PRESTON BEACH LIMESTONE QUARRY

Air Quality Impact Assessment

Prepared for:

Carlo Doyle's Haulage Pty Ltd
Lot 3838 Goodwood Road
Capel WA 6271

SLR Ref: 675.30072-R01
Version No: -v1.0
August 2021

PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Ground Floor, 503 Murray Street
Perth WA 6000 Australia

T: +61 8 9422 5900
E: perth@slrconsulting.com   www.slrconsulting.com

BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Carlo Doyle's Haulage Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
675.30072-R01-v1.0	9 August 2021	Jason Shepherd	Johan Meline	Jason Shepherd

CONTENTS

CONTENTS

DOCUMENT REFERENCES

TABLES

CONTENTS

FIGURES

APPENDICES

1 Introduction

Doyle's Lime Services (the proponent) is proposing to develop a small limestone and sand quarry on Lot 1002 Preston Beach Road North, Preston Beach, Western Australia (herein referred to as the Proposal).

The Proposal will involve screening and crushing of limestone, and grading and maintenance of Preston Beach Road North for access. The proponent engaged SLR Consulting Australia Pty Ltd (SLR) to prepare an air quality impact assessment (AQIA) report for the Proposal.

1.1 Background

The Proposal seeks to provide a continued resource of strategically located limestone, suited to a variety of end products. The majority of the product from this quarry will be used in the agricultural industry with lime being transported as far as Hyden in the east through Brookton to Wagin and Collie in the south. The northern limit of the limestone supply is north of Perth where the northern supplies of limesand have a transport cost advantage.

The Proposal will cover an area of area of approximately 14.74 ha at 15 m Australian Heigh Datum (AHD), with limestone and sand resources of approximately 12.6 ha and 1.19 ha, respectively. It will be excavated to about 5 to 6 m AHD in eight stages, each about 2 ha, over 20 years. It is anticipated that approximately 50,000 tonnes (t) of limestone and 10,000 t of sand will be extracted each year, depending on supply and demand. Access to the property will be via the existing limestone road, Preston Beach Road North, and the sealed Preston Beach Road that exits onto National Route 1, Forrest Highway. The quarry operations will be campaign based with operations for about four months of the year, from December to April.

2 Proposal Overview

2.1 Proposal Location

Most of Lot 1002 is currently parkland that has been cleared and grazed for many years. Historically it was used for intense winter grazing by cattle and as an airstrip for the aerial spreading of fertiliser and seed on local farming properties. A road reserve runs along the eastern boundary of Lot 1002 and cuts Lot 1001. The Yalgorup National Park surrounds Lot 1002. The National Park is an internationally recognised, Class A Conservation Reserve. The closest dwelling is located approximately 1 km away to the south. The Proposal location is shown in Figure 1.

Figure 1 Site Location

2.2 Proposal Description

The limestone within the quarry is relatively soft and can be removed with a loader without the need for a bulldozer or blasting. It will then be screened to produce products of the correct size. A small mobile crusher is required to prepare the correct grainsize. A summary of the proposed limestone extraction activities is provided below:

- All topsoil will be removed for spreading directly onto areas to be revegetated and screening or perimeter bunds. If direct spreading is not possible the topsoil will be stored in low dumps, for spreading at a later date.
- Soil and overburden, as yellow and brown sand and low-grade limestone, will then be removed and either directly transferred to a rehabilitation area or stored in low dumps for later rehabilitation use. Where this is not used overburden will be stored in dumps for future use in rehabilitation or the creation of bunds.
- Limestone interburden, if encountered, will be incorporated into the overburden dumps for later use in re-contouring the land surface at the conclusion of excavation.
- A front-end loader will be used to dig and push the limestone down the excavation face and track roll the limestone in the process.
- The preliminary crushed limestone will then be picked up by a loader and fed to the mobile crusher.
- All static and other equipment, such as crushers and screens (where used), will be located on the floor of the quarry.
- Sand will then be excavated with a loader, loading directly to a road truck.
- Excavation will commence on the western ridge and then move to the eastern ridge, working on the floor of the pit towards the edges to minimise the potential visual impact.
- Upon completion of each section of quarry the section will be reformed and back filled, where subgrade material is available.
- At the end of excavation, the floor of the quarry will be deep ripped, covered by overburden and topsoil, and rehabilitated to a constructed soil.
- Access to the quarry will be along Preston Beach Road, which is sealed, and then to Preston Beach Road North which is limestone and will need grading and maintenance.
- From December to April, a maximum of 10 trucks per day is anticipated (depending on demand) which will equate to one to two trucks per hour.
- The access and internal roads will be limestone based and watered as needed to suppress dust.

Hours of operation will be 6:30 am to 5:00 pm, Monday to Friday and 7:00 am to 1:00 pm, Saturday.

The Proposal footprint is presented in Figure 2 while Figure 3 presents a flow diagram of the operations as assessed. The Proposal operations are summarised in Table 1.

