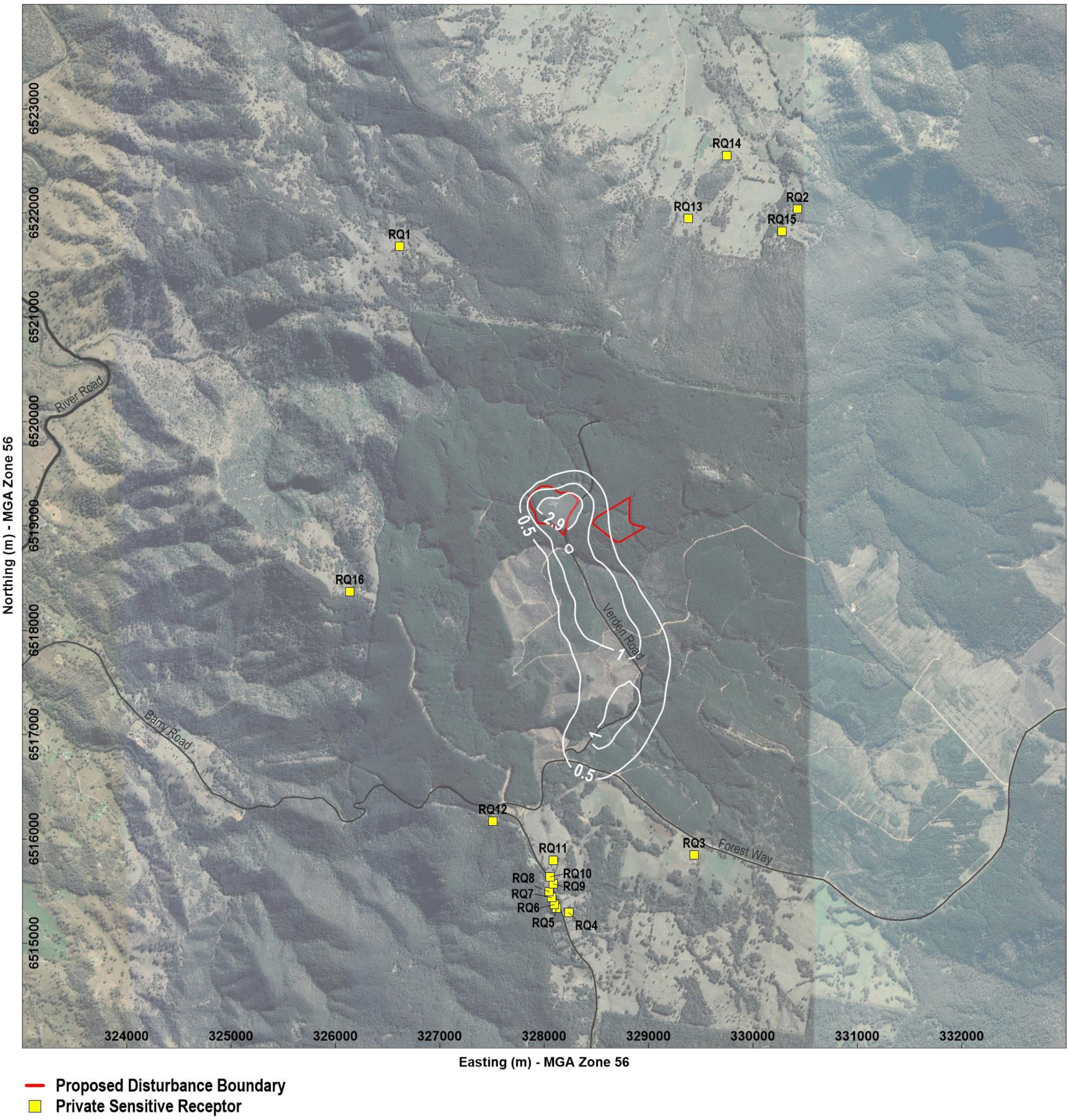

Figure 15 Predicted annual average $PM_{2.5}$ due to the Project

6.1.3 Particulate Matter (as TSP)

Figure 16 shows the modelled annual average TSP concentrations due to the Project. These results have been assessed against the EPA's annual average TSP criterion of 90 µg/m³. The extent of 90 µg/m³ has been represented by the 58 µg/m³ contour which includes the estimated background level of 32 µg/m³ (from Table 9). These results indicate compliance with the EPA's assessment criterion for annual average TSP (90 µg/m³) at all private sensitive receptors.