Figure 2 Proposal Footprint

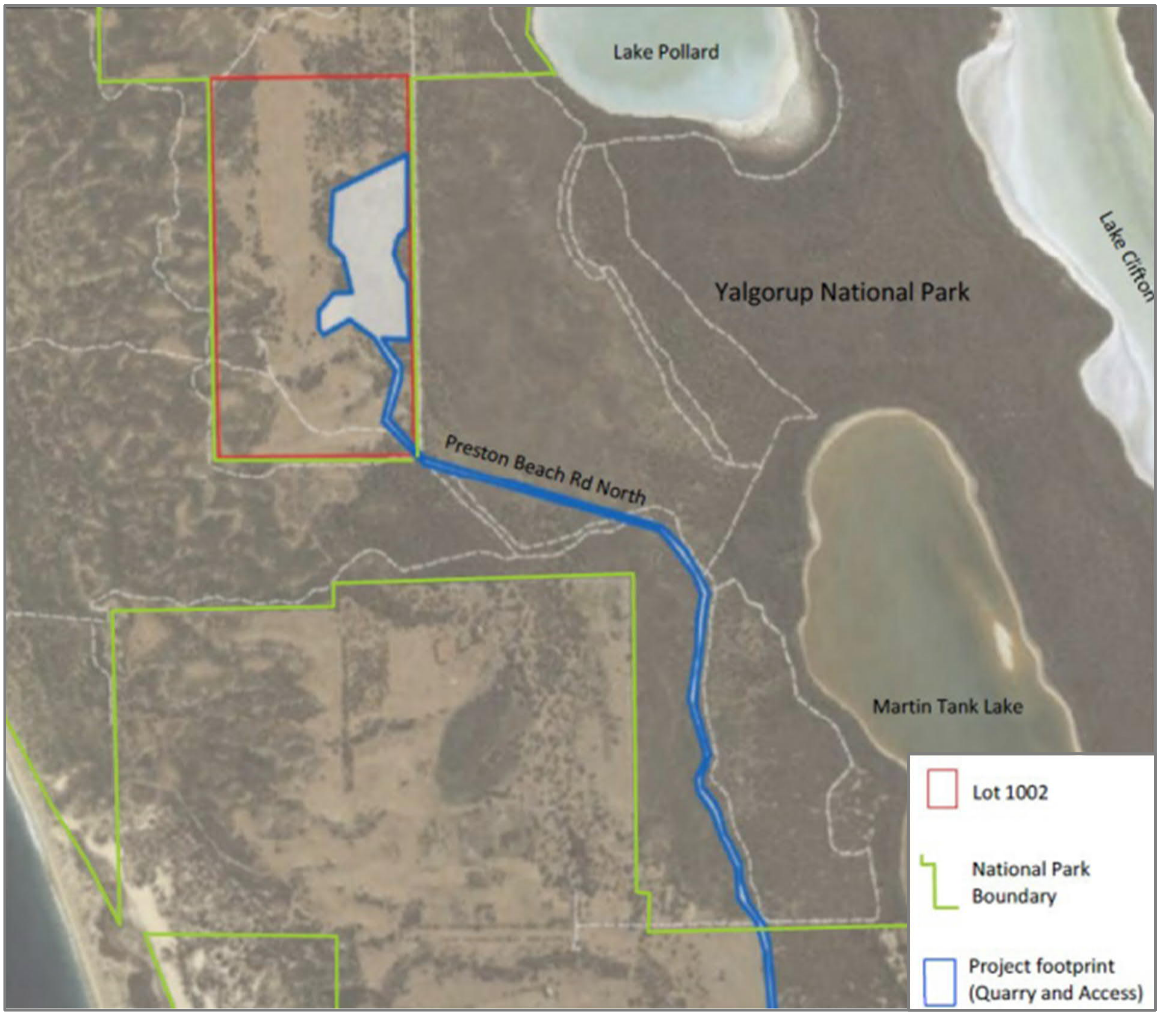


Figure 3 Proposal Activity Flow Chart

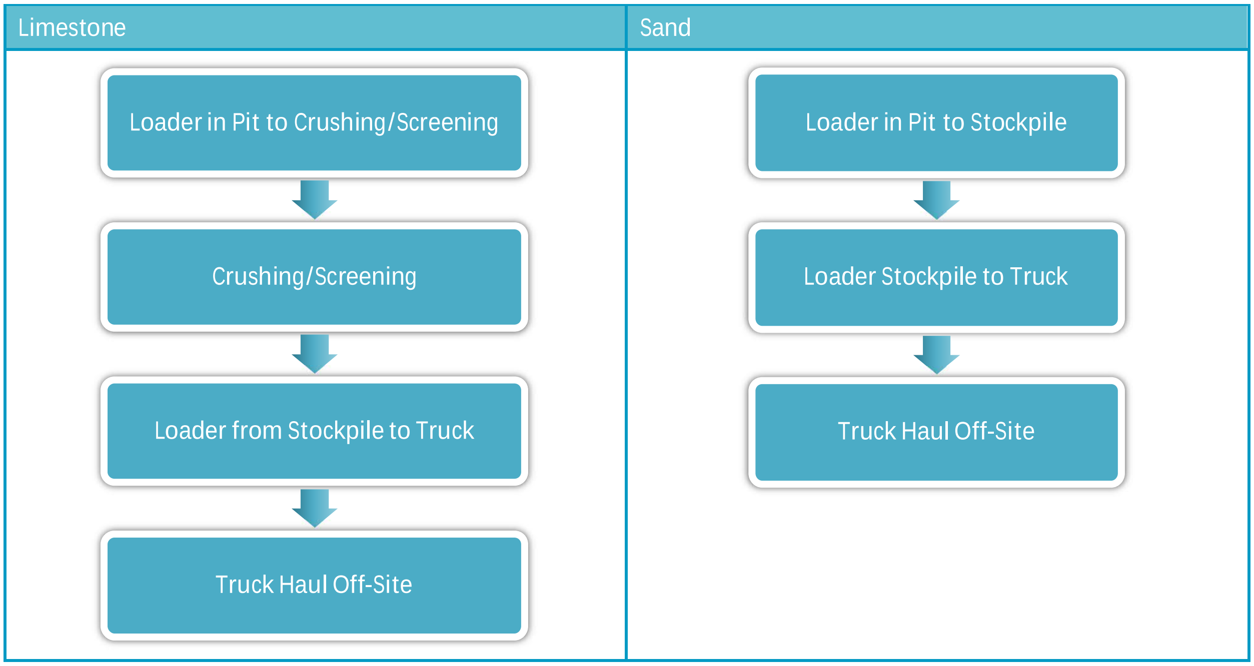


Table 1 Proposed Operations

Description	Value
Throughput and progression timelines	
Limestone	50,000 tpa
Sand	10,000 tpa
Campaign Excavation	4 months (between December and April)
Crushing/Screening	4 months (between December and April)
Equipment inventory (fixed and mobile)	
Loader	Limestone to crusher, product to truck, sand to truck
Trucks	40-50 t (assume 40 t empty, 70 t laden)
Crushing/Screening	Small mobile (assume 57 t/h)
Water cart	1 10,000 L
Light vehicles	1 ute
Hours of operation	
Pit activity	6:30 am to 5:00 pm Mon-Fri; 7:00 am to 1:00 pm Sat
Processing	6:30 am to 5:00 pm Mon-Fri; 7:00 am to 1:00 pm Sat
Haulage	6:30 am to 5:00 pm Mon-Fri; 7:00 am to 1:00 pm Sat; 10 return trips per day.
Pit and Stockpiles	
Pit (including stockpiles)	2.0 ha active per year

2.3 Proposal Air Quality Indicators

The key pollutants associated with mining and extractive industries are suspended particulate matter and dust deposition. While emissions of pollutants associated with the combustion of diesel fuel, including nitrogen oxides (NO_x), sulphur dioxide (SO_2), carbon monoxide (CO) and Volatile Organic Compounds (VOCs), will be generated by the proposed operations at the quarry, these emissions are unlikely to compromise air quality goals at the closest receptors, given the nature, separation distance and scale of the operation. Based on this the diesel fuel combustion emissions have not been considered further.

In common usage, the terms "dust" and "particulates" are often used interchangeably. The term "particulate matter" refers to a category of airborne particles, typically less than 30 microns (µm) in diameter and ranging down to 0.1 µm and is termed total suspended particulate (TSP).

Particulate matter has the capacity to affect health and to cause nuisance effects and is categorised by size and/or by chemical composition. The potential for harmful effects depends on both. The particulate size ranges are commonly described as:

- TSP – refers to all suspended particles in the air. In practice, the upper size range is typically 30 micrometres (µm) to 50 µm.
- PM_{10} – refers to all particles with equivalent aerodynamic diameters of less than 10 µm, that is, all particles that behave aerodynamically in the same way as spherical particles with diameters less than 10 µm and with a unit density.
- $PM_{2.5}$ – refers to all particles with equivalent aerodynamic diameters of less than 2.5 µm diameter. These are often referred to as 'fine' particles and are a sub-component of PM_{10}.
- Deposited dust – refers to particulate that settles out over a given area and time under the influence of gravity. Deposited dust can include particles of any size, but it generally comprises particles larger than 20 (µm) in diameter that rapidly settle out of the air near the point of emission. It is measured to assess if an emission source is causing a nuisance, such as soiling of property and materials.

Both natural and anthropogenic processes contribute to the atmospheric load of particulate matter. Coarse particles ($PM_{2.5-10}$) are derived primarily from mechanical processes, resulting in the suspension of dust, soil, or other crustal materials from roads, farming, mining, dust storms, and so forth. Coarse particles also include sea salts, pollen, mould, spores, and other plant parts.

Fine particles, or $PM_{2.5}$, are derived primarily from combustion processes, such as vehicle emissions, wood burning, coal burning for power generation, hazard reduction burns, and bush fires. Fine particles also consist of transformation products, including sulphate and nitrate particles, and secondary organic aerosol from volatile organic compound emissions.

The size of particles determines their behaviour in the respiratory system, including how far the particles are able to penetrate, where they deposit, and how effective the body's clearance mechanisms are in removing them. Additionally, particle size is an important parameter in determining the residence time and spatial distribution of particles in ambient air, which are key considerations in assessing exposure.

$PM_{2.5}$, and in particular the ultrafine sub-micron particles, may penetrate beyond the larynx and into the thoracic respiratory tract and evidence suggests that particles in this size range are more harmful than the coarser component of PM_{10}.

2.3.1 Respirable Crystalline Silica

Silica is one of the most abundant minerals found in the earth's crust. Crystalline silica is most dangerous to health when dust is generated, becomes airborne and is then inhaled. Respirable crystalline silica (RCS) dust particles are small enough to penetrate deep into the lungs and can cause irreversible lung damage.

In the context of ambient air concentrations, RCS is generally represented by the $PM_{2.5}$ fraction. RCS is a hazardous substance, the inhalation of which can lead to silicosis, an incurable lung disease that can lead to disability and death. RCS can also contribute to lung cancer, renal cancer and chronic obstructive pulmonary disease.

Dust containing RCS is most commonly associated with high-energy processes involving silica-containing materials, such as cutting, grinding, drilling, polishing and crushing of silica-containing materials, and is relevant to this assessment.

3 Legislative Context and Assessment Criteria

3.1 Commonwealth Legislation

The National Environment Protection Council (NEPC) was established under the National Environment Protection Council Act 1994 with the primary function of:

- developing National Environment Protection Measures (NEPMs)
- assessing and reporting on the implementation and effectiveness of the NEPMs in each State and Territory.

3.1.1 National Environment Protection (Ambient Air Quality) Measure

The National Environment Protection (Ambient Air Quality) Measure (Air NEPM) (NEPC, 2016) contains standards and goals for key pollutants that are required to be achieved nationwide, with due regard to population exposure. Air NEPM standards apply at performance monitoring locations, with each station located in such a manner that it obtains a representative measure of air quality likely to be experienced by the general population in a region or sub-region of 25,000 people or more.

The National Environment Protection (Ambient Air Quality) Measure (Air NEPM) contains standards for key pollutants that are required to be achieved nationwide, with due regard to population exposure, that are designed to protect human health and wellbeing. It is the intent of the Air NEPM that the criteria are applicable to the air quality likely to be experienced by the general population as a result of regional anthropogenic activity in urban environments. That is, the criteria are not applicable to locations, that due to their proximity to, are strongly influenced by e.g., road traffic, mining, industry etc, nor to locations strongly influenced by naturally occurring emissions or emission events, e.g., desert dust, bush-fires etc.

The relevant Air NEPM air quality standards are provided in Table 2.

Table 2 Air NEPM Ambient Air Quality Standards

Pollutant	Averaging Period	Maximum Concentration (µg/m^3)
PM_{10}	24 hours Annual	50 25
$PM_{2.5}$	24 hours Annual	25 (20 in 2025) 8 (7 in 2025)

3.2 Western Australian Legislation

The *Environmental Protection Act 1986* (the EP Act) provides for "*the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing*".

Development proposals and activities that are likely to generate dust may be subject to the provisions of the EP Act and policies developed pursuant to that Act.

The Department of Water and Environmental Regulation (DWER) regulates industrial emissions and discharges to the environment through a works approval and licensing process, under Part V of the EP Act.

Industrial premises with potential to cause emissions and discharges to air, land or water are known as 'prescribed premises' and trigger regulation under the EP Act. Prescribed premises categories are outlined in Schedule 1 of the Environmental Protection Regulations 1987.

The EP Act requires a works approval to be obtained before constructing a prescribed industrial premises and makes it an offence to cause an emission or discharge unless a licence or registration is held for the premises.

In Western Australia, the Air NEPM particulate criteria are applied to sensitive receptors, defined as residences, hospitals, school and other places where people may congregate including sporting and recreational venues. The remoteness and low population of the Proposal location means that these criteria are not strictly applicable to assessing the ambient air quality, nor for assessing predicted impacts of a quarrying operation.

The draft DWER document "*Guideline: Air Emissions*" (DWER, 2019) does not discuss fugitive dust, indicating that this emission type is to be considered in "*Guideline: dust emissions*", which is under development.

It is noted that DWER do not have generic dust criteria applicable to quarrying/mining operations, however it has indicated that draft criteria for silica (as $PM_{2.5}$) are under consideration as provided in Table 3.

Table 3 DWER Draft Criteria

Pollutant	Averaging Period	Maximum Concentration (µg/m^3)
Silica (as $PM_{2.5}$)	24 hours	10 (at 0°C) 9.2 (at 25°C)
	Annual	3 (at 0°C) 2.7 (at 25°C)

3.2.1 EPA Environmental Impact Assessment Requirements

The Western Australian Environmental Protection Authority (EPA) uses environmental principles, factors and associated objectives as the basis for assessing whether a proposal's impact on the environment is acceptable.

The Statement of Environmental Principles, Factors and Objectives (EPAWA, 2018) defines the environmental principles, factors and objectives that underpin the environmental impact assessment (EIA) process. Supporting the Statement of Environmental Principles, Factors and Objectives is a series of guidelines developed to communicate how each environmental factor is considered by the EPA in the EIA process. The most applicable Environmental Factor Guidelines (and their objectives) to this air quality assessment is:

- Air Quality: 'to maintain air quality and minimise emissions so that environmental values are protected' (EPAWA, 2016)

3.2.2 Environmental Factor Guideline: Air quality

The Air Quality environmental factor relates to the chemical, physical, biological and aesthetic characteristics of air. The considerations for EIA processes for Air Quality Factor Guideline are:

- Application of the mitigation hierarchy to avoid and minimise emissions, where possible
- Characterisation of potentially harmful emissions and the pathways by which they may be released to air
- Whether numerical modelling and other analyses to predict potential impacts has been undertaken using recognised standards with accepted inputs and assumptions
- Whether existing background air quality, including natural variations, has been established through monitoring and accepted proxy data
- Whether analysis of potential health and amenity impacts has been undertaken using recognised criteria and standards, where relevant, informed by Australian and international standards
- The application of technology appropriate to the potential environmental impacts and risks
- The significance of the likely change to air quality as well as the environmental values affected by those changes, in the context of existing and predicted cumulative impacts
- Whether proposed mitigation is technically and practically feasible
- Whether siting of the proposal's main emission sources takes into consideration current and future sensitive land uses.

Where Air Quality is a relevant environmental factor affecting human health or amenity the EPA may require the following information to inform an EIA:

- Characterisation of the feedstock and the pollutants and contaminants that are likely to be emitted
- Characterisation of and proximity to sensitive receptors
- Background ambient air modelling[1] and the impact of emissions on sensitive receptors, including likely impacts during, worst, best and most likely case scenarios

[1] It is SLR's understanding that '*background ambient air modelling*' refers to a representative measured background concentration (e.g. local to, but not necessarily at the Proposal site) plus the predicted impact of existing potential sources of pollutants (relevant to the Proposal) near to the Proposal site that due to distance would not be considered to be included in the representative background concentration. This is mostly relevant to locations where local ambient air quality monitoring data is available (e.g. Perth) and there are existing sources of relevant pollutants near to the Proposal site.

- Assessment against published standards and criteria
- Identification of emission reduction equipment and proposed technologies and, where relevant, demonstration of the use of proven technologies
- Description of proposed management and monitoring arrangements.

The factor guideline recognises that:

- In recent years, there has been scientific evidence that small particulate has the potential to impact human health irrespective of their chemical composition.
- When undertaking EIA, existing or future cumulative impacts to an air shed will be an important consideration.
- Development activities that have the potential to impact air quality include, but are not necessarily limited to:
    - The burning of fossil fuels for the production of energy
    - Bulk handling and transport (both road and rail) of materials, including the loading and unloading of bulk materials
    - Stockpiling of bulk material
    - The crushing and screening of materials
    - Mining, handling, processing and transfer of metallic and non-metallic minerals that include activities causing dust.

3.3 Other Jurisdictions

In the absence of state specific assessment criteria for predicted fugitive dust emission impacts, the criteria of other jurisdictions may be considered.

3.3.1 Victoria

The draft EPA Victoria (EPAV) "*Guideline for assessing and minimising air pollution in Victoria*" (EPAV, 2021) is a technical guideline for air quality practitioners and specialists with a role managing pollution discharges to air and provides a framework to assess and control risks associated with air pollution. The document provides risk-based air quality assessment criteria (AQACs) for the assessment and management of air emissions. The AQACs are not threshold values above which all individuals in the community will experience health effects. Rather, pollution exceeding one or more AQACs indicates that the issue requires addressing through further assessment or more effective risk control measures. The objective, averaging period and maximum exceedances for the indicators of PM_{10} and $PM_{2.5}$ are the standards in the Air NEPM, subject to one modification for PM. The EPAV AQACs for PM_{10}, $PM_{2.5}$ and RCS (as $PM_{2.5}$) are provided in Table 4.

Table 4 EPAV Draft AQACs

Pollutant	Averaging Period	Cumulative Concentration (µg/m^3)
PM_{10}	24 hours	50
	Annual	20
$PM_{2.5}$	24 hours	25

Pollutant	Averaging Period	Cumulative Concentration (µg/m³)
	Annual	8
RCS (as $PM_{2.5}$)	Annual	3

3.3.2 New South Wales

The New South Wales (NSW) EPA "*Approved Methods Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*" (the Approved Methods) (NSW EPA, 2017) lists the statutory methods for modelling and assessing emissions of air pollutants from stationary sources in NSW. The Approved Methods impact assessment criteria for the relevant pollutants, including for dust deposition, are provided in Table 5.

Table 5 NSW Approved Methods Criteria

Pollutant	Averaging Period	Concentration (µg/m³)
PM_{10}	24 hours	50
	Annual	20
$PM_{2.5}$	24 hours	25
	Annual	8
Deposited dust	Annual	4 g/m²/month

3.4 Adopted Assessment Criteria

Criteria adopted for assessing the predicted air quality impacts of the Proposal on the surrounding area are adopted from the Air NEPM and EPAV draft AQACs and the NSW Approved Methods.

Table 6 Proposal Assessment Criteria

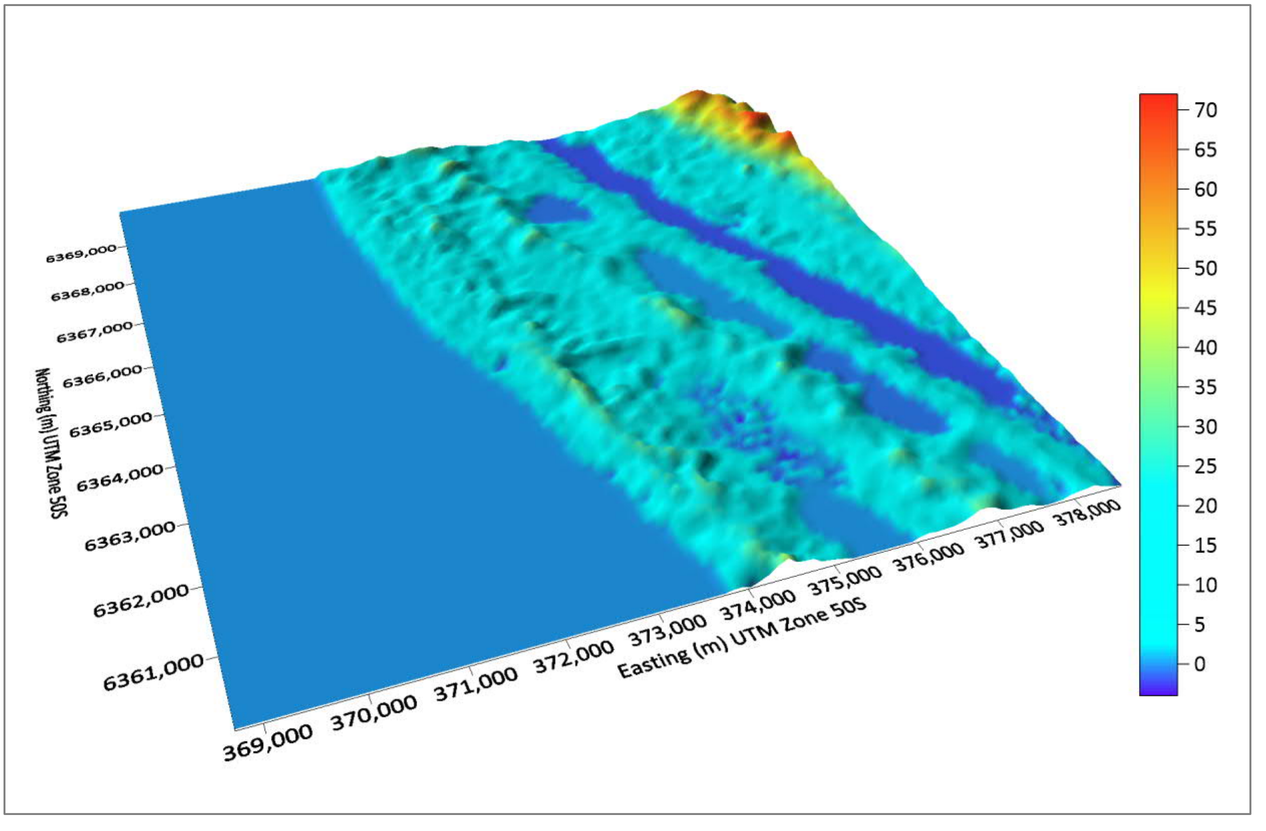
Pollutant	Averaging Period	Maximum Concentration (µg/m³)	Source
PM_{10}	24 hours	50	(NEPC, 2016)
	Annual	25	(NEPC, 2016)
$PM_{2.5}$	24 hours	25	(NEPC, 2016)
	Annual	8	(NEPC, 2016)
RCS (as $PM_{2.5}$)	Annual	3	(EPAV, 2021)
Deposited dust	Annual	4 g/m²/month	(NSW EPA, 2017)