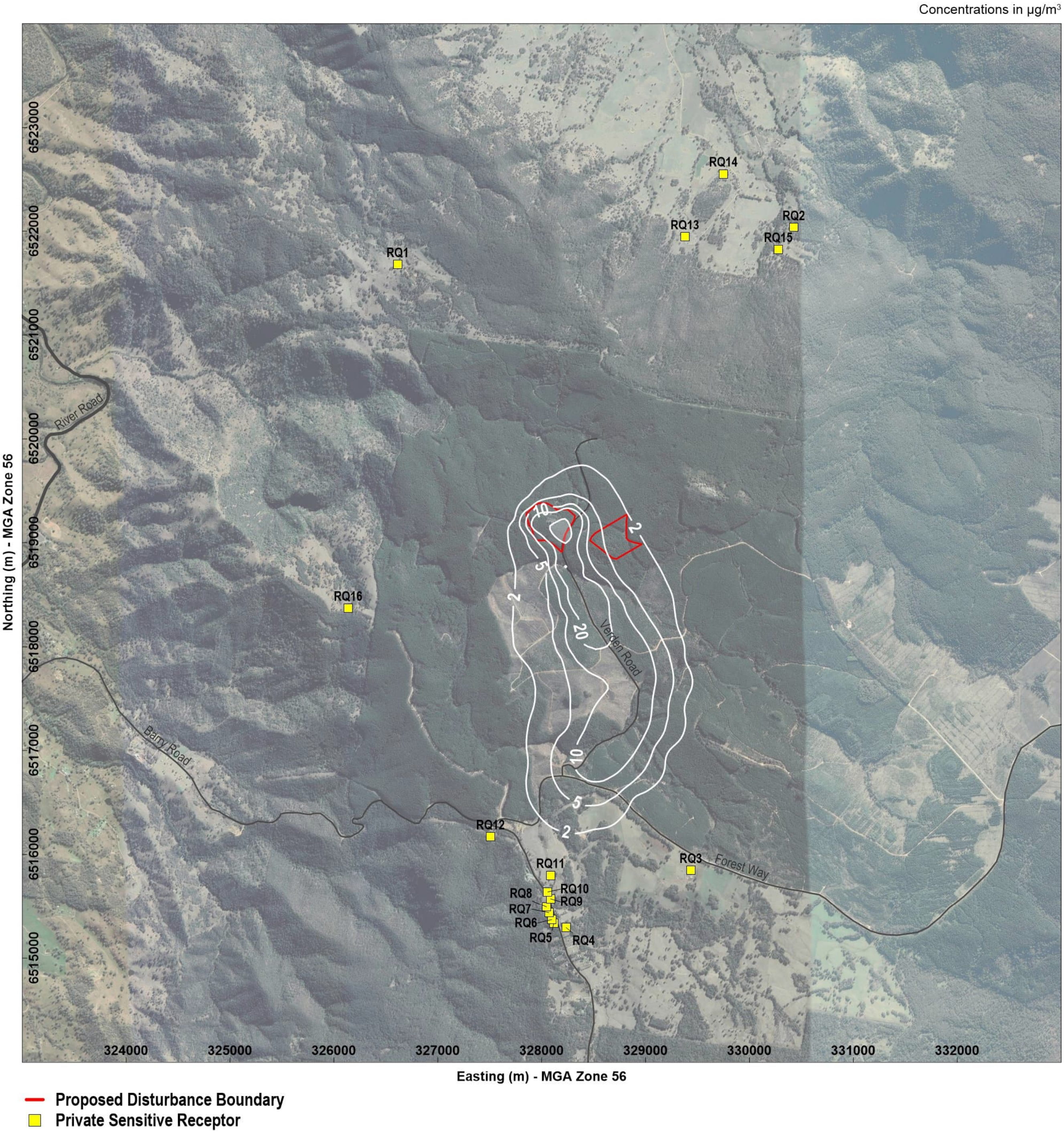

Figure 16 Predicted annual average TSP due to the Project

6.1.4 Deposited Dust

Figure 17 shows the modelled annual average deposited dust levels due to the Project. These results have been assessed against the EPA's criteria of 2 g/m²/month (incremental) and 4 g/m²/month (cumulative). These results indicate compliance with the EPA's assessment criteria at all private sensitive receptors.

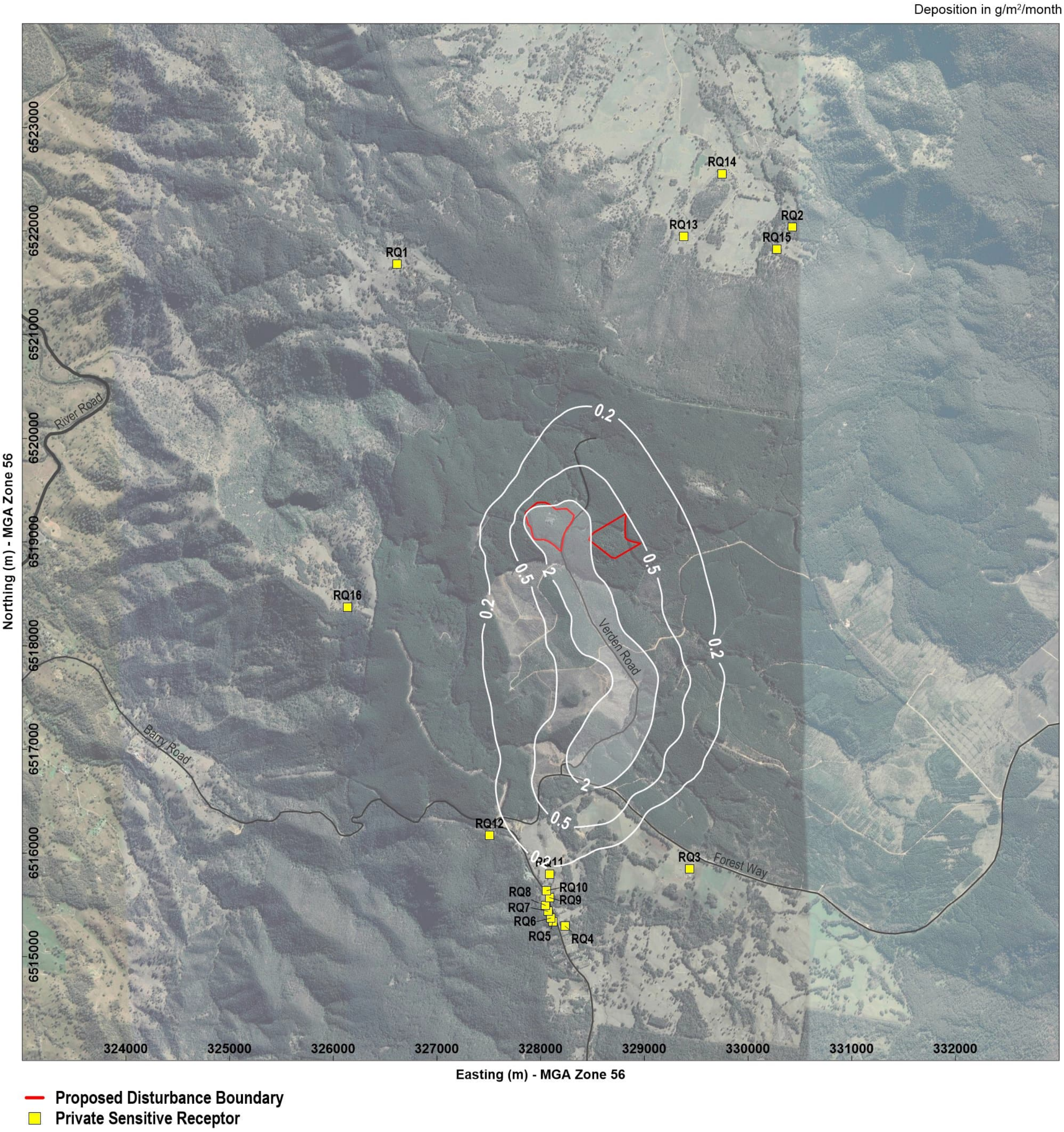

Figure 17 Predicted annual average deposited dust due to the Project

6.2 Post Blast Fume

Figure 18 shows the modelled maximum 1-hour average NO_2 concentrations due to post-blast fume, based on the methodology outlined in Section 5.2. The 59 µg/m³ contour represents the extent of the EPA's 164 µg/m³ assessment criterion with the inclusion of maximum background levels (105 µg/m³ from Table 9). These results show that, under worst-case meteorological conditions with a rated 3 fume, blasting every day between 9 am and 5 pm and maximum background concentrations, the maximum 1-hour average NO_2 concentrations will not exceed the EPA's criterion at any off-site sensitive receptor.

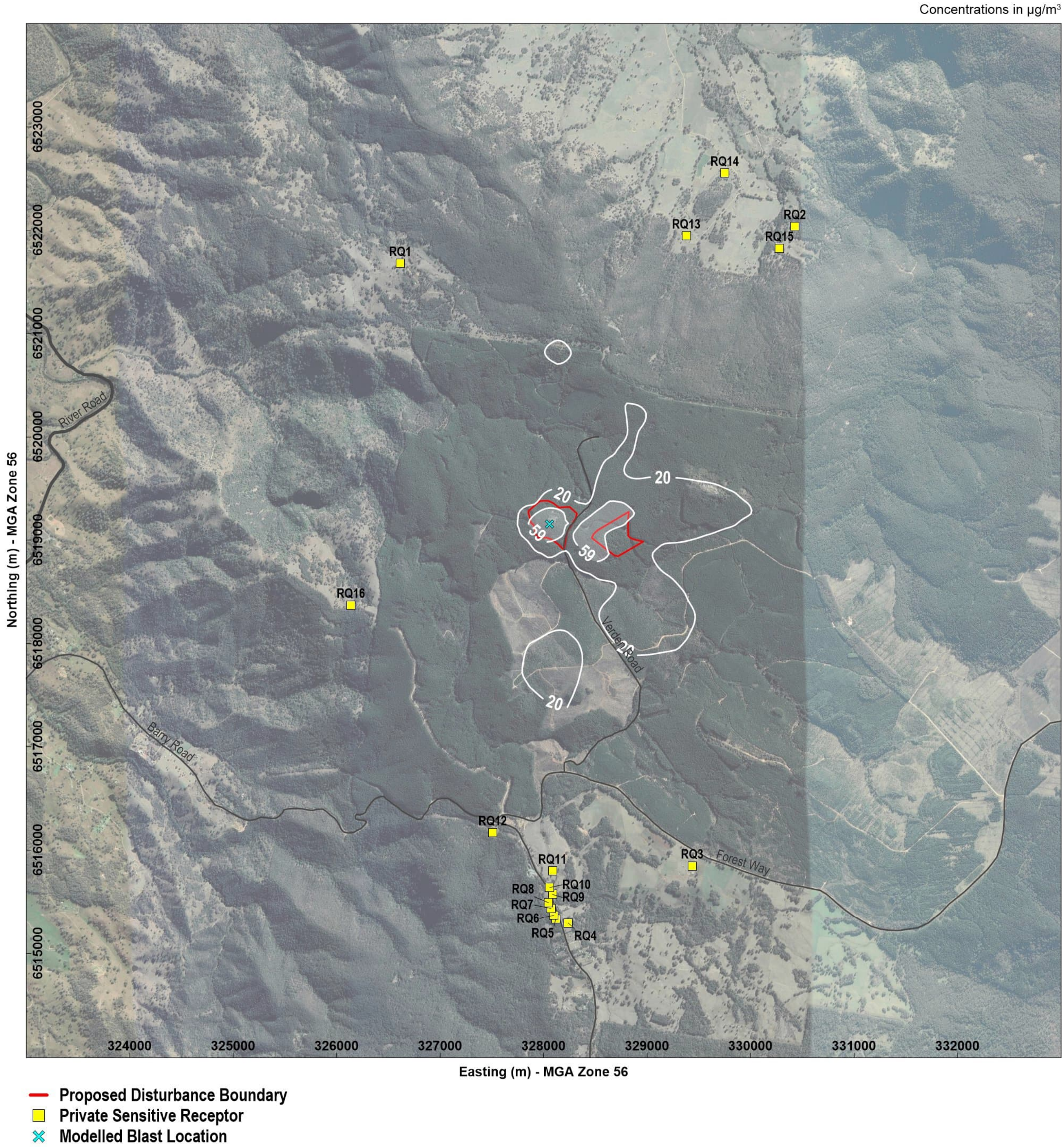

Figure 18 Predicted maximum 1-hour average NO_2 due to blasting

6.3 Diesel Exhaust

Figure 19 shows the modelled maximum 1-hour average NO_2 concentrations due to diesel exhaust emissions, based on the conservative methodology outlined in Section 5.2. The results assume that 20% of the NO_x is NO_2 at the locations of maximum ground-level concentrations. Compliance with the EPA's 164 µg/m³ criterion is expected at all private sensitive receptors, including with consideration of a maximum background concentration of 105 µg/m³.

Figure 20 shows the modelled annual average NO_2 concentrations. These results assume that 100% of the NO_x is NO_2. Compliance with the EPA's 31 µg/m³ criterion is expected at all private sensitive receptors, including with consideration of a background concentration of 6 µg/m³.