4 Receiving Environment

4.1 Topography

The topography surrounding the site is relatively flat, with no major terrain features other than the lakes and coastline. A three-dimensional representation of the topography in the region, centred on the Proposal, is presented in Figure 4.

Figure 4 Site Topography



4.2 Local Meteorology

Local wind speed and direction influence the dispersion of air pollutants. Wind speed determines both the distance of downwind transport and the rate of dilution as a result of 'plume' stretching. Wind direction, and the variability in wind direction, determines the general path pollutants will follow and the extent of crosswind spreading. Surface roughness (characterised by features such as the topography of the land and the presence of buildings, structures and trees) affects the degree of mechanical turbulence, which also influences the rate of dispersion of air pollutants.

In relation to dust emissions due to wind erosion, temperature, rainfall and relative humidity all influence the soil moisture content and hence the threshold friction velocity, which is the minimum friction velocity required to initiate movement of soil particles by wind.

The Bureau of Meteorology (BoM) maintains and publishes data from weather stations across Australia. The nearest BoM stations to the Proposal is at Mandurah, approximately 35 km north of the Proposal. Mandurah AWS is a similar distance from the coast as the Proposal and without any significant terrain features between the two locations, significant differences between weather at the AWS and that experienced at the Proposal are unlikely.

The Mundurah AWS (Station 9977, elevation 3 m), has data available for the following parameters:

- temperature (°C)
- rainfall (mm)
- relative humidity (%)
- wind speed (m/s) and wind direction (degrees).

A review of the long-term (2001-2021) data collected by this AWS is provided in the following sections.

4.2.1 Temperature

Long-term temperature statistics for Mandurah are summarised in Figure 5. Mean maximum temperatures range from 17.5°C in winter to 29.7°C in summer, while mean minimum temperatures range from 10.7°C in winter to 19.3°C in summer. Longer periods of higher temperatures can dry out soil resulting in both higher background dust and on-site dust emissions.

4.2.2 Rainfall

Long-term rainfall statistics for Mandurah are summarised in Figure 6. The mean annual rainfall is 647 millimetres (mm), with the highest average monthly rainfall of 117 mm/month in June and an average of 14.8 rain days recorded in this month. The average monthly rainfall is relatively high in winter, reducing from spring through to early autumn, with the lowest average of 15.2 mm/month recorded in December. This month also recorded an average of 3.7 rain days per month.

4.2.3 Relative Humidity

No long-term humidity statistics are reported for Mandurah, or indeed at Bunbury, the next closest BOM station 53 km south of the Proposal.

4.2.4 Wind

Wind data for Mandurah for the five years between 2016 and 2020 are presented in Figure 7 and Figure 8. The wind roses show the frequency of occurrence of winds by direction and strength and indicate that winds are predominantly from the south throughout the year with the exception of the winter months. The daytime winds (6:00 am to 6:00 pm) winds are similar to the annual average distribution, with some increased influence from the southwest associated with sea breezes. The night time winds are predominantly from the southeastern quadrant.

Figure 5 Long Term Temperature Data for Mandurah

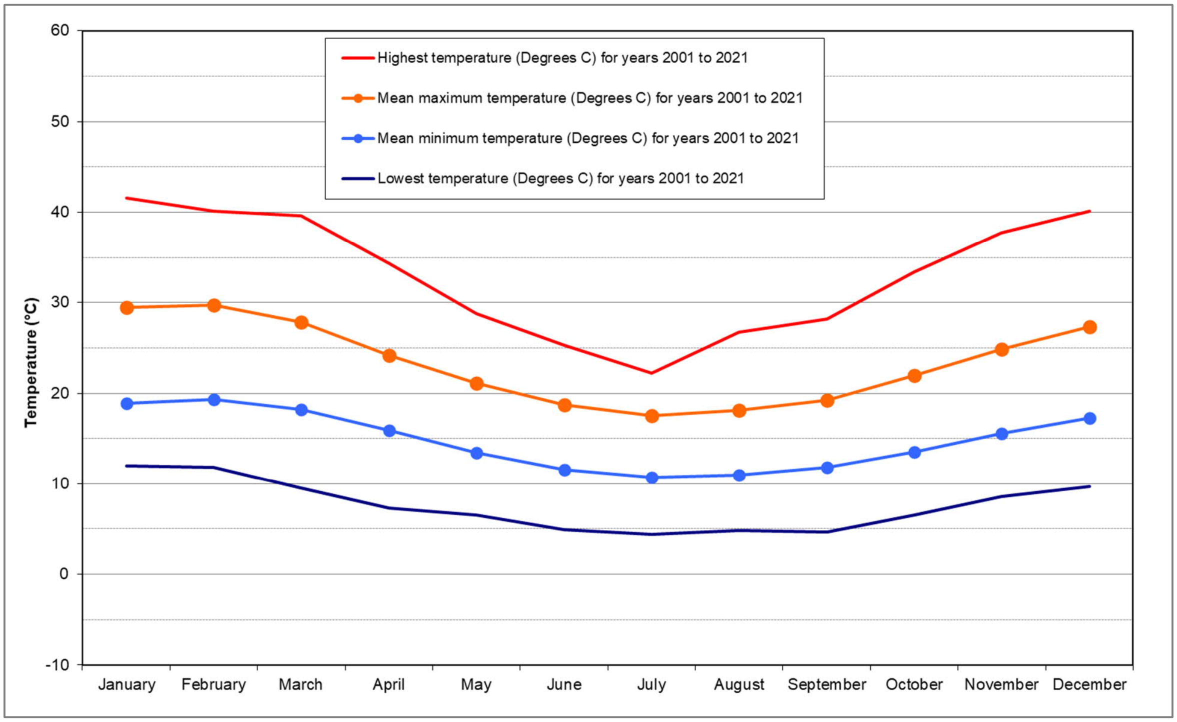


Figure 6 Long Term Monthly Rainfall Data for Mandurah

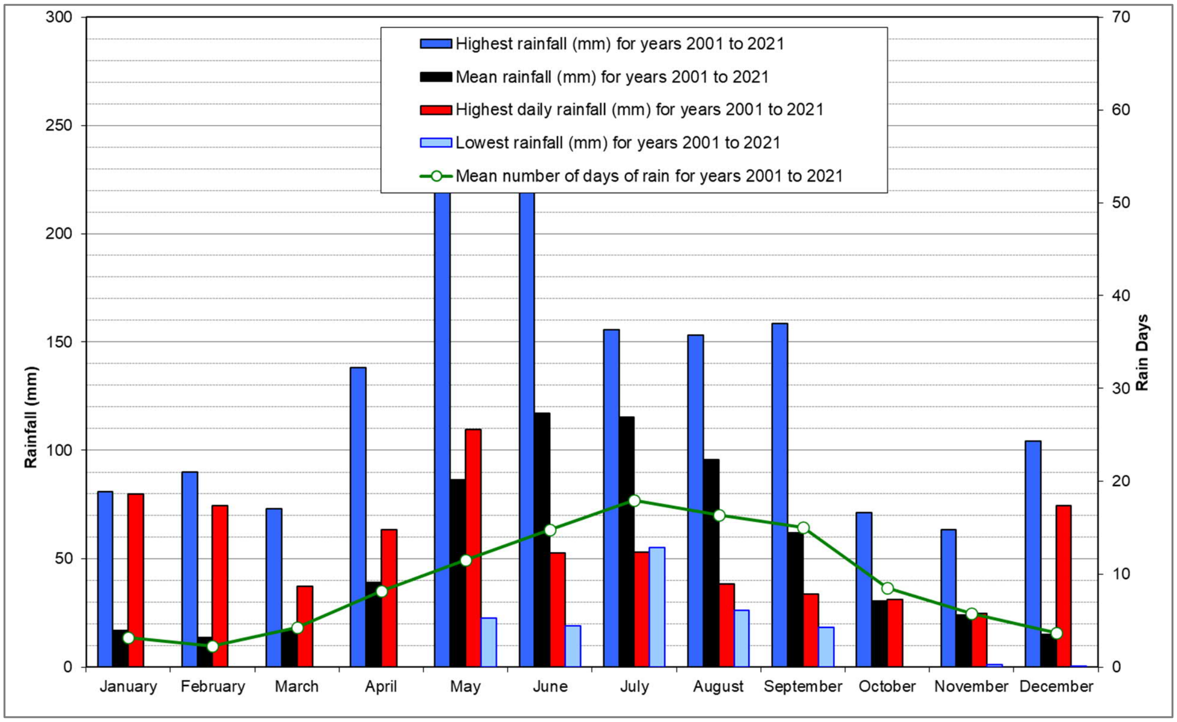


Figure 7 Seasonal Wind Roses for Mandurah (2016-2020)

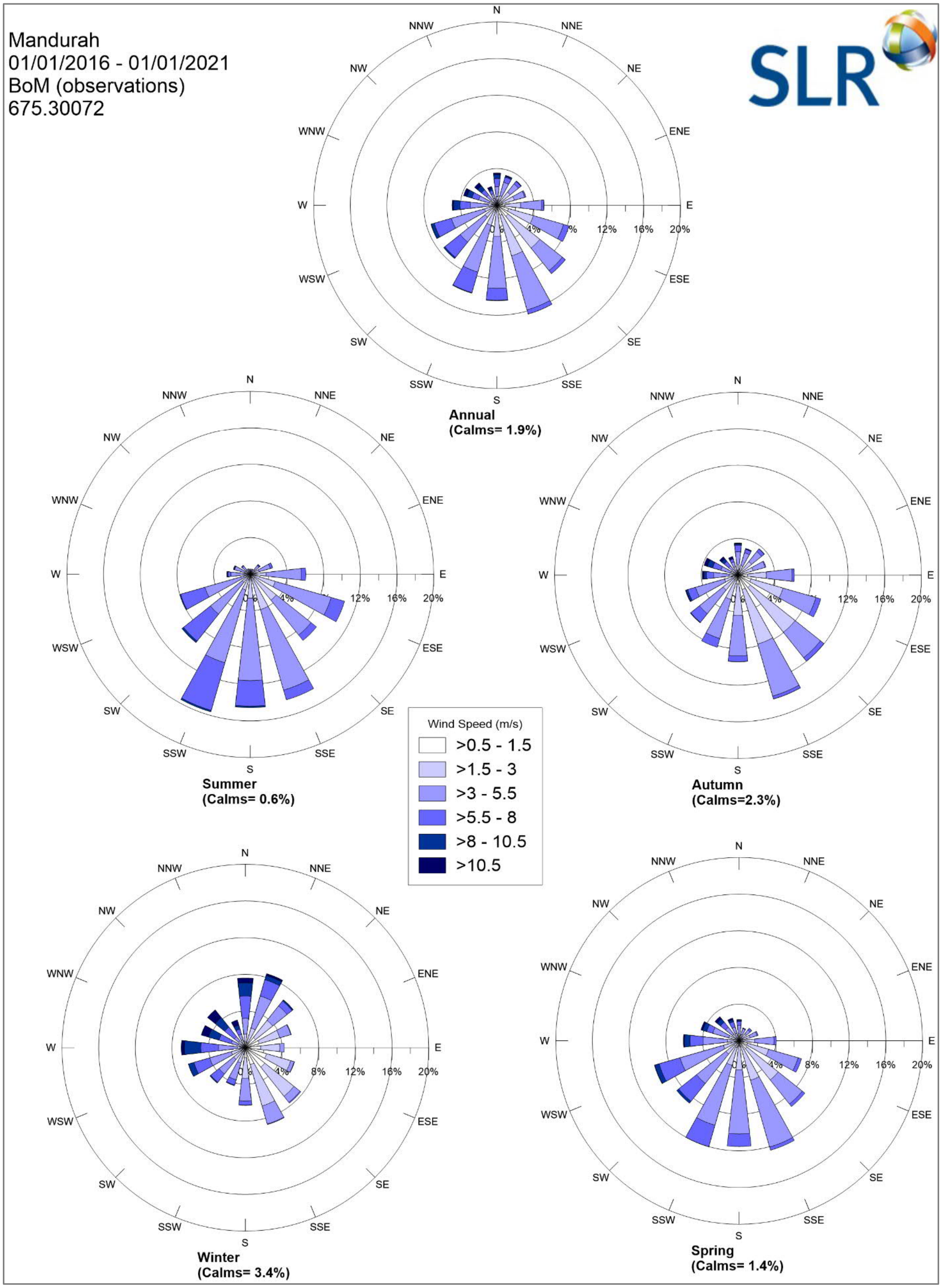
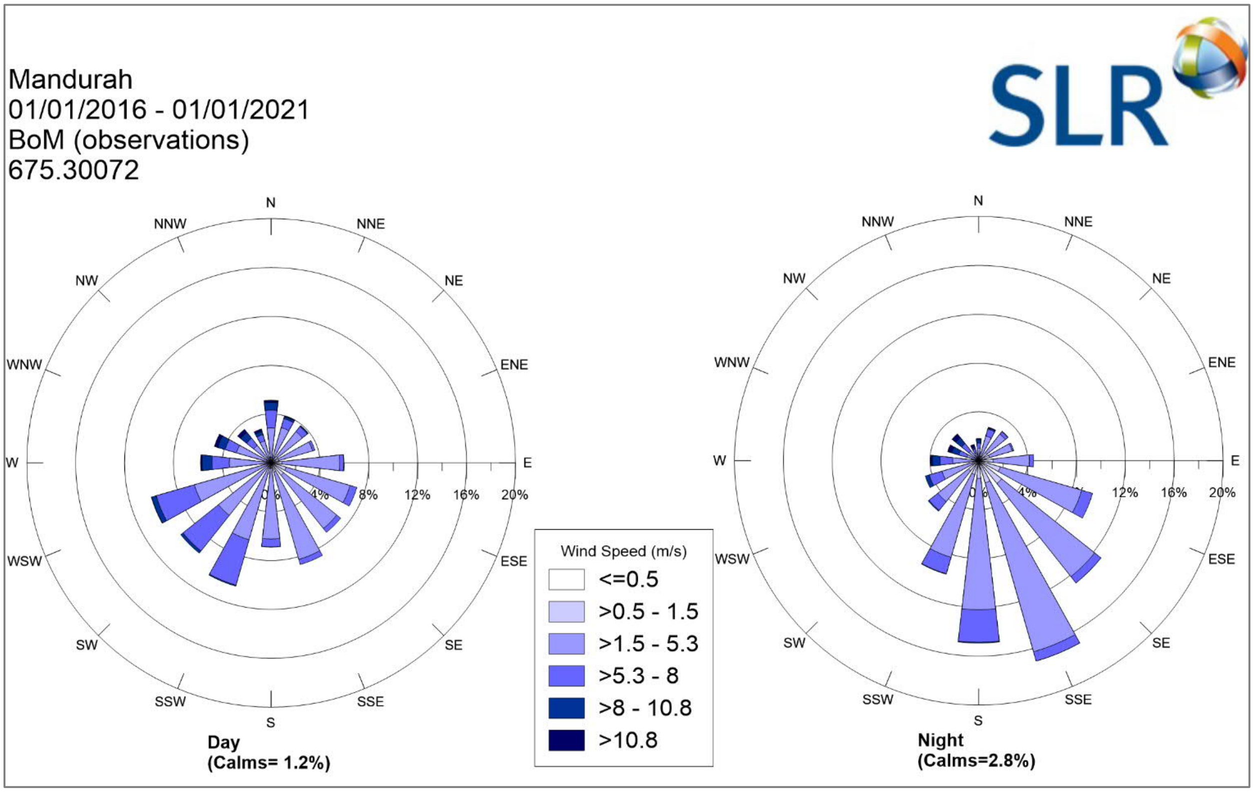


Figure 8 Day / Night Wind Roses for Mandurah (2016-2020)



4.2.5 Evaporation

The BoM publish total evaporation maps for Australia showing the amount of water which evaporates from an open pan (BoM, n.d.). Annual average and seasonal average evaporation rates for the area in which the Proposal is situated are conservatively estimated from these maps which indicate the following:

- approximate total annual average evaporation rate: 1400 mm, or 0.32 mm/h assuming evaporation occurs during daytime (12 hours) only
- approximate total summer average evaporation rate: 600 mm, or 0.51 mm/h assuming evaporation occurs during daytime (12 hours) only.

Using water carts and water sprays to supress dust emissions will achieve less control in areas with greater evaporation than areas with less evaporation. Greater rates of watering are likely to be required in summer when evaporation rates are increased to achieve adequate dust control.