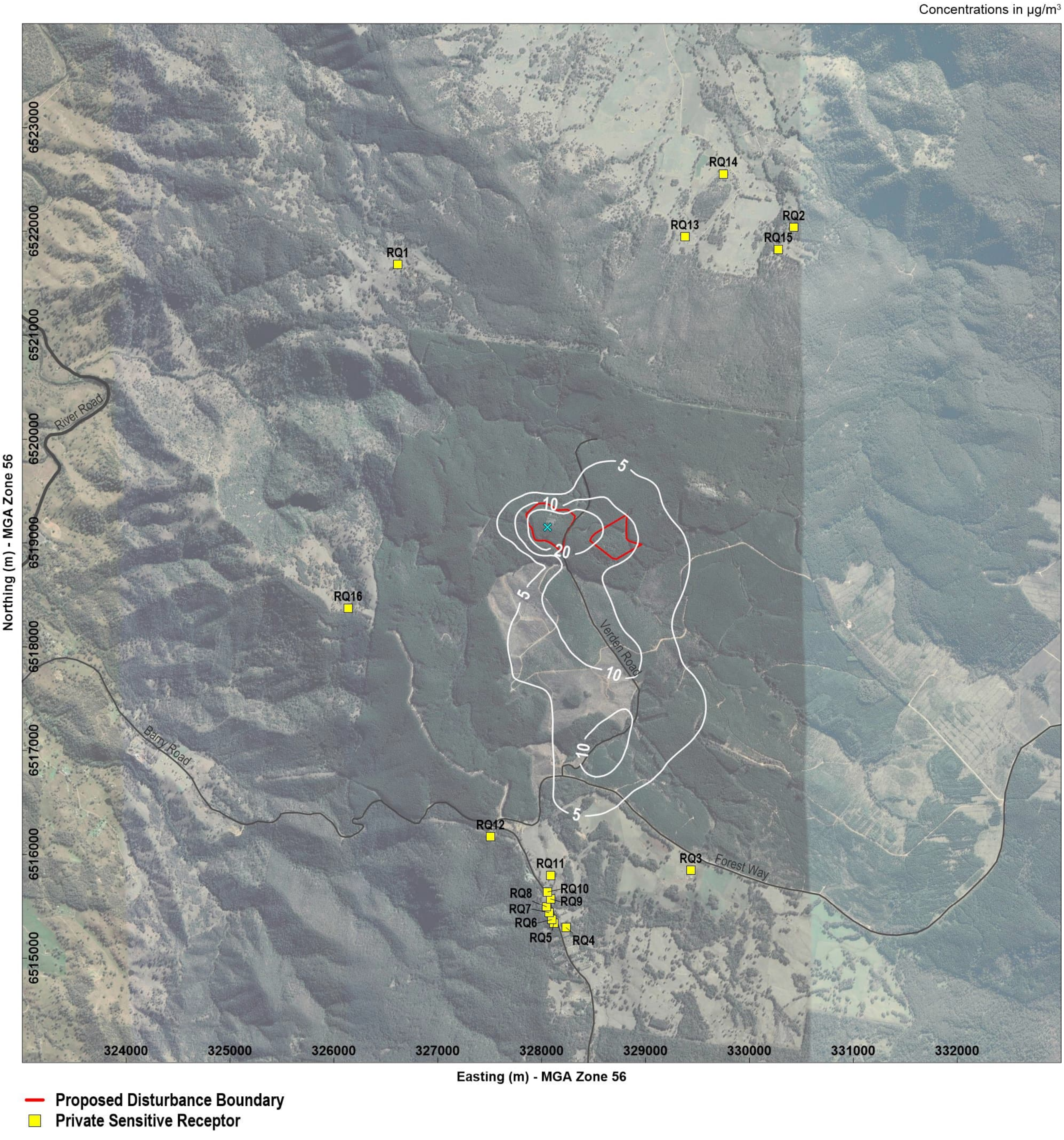

Figure 19 Predicted maximum 1-hour average NO_2 due to diesel exhausts

Concentrations in µg/m³

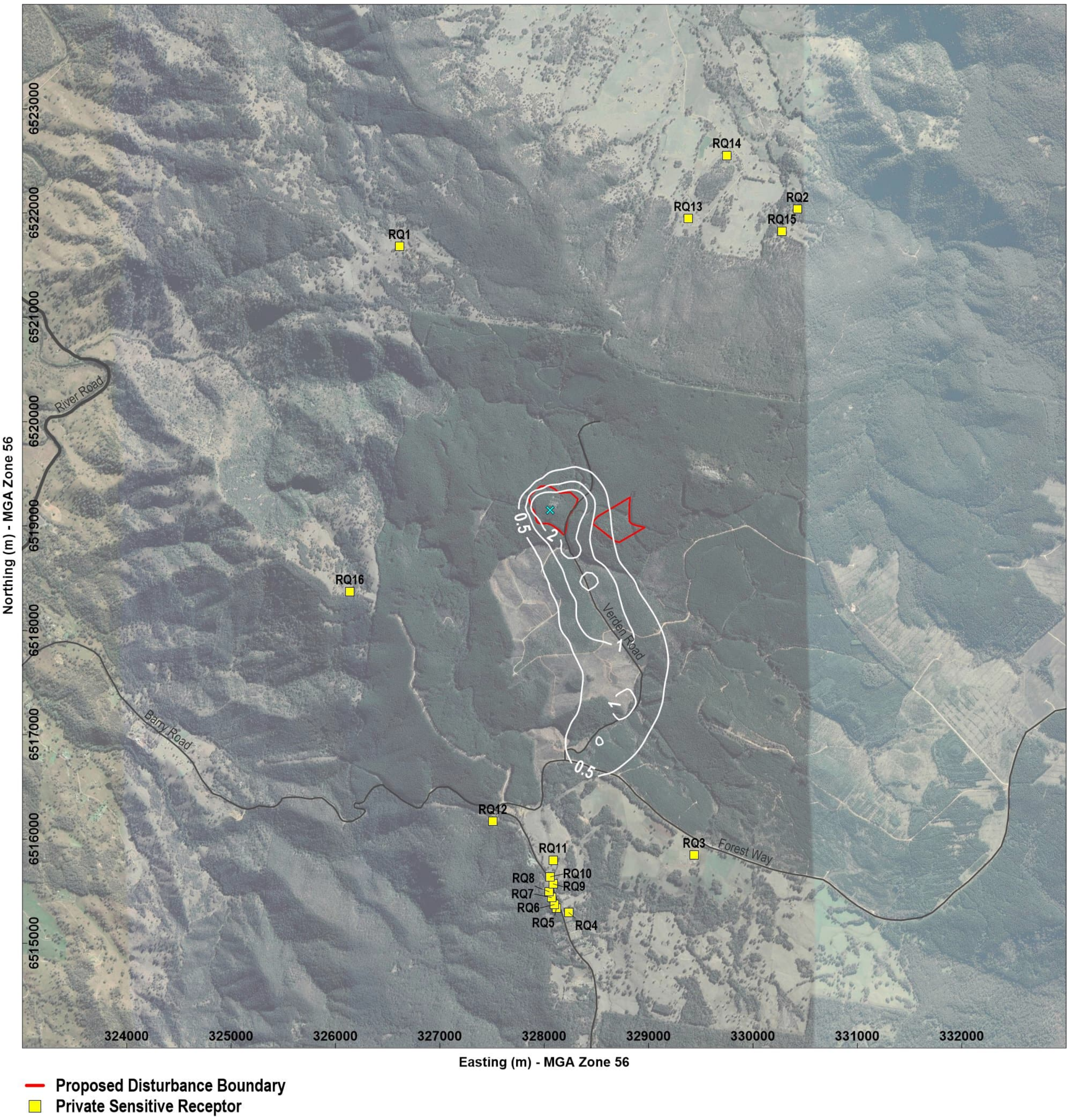

Figure 20 Predicted annual average NO_2 due to diesel exhausts

7. Greenhouse Gas Assessment

7.1 Emissions

Table 14 shows the estimated emissions of GHGs due to all identified GHG-generating activities associated with the Project. The direct emissions from the Project (i.e. Scope 1 and 2) are estimated to average 1,525 t CO_2-e per year. It is relevant to note that the operation of the wind farm is expected to reduce CO_2-e emissions by 654,400 tonnes per annum.

Table 14 Estimated GHG emissions

Activity	Usage (kL)	Emission factor (kg CO_2-e/kL)			Emissions (t CO_2-e/year)			
		Scope 1	Scope 2	Scope 3	Scope 1	Scope 2	Scope 3	Total
Diesel usage (on-site equipment)	509	2721.3	0	138.96	1,386	-	71	1,457
Diesel usage (trucks transporting product)	51*	2717.4	0	138.96	138	-	7	145
Total	560	-	-	-	1,525	-	78	1,602

* Estimated based on 6 km return distance over Verden Road, fuel consumption of 40 L/100 km, and 68 return trips per day.

7.2 Context

The Commonwealth Department of Industry, Science, Energy and Resources (DISER) (2021b) provides a National Greenhouse Gas Inventory, where statistics on emissions per annum are stored, and detailed analysis of sources can be determined. To develop the context for this assessment, the impacts of the emissions projected in this assessment have been compared with the latest emissions officially recorded on the National Greenhouse Gas Inventory. The latest available annual data through the inventory is from 2019 (DISER, 2021b).

Table 15 presents these national and state figures in context with the projected emissions from the Project. The estimated annual average Scope 1 and 2 emissions from the Project (0.0015 Mt CO_2-e) represent approximately 0.0003% of Australia's 2019 emissions.

Table 15 Comparison of GHG emissions in the State and National context

Parameter	Australia (2019)	NSW (2019)	Project
Annual direct emissions (Mt CO_2-e)	529.3	136.6	0.0015 (0.0003% of Australia) (0.0011% of NSW)

8. Monitoring and Management

The modelling showed that off-site dust concentrations and deposition levels would be well below the relevant EPA assessment criteria. Therefore, an appropriate air quality management strategy would include standard mitigation measures such as:

- Minimising the area of disturbed land at any one time
- Adopting controls for haul road dust emissions
- Use of water sprays when drilling if / as required
- Use of water sprays on stockpile areas if / as required
- Visual monitoring to identify excessive dust generation

Mitigation of GHG emissions will be inherent in the development of the quarry plan. The mitigation measures to minimise the level of GHG emissions from the Project will include:

- Planning and designing of operations to minimise fuel usage and to maximise energy efficiency
- Maintenance of plant and equipment to minimise fuel consumption and associated emissions
- Training staff on improvement strategies to minimise fuel usage and maximise energy efficiency

As previously mentioned, the intended use of the materials is for a renewable energy facility that is expected to reduce CO_2-e emissions by 654,400 tonnes per annum.

9. Conclusions

This report has provided an assessment of the potential air quality impacts of the Verden Road Quarry. The assessment involved identifying the key air quality issues, characterising the existing environment, quantifying emissions to air and modelling the potential impact of the Project on local air quality. The key air quality issues were identified as operational dust, post-blast fume and diesel exhaust. These issues were the focus of the assessment. GHG emissions were also estimated in accordance with recognised methodologies.

A detailed review of the existing environment was carried out including an analysis of historically measured concentrations of key quality indicators from regional monitoring stations. The review showed that air quality in many parts of NSW, including the Northern Tablelands, is heavily influenced by climatic conditions such as drought. However, due to the absence of any significant sources of air pollution, the concentrations of key air quality indicators near the Project are expected to be well below acceptable (EPA) levels.

The key outcomes of the modelling and subsequent assessment were as follows:

- The Project would not cause adverse impacts with respect to dust concentrations or deposition levels, based on modelling which showed compliance with air quality criteria at all sensitive receptors.
- Post blast fume emissions are not expected to result in any adverse air quality impacts (as NO_2), based on modelling which showed compliance with air quality criteria.
- Emissions from diesel exhausts associated with off-road vehicles and equipment are not expected to result in any adverse air quality impacts, based on modelling which showed compliance with air quality criteria.
- The estimated annual Scope 1 and 2 emissions due to the Project is 1,525 t CO_2-e, which represents less than 0.0003% of Australia's 2019 emissions. The operation of the wind farm is expected to reduce CO_2-e emissions by 654,400 tonnes per annum.

Based on this assessment, it has been concluded that the Project is a relatively small, temporary, and remote operation that is unlikely to cause any adverse air quality impacts at sensitive locations.

10. References

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Appendix A. Annual and seasonal wind-roses

Figure A1 Annual and seasonal wind-roses for data collected at M4 in 2021

Appendix B. Model settings and setup

Geophysical

Figure B1 shows the model grid, land-use and terrain information, as used by CALMET.

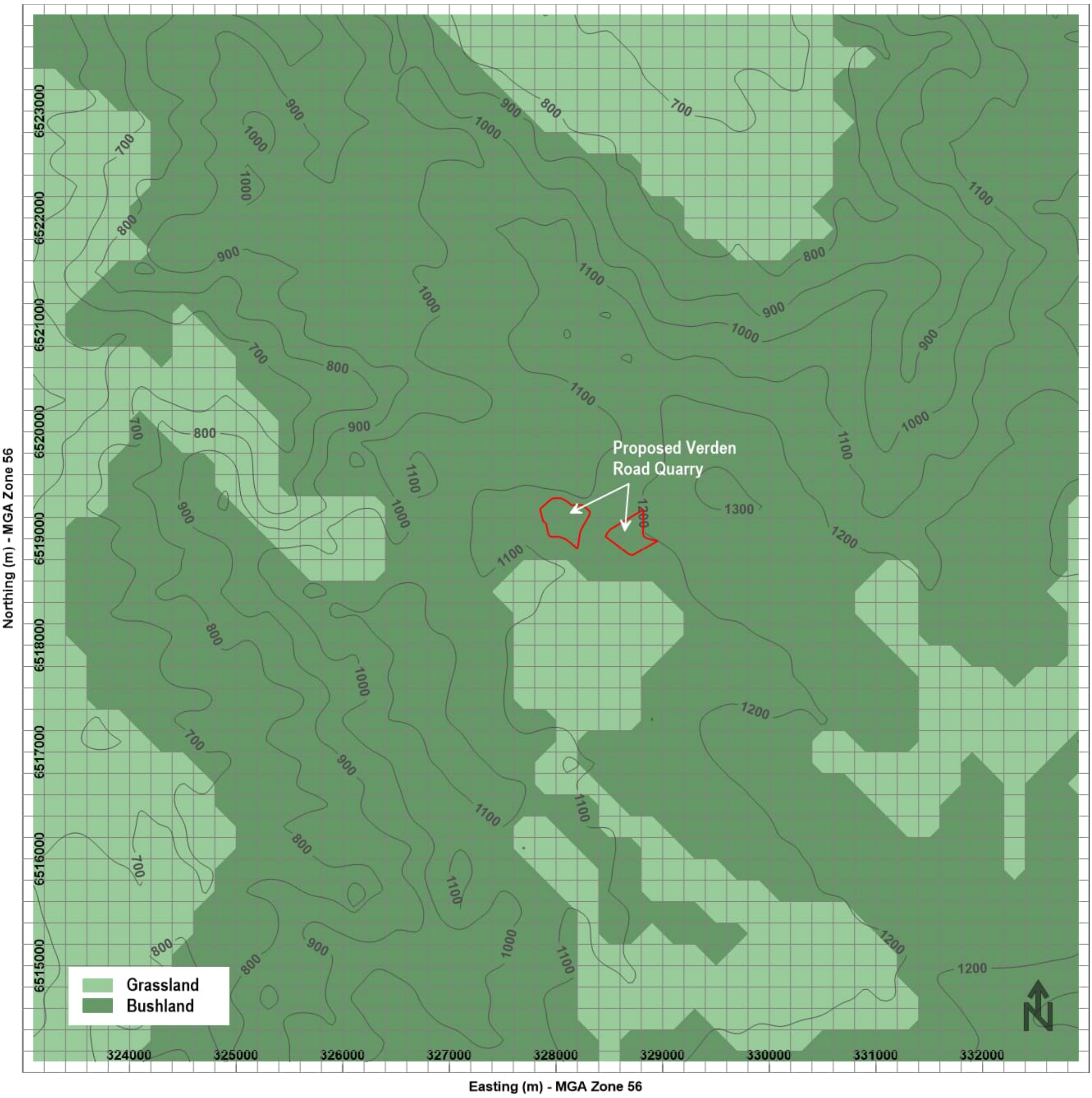

Figure B1 Model domain, grid, land use and terrain information

Meteorology

The CALPUFF model, through the CALMET meteorological pre-processor, simulates complex meteorological patterns that exist in a particular region. The necessary upper air data for CALMET were generated by the CSIRO's prognostic model, TAPM, and the required surface observation data were sourced from local weather stations. CALMET was used to produce a year-long, three-dimensional output of meteorological conditions for input to the CALPUFF air dispersion model. The meteorological modelling followed the guidance of TRC (2011) and adopted the "observations" mode.

Table B1 Model settings and inputs for TAPM

Parameter	Value(s)
Model version	4.0.5
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grids point	35 x 35 x 25
Year(s) of analysis	2021
Centre of analysis	31º27' S, 151º11.5' E
Terrain data source	30 m Shuttle Research Topography Mission (SRTM)
Land use data source	Default
Meteorological data assimilation	M4. Radius of influence = 15 km. Number of vertical levels for assimilation = 6

Table B2 Model settings and inputs for CALMET

Parameter	Value(s)
Model version	6.334
Terrain data source(s)	30 m SRTM and Project DEM
Land use data source(s)	Digitised from aerial imagery
Meteorological grid domain	10 km x 10 km
Meteorological grid resolution	0.2 km
Meteorological grid dimensions	50 x 50 x 9 grid points
Meteorological grid origin	323000 mE, 6514000 mN. MGA Zone 56
Surface meteorological stations	M4: wind speed, wind direction Tamworth: wind speed, wind direction TAPM (at location of M4): temperature, humidity, ceiling height, cloud cover and air pressure
Upper air meteorological stations	Upper air data file for the location of the M4 meteorological station, derived by TAPM. Biased towards surface observations (-1, -0.8, -0.6, -0.4, -0.2, 0, 0, 0, 0)
Simulation length	8760 hours (1 Jan 2021 to 31 Dec 2021)
R1, R2	0.5, 1
RMAX1, RMAX2	5, 20
TERRAD	5

Figure B2 shows a snapshot of winds at 10 metres above ground-level as simulated by the CALMET model under stable conditions. This plot shows the effect of the topography on local winds, for this particular hour, and highlights the non-uniform wind patterns in the area, further supporting the use of a non-steady-state model such as CALPUFF.