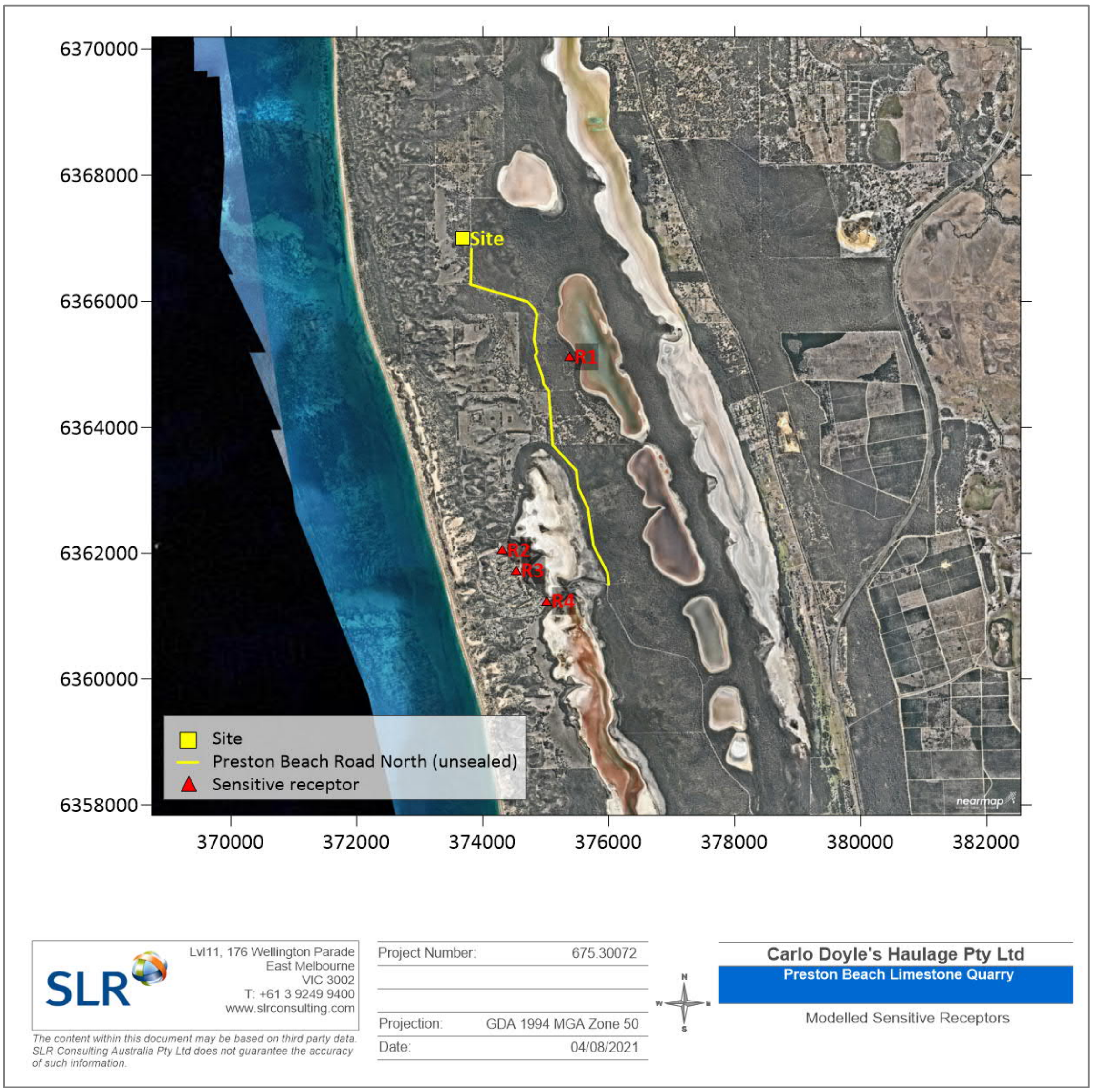
4.3 Sensitive Receptors

Nearby sensitive receptors identified as having the potential to experience elevated particulate levels due to the Proposal include a nearby camp site and residences in Preston Beach. Details of discrete receptors included in the assessment representing these nearest sensitive receptors are provided in Table 7 and their location with respect to the Site is presented in Figure 9.

Table 7 Nearby Sensitive Receptors included in Assessment

ID	Description	UTM Coordinates	Distance/Direction from Proposal
R1	Camp site	375,381 m E, 6,365,120 m S	2.3 km southwest (0.5 km from Preston Beach Road North)
R2	Preston Beach residence (Panorama Drive)	374,311 m E, 6,362,050 m S	4.8 km south (1.5 km from Preston Beach Road North)
R3	Preston Beach residence (Lakeside Terrace)	374,532 m E, 6,361,728 m S	5.1 km south (1.3 km from Preston Beach Road North)
R4	Preston Beach residence (Preston Beach Road)	375,018 m E, 6,361,242 m S	5.7 km south (1.0 km from Preston Beach Road North)

Figure 9 Location of Nearby Sensitive Receptors



4.4 Background Air Quality

Existing air quality in the area surrounding the Proposal will be affected by a combination of emissions from sources in the local area, as well as emissions that flow into the area from the wider region. In relation to local sources of air emissions, although there are no significant industrial sources in proximity to the Proposal, the coastal location mean the air environment is likely to be affected by marine aerosols, potentially observed in elevated $PM_{2.5}$ concentrations.

The air environment in the region surrounding the Proposal will be affected by:

- Dust from agricultural activities, coastal sand and salt wind driven emissions and long-range transport of fine particulate matter from other regions.
- Intermittent and short-term regional emissions of particulate matter and products of combustion from grass/bush fires, controlled burns and dust storms.

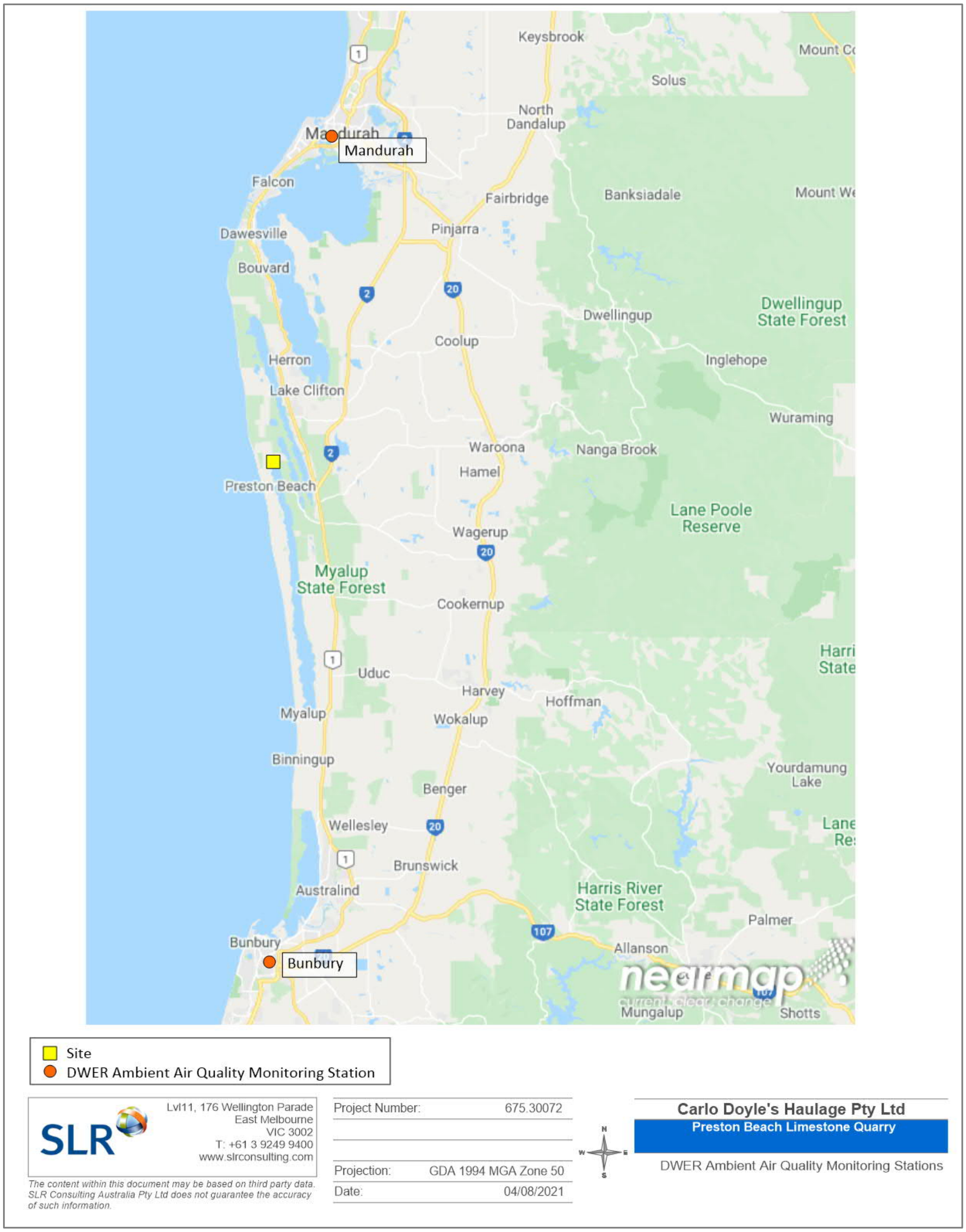
4.4.1 PM_{10} and $PM_{2.5}$

Western Australia (WA) is a signatory to the National Environment Protection (Ambient Air Quality) Measure (Air NEPM; refer Section 3.1.1) and is required to report annually on air monitoring results. DWER is responsible for the operation and maintenance of 15 air quality monitoring sites in WA. Nine of these sites are within the Perth metropolitan region and six are at regional locations. There is one monitoring station relatively close to the Proposal in Mandurah approximately 35 km north, however it was only commissioned in late 2019 and no data is publicly available at this time. The next nearest monitoring station that monitors concentrations of PM_{10} and $PM_{2.5}$ is at Bunbury, approximately 50 km south of the Proposal. Figure 10 presents the locations of these two monitoring stations relative to the Proposal location. A description of these two monitoring stations is provided in Table 8.