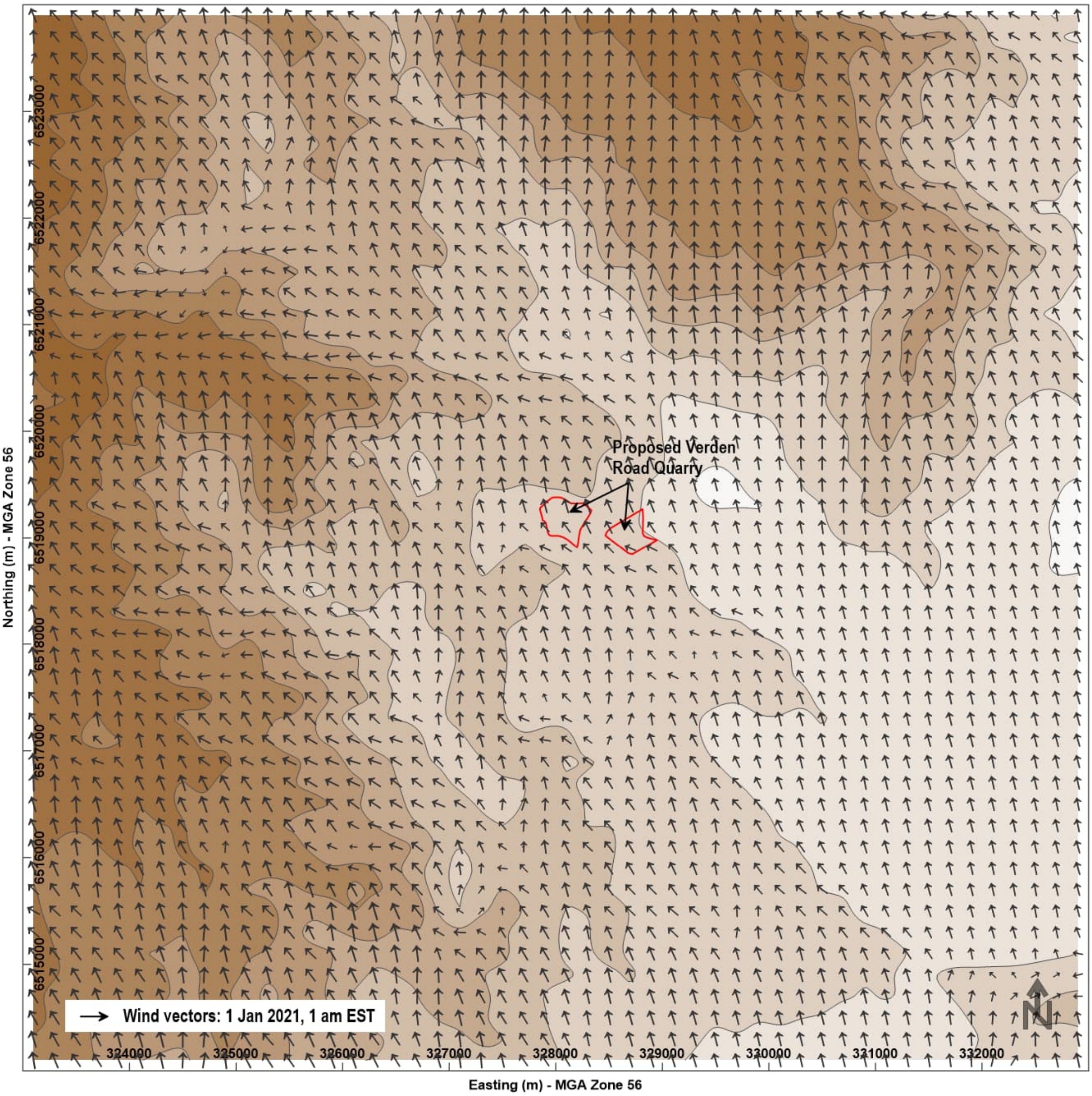

Figure B2 Example of CALMET simulated ground-level wind flows

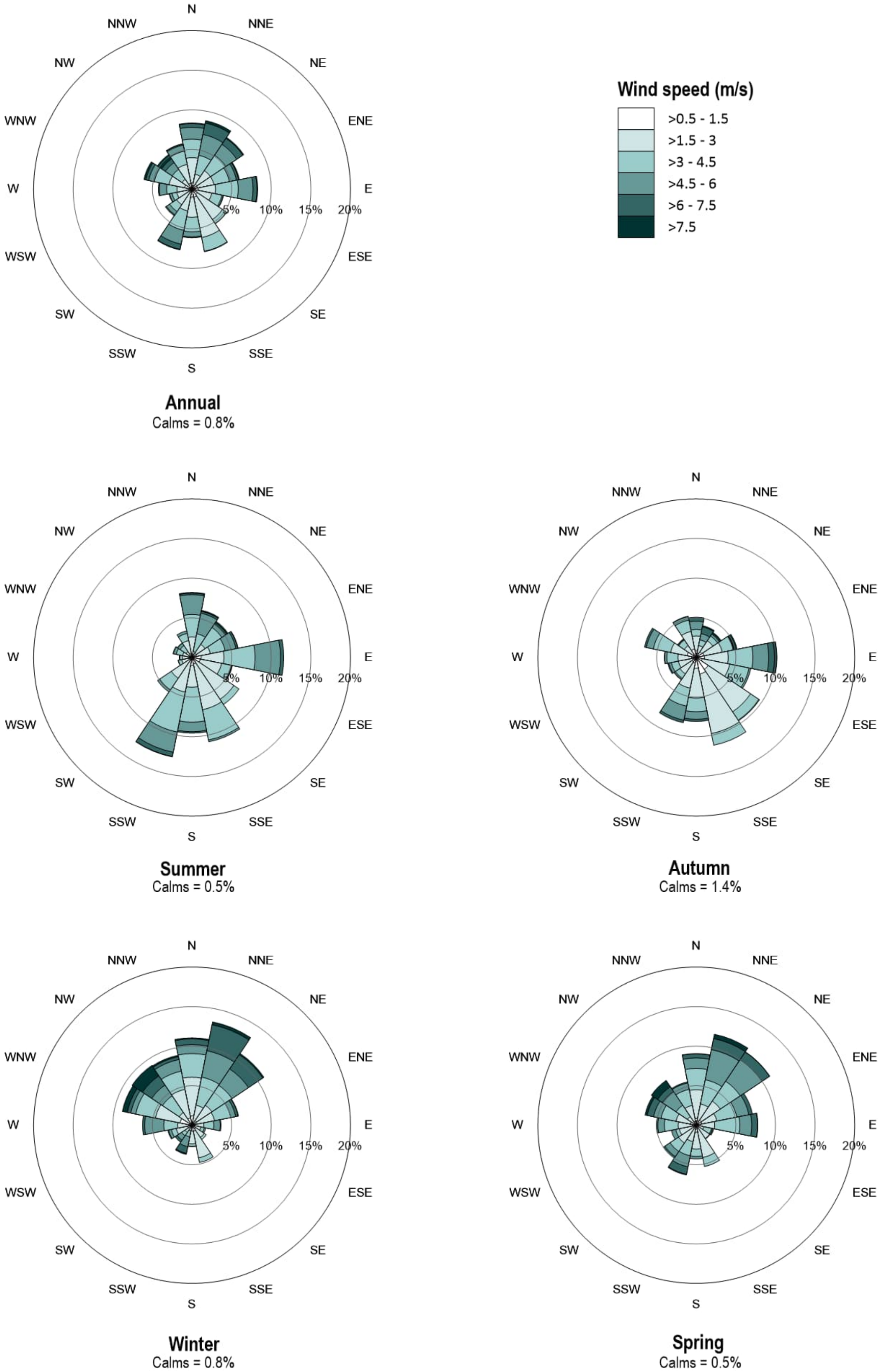

Figure B3 Annual and seasonal wind-roses from modelled data for the Project site in 2021

Table B3 shows the model settings and input for the dispersion model, CALPUFF.

Table B3 Model settings and inputs for CALPUFF

Parameter	Value(s)
Model version	6.42
Computational grid domain	50 x 50
Chemical transformation	None
Dry deposition	Yes
Wind speed profile	ISC rural
Puff element	Puff
Dispersion option	Turbulence from micrometeorology
Time step	3600 seconds (1 hour)
Terrain adjustment	Partial plume path
Number of volume sources	See below. Height = 5 m, SY = 20 m, SZ = 10 m.
Number of discrete receptors	448. See below.

Sources

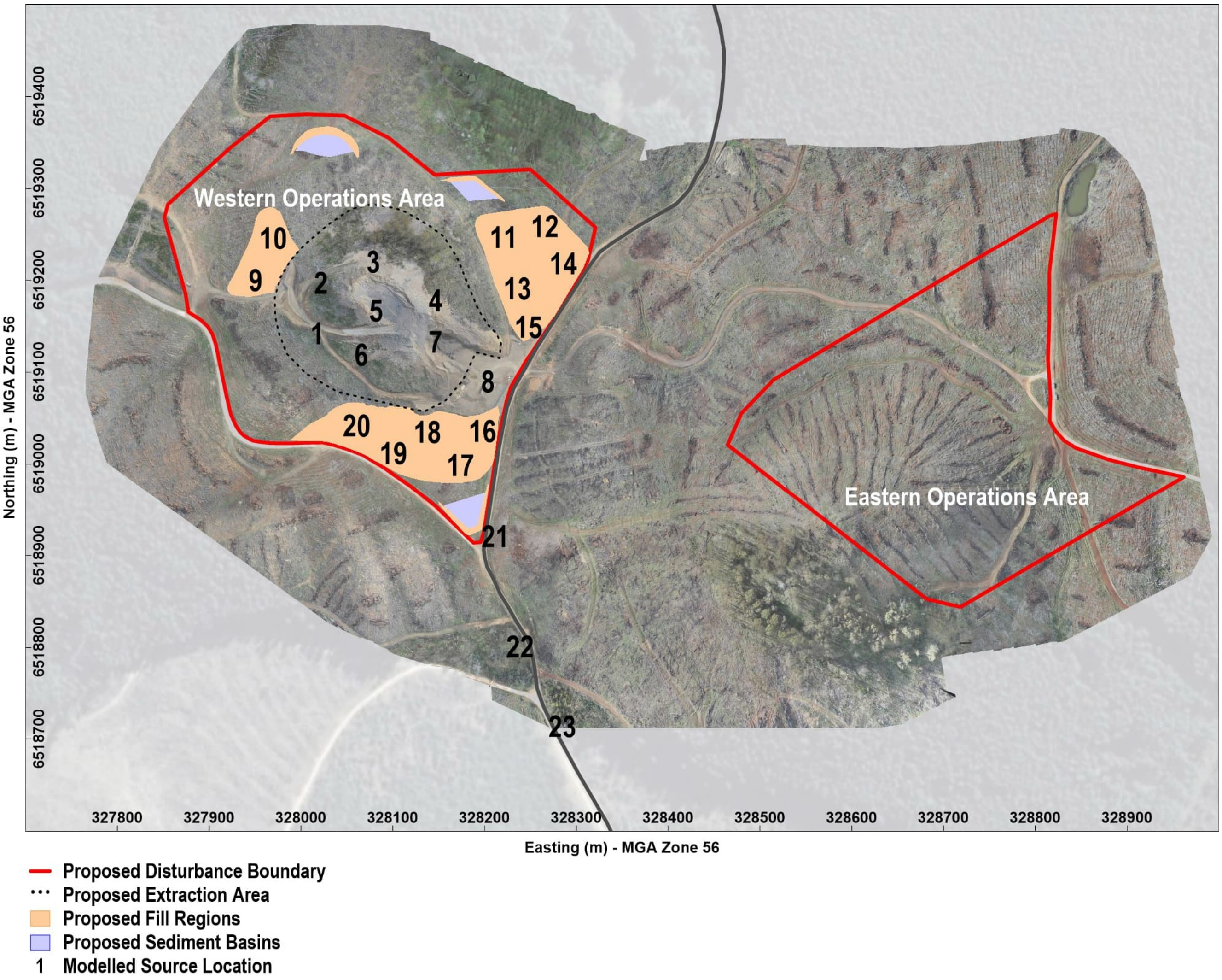

Figure B4 Modelled source locations

Receptors

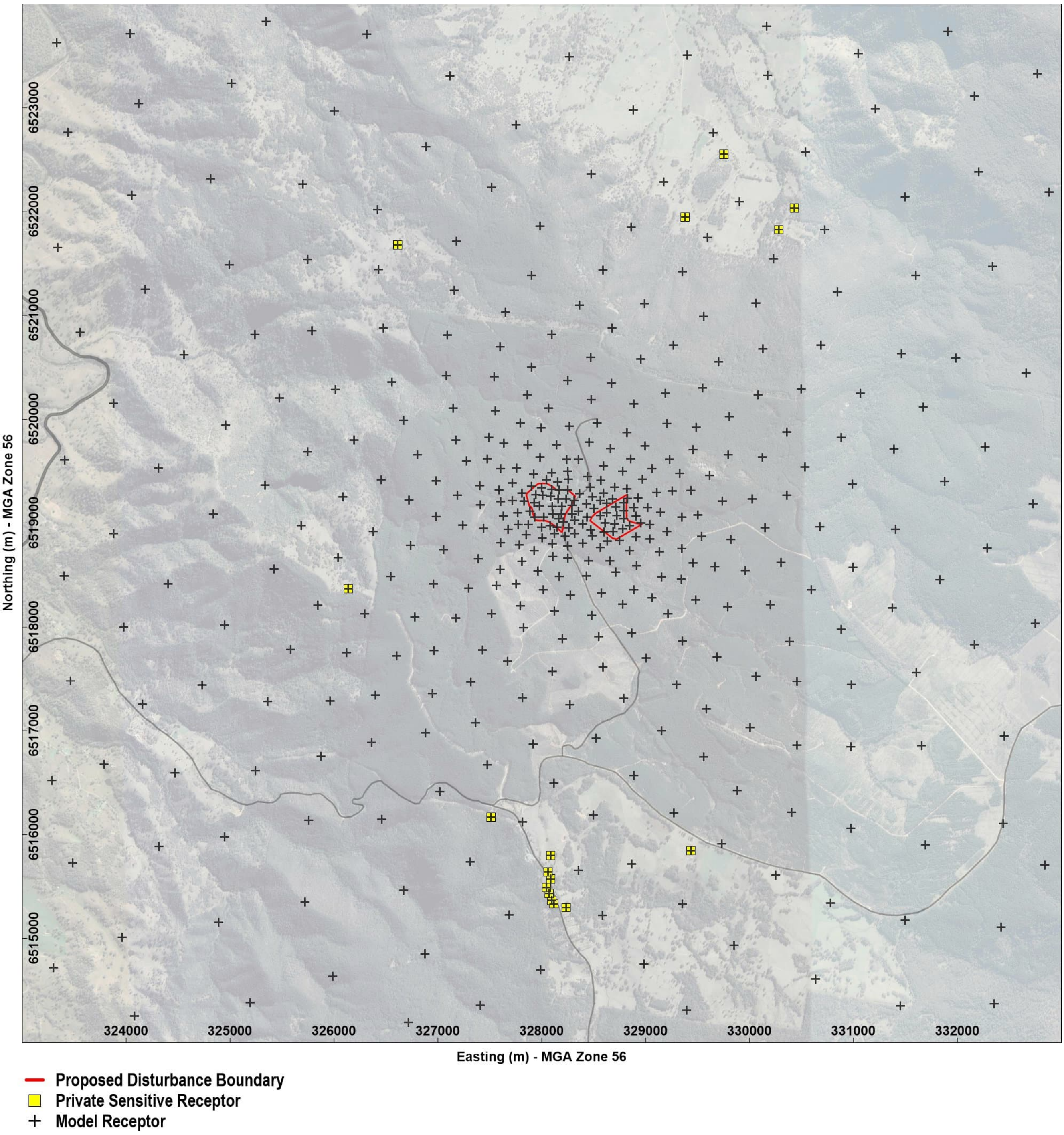

Figure B5 Model receptor locations

Appendix C. Emission calculations

Emission calculations																			
Verden Road Quarry																			
	Annual emissions (kg/y)						TSP		PM10		PM2.5		Variables						
Activity	TSP	PM10	PM2.5	Control (%)	Intensity	Units	Factor	Units	Factor	Units	Factor	Units	Area (m2)	(ws/2.2)^1.3	Moisture (%)	kg/VKT	t/truck	km/trip	Silt (%)
Dozer working	48867	11897	5131	0	2920	h/y	16.7	kg/h	4.07	kg/h	1.757	kg/h	-	-	2	-	-	-	10
Excavators working	1560	738	78	0	730000	t/y	0.00214	kg/t	0.001	kg/t	0.000	kg/t	-	1.80	2	-	-	-	-
Drilling rock	331	174	17	70	1872	holes/y	0.59	kg/hole	0.31	kg/hole	0.030	kg/hole	-	-	-	-	-	-	-
Blasting rock	362	187	18	0	52	blasts/y	7.0	kg/blast	3.6	kg/blast	0.348	kg/blast	1000	-	-	-	-	-	-
Loading rock to mobile crusher by FEL	1560	738	78	0	730000	t/y	0.00214	kg/t	0.001	kg/t	0.000	kg/t	-	1.80	2	-	-	-	-
Crushing (mobile jaw crusher)	4052	1588	203	50	730000	t/y	0.01	kg/t	0.004	kg/t	0.001	kg/t	-	-	-	-	-	-	-
Screening (mobile screen 1)	10950	3650	548	50	730000	t/y	0.03	kg/t	0.01	kg/t	0.002	kg/t	-	-	-	-	-	-	-
Crushing (mobile cone crusher)	4052	1588	203	50	730000	t/y	0.01	kg/t	0.004	kg/t	0.001	kg/t	-	-	-	-	-	-	-
Screening (mobile screen 2)	10950	3650	548	50	730000	t/y	0.03	kg/t	0.01	kg/t	0.002	kg/t	-	-	-	-	-	-	-
Loading product stockpiles	780	369	39	50	730000	t/y	0.00214	kg/t	0.001	kg/t	0.000	kg/t	-	1.80	2	-	-	-	-
Wind erosion from exposed areas	5256	2628	394	0	6	ha	876.0	kg/ha/y	438.0	kg/ha/y	65.7	kg/ha/y	-	-	-	-	-	-	-
Wind erosion from product stockpiles	438	219	33	50	1	ha	876.0	kg/ha/y	438.0	kg/ha/y	65.7	kg/ha/y	-	-	-	-	-	-	-
Loading product to trucks	1560	738	78	0	730000	t/y	0.00214	kg/t	0.001	kg/t	0.000	kg/t	-	1.80	2	-	-	-	-
Hauling product off-site (Verden Rd)	273750	52143	13036	50	730000	t/y	0.75000	kg/t	0.1429	kg/t	0.036	kg/t	-	-	-	4.0	32	6	-
	364468	80306	20402																

```
 --------------------------------      04-Oct-2022 17:16
  DUST EMISSION CALCULATIONS XL1
 --------------------------------

  -----ACTIVITY SUMMARY-----

 ACTIVITY NAME : Dozer working
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 48867 kg/y TSP  11897 kg/y PM10  5131 kg/y PM2.5
 FROM SOURCES  : 14
1 2 3 4 5 6 7 9 10 11 12 13 14 15