Table 8 DWER Ambient Air Quality Monitoring Stations Measuring PM_{10} and $PM_{2.5}$

Site	Description	Data Availability	Approximate Distance from Proposal
Mandurah	City on the south-west coast of Western Australia 70 km south of Perth. It is the State's second-largest city and has a Mediterranean climate. The site is about 100 m from the coast and is affected by marine aerosols.	PM_{10}: October 2019 to present $PM_{2.5}$: October 2019 to present	35 km north
Bunbury	Large rural town 145 km south of Perth with moderate-density housing.	PM_{10}: June 1999 to present $PM_{2.5}$: April 1997 to present	50 km south

Figure 10 DWER Ambient Air Quality Monitoring Stations (PM_{10} and $PM_{2.5}$) Near to Proposal



Bunbury is considered conservatively representative of the rural Proposal area, being located in a less rural area. The ambient PM_{10} and $PM_{2.5}$ concentration data recorded at this station are likely to be higher than that expected at the Proposal site and its surrounding areas. In the absence of any other available ambient monitoring data, the 75th percentile of the recorded 24-hour average PM_{10} and $PM_{2.5}$ monitoring data at Bunbury were used as the representative background level for the Proposal site and its surrounding areas.

Table 9 and Table 10 summarises available PM_{10} and $PM_{2.5}$ concentration data recorded at Bunbury by DWER in the last three reported years (2017-2019), as presented in the Western Australia Air Monitoring Reports published by DWER.

Table 9 Annual Average PM_{10} and $PM_{2.5}$ Concentrations: Bunbury

Year	PM_{10} Concentration (µg/m^3)	$PM_{2.5}$ Concentration (µg/m^3)
2017	16.5	8.7
2018	16.1	8.4
2019	16.6	8.5
Average	16.4	8.5

Table 10 24-Hour Average PM_{10} and $PM_{2.5}$ Concentration Statistics: Bunbury

Year	Maximum	99th	98th	95th	90th	75th	50th
PM_{10} Concentration (µg/m^3)							
2017	45.5	36.1	32.9	27.8	24.5	20.1	15.9
2018	51.9	37.8	35.2	27.8	24.4	18.7	15.0
2019	131	38.4	31.8	26.8	23.6	18.5	15.3
					Average	19.1	
$PM_{2.5}$ Concentration (µg/m^3)							
2017	33.9	27.2	21.5	14.3	12.7	9.8	7.7
2018	38.4	26	22.2	17.2	12.5	9.7	7.2
2019	118	27.3	22.5	14.2	12.1	9.3	7.3
					Average	9.6	

4.4.2 RCS

Ambient monitoring data of RCS is not available for the region. Findings from a literature review showed that only one RCS monitoring campaign was carried out in Australia which was conducted by Queensland Government (QG) to investigate impact of RCS due to quarrying operations. The monitoring was carried out for one year (December 2008 to December 2009) at two sites located in the wider community. Findings of the monitoring campaign and recorded 7-day average RCS and $PM_{2.5}$ data were made publicly available (DSITIA, 2009) by Queensland Department of Environment and Science (DES) formerly known as Department of Science, Information Technology, Innovation and the Arts (DSITIA).

The findings of this campaign are summarised below:

- Annual average $PM_{2.5}$ crystalline silica concentrations in the Mount Cotton community were very low, at less than ten percent of the guideline value of 3 µg/m³ set in the Victorian Governments Protocol for Environmental Management for Mining and Extractive Industries (PEMMEI).
- Crystalline silica was detected in 90 percent of $PM_{2.5}$ samples collected at the monitoring site located within 300 meters (m) of the quarry boundary, but in less than 50 percent of samples at a distance of 1.5 kilometres (km) from the quarry

In addition to the above, further investigation of RCS data presented in the DSITIA report showed the following:

- An annual average RCS concentration of 0.2 µg/m³ was recorded at Site 1, located in the Mount Cotton Community, approximately 1.5 km from the quarry.
- An annual average RCS concentration of 0.3 µg/m³ was recorded at Site 2, located approximately 300 m from the quarry boundary.
- The average ratio of the RCS and $PM_{2.5}$ concentrations was 0.027 and 0.028 at Site 1 and Site 2 respectively.

Based on the findings of the above study, background RCS concentrations the Proposal site were estimated using $PM_{2.5}$ concentration data recorded at Bunbury and a conservative RCS/$PM_{2.5}$ ratio of 0.03. The estimated RCS background levels for the Proposal are presented in Table 11.

Table 11 Estimated RCS (as $PM_{2.5}$) Background Levels

Year	Annual Average (µg/m³) [a]
2017	0.3
2018	0.3
2019	0.3
Average	0.3

a Estimated based on annual average $PM_{2.5}$ monitoring data at Bunbury

The data presented in Table 11 showed that the estimated annual average RCS concentrations based on $PM_{2.5}$ concentrations recorded in Bunbury are higher than that recorded at the Mount Cotton Community monitoring site and are similar to that recorded near the quarry site. Another study in the UK (Stacey, Butler, Thorpe, & Roberts, 2018) measured urban background RCS concentrations less than 0.3 µg/m^3, and a median RCS level at a rural location of 0.02 µg/m^3.

Given the above, and considering that the Bunbury air quality monitor is located in close proximity to urban areas, the use of an RCS/$PM_{2.5}$ ratio of 0.03 (3%) to estimate ambient level RCS concentrations based on $PM_{2.5}$ concentrations measured in Bunbury, is appropriate and likely to provide a conservative estimate of RCS concentrations at the Proposal site.

4.4.3 Adopted Background Concentrations

In the absence of ambient air quality data monitored close to the Proposal site, and based on the analysis presented in Section 4.4.1 and Section 4.4.2, this assessment uses the average yearly 75th percentile PM_{10} and $PM_{2.5}$ concentrations recorded at Bunbury during the 2017-2019 period to conservatively represent the existing background level at the Proposal site and the surrounding area.

The adopted background concentrations for this assessment are provided in Table 12, noting that the assumed annual average background $PM_{2.5}$ concentrations are above the relevant criterion. This means that regardless of the level of contribution from the Proposal, the cumulative annual average $PM_{2.5}$ level will be above the guideline due to the high background level. Therefore, focus should be given to incremental annual average $PM_{2.5}$ level rather than cumulative annual average $PM_{2.5}$ level for the purpose of assessment.

Table 12 Adopted Background Level

Pollutant	Averaging Period	Concentration (µg/m^3)	Guideline (µg/m^3)
PM_{10}	24 hours Annual	19.1 16.4	50 25
$PM_{2.5}$	24 hours Annual	9.6 8.5	25 8
RCS (as $PM_{2.5}$)	Annual	0.3	3

5 Source and Emissions Inventory

5.1 Emission Estimation Methodology

Fugitive emissions of PM_{10} and $PM_{2.5}$ were estimated using published emission factors from the National Pollutant Inventory (NPI) Emission Estimation Technique Manual for Mining (DSEWPC, 2012) [incorporating (SPCC, 1986)], USEPA AP-42 Compilation of Air Emissions Factors (USEPA, 2006 and Updates) and ACARP (ACARP, 2015), as appropriate.

As the Proposal is to operate for approximately three to four months between the months of December and April, the Proposal would not be operational for significant periods (8 months out of 12 months) of the year. To predict the potential impacts under worst case meteorological conditions during December to April, the potential emissions were estimated based on peak weekly average operational parameters and material handling throughputs.

Notable assumptions made in calculating the emission rates for each activity are as follows:

- Operations were conservatively assumed to occur between December and April (five months) which will over predict annual average GLCs providing a conservative assessment in this regard. No dust generation other than wind erosion is assumed outside this period.
- An area equal to the proposed active area of the pit was used to estimate windblown dust from the pit.
- A modelled controlled scenario assumes only water sprays on the crushing activities and water cart use in the pit to reduce wind erosion. In reality, additional management and mitigation measures will be used to minimise dust (refer Section 9).
- For comparison, a modelled uncontrolled scenario assumes no emissions controls on any of the dust generating activities.
- Estimated emissions based on peak weekly activity rates was used for modelling.
- Haulage distances (total vehicle kilometres travelled (VKT)) on unpaved roads were estimated based on the length of the access route and number of trips per day (calculated from total annual tonnage and truck payload).
- A water cart will be used within the pit, however with only 2 truck trips per hour, it may not be practicable to water all of the 6.5 km public unsealed Preston Beach Road North. No watering has been assumed for Preston Beach Road North for either the uncontrolled or controlled scenarios to provide conservative assessment.

Haul Road Watering to Supress Wheel Generated Dust

The NPI EETM for Mining indicates emission control of wheel generated dust as follows:

- Level 1 watering (2 L/m^2/h): 50% control
- Level 2 watering (>2 L/m^2/h): 75% control

Site specific watering emission control *C* expressed as a percentage can be estimated from typical evaporation rates for the area and haul road traffic rate using the following equation (Air & Waste Management Association, 2000):

$$C = 100 - \frac{0.8pdt}{i}$$

where *p* is the average hourly daytime evaporation rate, *d* is the average hourly daytime traffic rate, *t* is the time (hours) between water application and *i* is the application intensity (L/m^2).