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Excavators working
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 1560 kg/y TSP  738 kg/y PM10  78 kg/y PM2.5
 FROM SOURCES  : 8
1 2 3 4 5 6 7 8
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Drilling rock
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 331 kg/y TSP  174 kg/y PM10  17 kg/y PM2.5
 FROM SOURCES  : 7
1 2 3 4 5 6 7
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Blasting rock
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 362 kg/y TSP  187 kg/y PM10  18 kg/y PM2.5
 FROM SOURCES  : 7
1 2 3 4 5 6 7
 HOURS OF DAY  :
0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0

 ACTIVITY NAME : Loading rock to mobile crusher by FEL
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 1560 kg/y TSP  738 kg/y PM10  78 kg/y PM2.5
 FROM SOURCES  : 5
4 5 6 7 8
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Crushing (mobile jaw crusher)
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 4052 kg/y TSP  1588 kg/y PM10  203 kg/y PM2.5
 FROM SOURCES  : 1
```

```
8
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Screening (mobile screen 1)
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 10950 kg/y TSP  3650 kg/y PM10  548 kg/y PM2.5
 FROM SOURCES  : 1
8
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Crushing (mobile cone crusher)
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 4052 kg/y TSP  1588 kg/y PM10  203 kg/y PM2.5
 FROM SOURCES  : 1
8
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Screening (mobile screen 2)
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 10950 kg/y TSP  3650 kg/y PM10  548 kg/y PM2.5
 FROM SOURCES  : 1
8
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Loading product stockpiles
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 780 kg/y TSP  369 kg/y PM10  39 kg/y PM2.5
 FROM SOURCES  : 1
8
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Wind erosion from exposed areas
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 5256 kg/y TSP  2628 kg/y PM10  394 kg/y PM2.5
 FROM SOURCES  : 19
1 2 3 4 5 6 7 9 10 11 12 13 14 15 16 17 18 19 20
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Wind erosion from product stockpiles
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 438 kg/y TSP  219 kg/y PM10  33 kg/y PM2.5
 FROM SOURCES  : 1
8
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Loading product to trucks
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 1560 kg/y TSP  738 kg/y PM10  78 kg/y PM2.5
 FROM SOURCES  : 5
16 17 18 19 20
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Hauling product off-site (Verden Rd)
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 273750 kg/y TSP  52143 kg/y PM10  13036 kg/y PM2.5
 FROM SOURCES  : 27
21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0
```