From the typical evaporation rates for the area (Section 4.2.5), a control of greater than 90% is calculated for the trafficked areas, including for the summer months, with a watering rate of less than 0.3 L/m^2/h when applied every three hours. However, for modelling purposes, no control was conservatively applied to the unpaved haul road wheel generated dust estimates.

Wind Speed Dependent Wind Erosion

The base wind erosion emission rates were varied hourly based on a cubic relationship with the wind speed for that hour to accurately simulate the increased dust generation at higher wind speeds. That is, for each hour, *h, the hourly emission rate, E* is:

$$E(h) = E_{base} * u(h)^3/\overline{u^3}$$

where E_{base} is base emission rate, *u* is the hourly wind speed contained within the meteorological file. Note that although increased wind speed generates increased wind erosion emission rates, it also promotes increased plume dispersion. This offsetting effect generally leads to reduced ground level concentrations.

5.2 RCS Emissions

In WA, the State Department of Mines and Petroleum maintains an exposure database on a wide range of contaminants that are relevant in the mining industry. An analysis of RCS exposure measurement data in this database, recorded from June 1986 to January 2015, showed that overall RCS content in the particulate samples varied between 0.1 to 10% with a median of 3.3%, and for industrial mineral and exploration the median RCS content was calculated to be 5% (Peters, et al., 2017). Given this, for the purpose of this study, it has been conservatively assumed that the RCS emission rates for all activities are equal to 10% of the $PM_{2.5}$ emission rates.

5.3 Accuracy of Modelling

All atmospheric dispersion models, including AERMOD, represent a simplification of the many complex processes involved in the dispersion of pollutants in the atmosphere. To obtain good quality results it is important that the most appropriate model is used and the quality of the input data (meteorological, terrain, source characteristics) is adequate.

The main sources of uncertainty in dispersion models, and their effects, are discussed below:

- Oversimplification of physics: This can lead to both under-prediction and over-prediction of ground level pollutant concentrations. Uncertainties are greater in Gaussian plume models as they do not include the effects of non-steady-state meteorology (i.e., spatially- and temporally-varying meteorology).
- Uncertainties in emission rates: Ground level concentrations are proportional to the pollutant emission rate. In addition, most modelling studies assume constant worst-case emission levels, or are based on the results of a small number of stack tests (where relevant), however in reality, operations (and thus emissions) are often quite variable. Accurate measurement of emission rates and source parameters requires continuous monitoring.
- Uncertainties in wind direction and wind speed: Wind direction affects the direction of plume travel, while wind speed affects plume rise and dilution of plume. Uncertainties in these parameters can result in errors in the predicted distance from the source of the plume impact, and magnitude of that impact. In addition, aloft wind directions commonly differ from surface wind directions. The preference to use rugged meteorological instruments to reduce maintenance requirements also means that light winds are often not well characterised.
- Uncertainties in mixing height: If the plume elevation reaches 80% or more of the mixing height, more interaction will occur, and it becomes increasingly important to properly characterise the depth of the mixed layer as well as the strength of the upper air inversion.
- Uncertainties in temperature: Ambient temperature affects plume buoyancy, so inaccuracies in the temperature data can result in potential errors in the predicted distance from the source of the plume impact, and magnitude of that impact.
- Uncertainties in stability estimates: Gaussian plume models use estimates of stability class, and 3D models use explicit vertical profiles of temperature and wind (which are used directly or indirectly to estimate stability class for Gaussian models). In either case, uncertainties in these parameters can cause either under-prediction or over-prediction of ground level concentrations. For example, if an error is made of one stability class, then the computed concentrations can be off by 50% or more.

The USEPA makes the following statement in its Modelling Guideline (US EPA, 2005) on the relative accuracy of models:

> *"Models are more reliable for estimating longer time-averaged concentrations than for estimating short-term concentrations at specific locations; and the models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area. For example, errors in highest estimated concentrations of ±10 to 40% are found to be typical, i.e., certainly well within the often quoted factor-of-two accuracy that has long been recognised for these models. However, estimates of concentrations that occur at a specific time and site are poorly correlated with actually observed concentrations and are much less reliable."*

6 Proposal Inputs

The basis of the emission estimation is summarised in Table 13. The resulting TSP, PM_{10} and $PM_{2.5}$ emission inventory is summarised in Table 14.

Table 13 Proposal Basis for Modelling Assessment

Parameter	Operational Data	Comment
Throughput	57 t/h	Client data. Limestone and limesand
Silt content - haul road	4.3 %	Conservatively assumed (AP42 13.2.2.1 sand and gravel plant road)
Sales truck gross weight	70 t	Client confirmed
Sales truck payload	30 t	Client confirmed
Sales truck empty weight	40 t	Client confirmed
Sales road length - Stockpile to sealed Preston Beach Road	6.5 km	Estimated based on aerial imagery
Number of return Sales trips	2 trips/h	Based on throughput and truck payload.
Active pit	2.0 ha	Estimated based on mine plan
Crusher area	0.0 ha	Assumed to be in active pit
Stockpiles	0.0 ha	Assumed to be in active pit

Table 14 Estimated Particulate Emissions

Activity	Emission Factor					Peak Emission Rate (kg/week)			Mitigation Measures Assumed in Emission Rate Estimate
	TSP	PM_{10}	$PM_{2.5}$	Unit	Source	TSP	PM_{10}	$PM_{2.5}$	
Loading sand to stockpile [a]	0.0013	0.00062	0.000094	kg/t	ACARP	2.7	1.3	0.19	None
Loading to crusher [a]	0.0013	0.00062	0.000094	kg/t	ACARP	13.3	6.3	0.95	None
Primary crushing (controlled) [a]	0.00060	0.00027	0.000050	kg/t	AP42	6.1	2.7	0.51	Water sprays
Primary crushing (uncontrolled) [a]	0.0027	0.0012	0.00022	kg/t	AP42	27.4	12.2	2.3	None
Secondary crushing (controlled) [a]	0.00060	0.00027	0.000050	kg/t	AP42	6.1	2.7	0.51	Water sprays
Secondary crushing (uncontrolled) [a]	0.0027	0.0012	0.00022	kg/t	AP42	27.4	12.2	2.3	None
Screening (controlled) [a]	0.0011	0.00037	0.000024	kg/t	AP42	11.2	3.8	0.24	Water sprays
Screening (uncontrolled) [a]	0.0125	0.00430	0.000279	kg/t	AP42	127	43.7	2.8	None
Conveyor transfer point (controlled) [a]	0.000070	0.000023	0.0000065	kg/t	AP42	1.4	0.47	0.13	Water sprays
Conveyor transfer point (uncontrolled) [a]	0.013	0.0043	0.00028	kg/t	AP42	30.5	11.2	3.2	None
Loading to sales trucks [a]	0.0013	0.00062	0.00009	kg/t	ACARP	16.0	7.6	1.1	None
Hauling product to Preston Beach Road [a]	1.13	0.28	0.028	kg/t	AP42	13,755	3,429	343	None
Wind erosion - Active Pit (controlled) [a]	0.40	0.20	0.02	kg/ha/hr	NPI	219	110	10.2	Water cart
Wind erosion - Active Pit (uncontrolled) [b]	0.40	0.20	0.02	kg/ha/hr	NPI	438	219	20.5	None
Total (controlled)						14,024	3,561	356	
Total (uncontrolled)						14,459	3,754	377	

a December to April
b All year round

7 Dispersion Modelling Methodology

7.1 Selection of Models

Emissions from the proposed quarry were modelled using a combination of the TAPM, CALMET and CALPUFF models. CALPUFF is a transport and dispersion model that ejects "puffs" of material emitted from modelled sources, simulating dispersion and transformation processes along the way. In doing so, it typically uses the fields generated by a meteorological pre-processor CALMET, discussed further below. Temporal and spatial variations in the meteorological fields selected are explicitly incorporated in the resulting distribution of puffs throughout a simulation period. The primary output files from CALPUFF contain hourly concentration evaluated at selected receptor locations. The CALPOST post-processor is then used to process these files, producing tabulations that summarise results of the simulation for user-selected averaging periods.

7.2 Meteorological Modelling

Meteorological mechanisms govern the dispersion, transformation and eventual removal of pollutants from the atmosphere. The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. Dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface-mixing layer define the vertical component. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume 'stretching'. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction, and the variability in wind direction, determines the general path pollutants will follow, and the extent of crosswind spreading. Pollution concentration levels therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field (Oke, 2002).

For this study, a site-representative three-dimensional meteorological dataset was compiled using a combination of the TAPM and CALMET models, as discussed in the following sections.

7.2.1 Selection of Worst-Case Year

Meteorological data recorded over the five-year period 2016-2020 at Mandurah was analysed to select a worst-case meteorological year in order to provide a conservative air quality impact assessment. An analysis of the wind speed, wind direction, temperature and relative humidity recorded in each of the calendar years aligned well with the five-year average data with no particular years of note, however the year 2019 reported the worst case combination of low average wind speed and greater number of calms, which generally results in reduced plume dispersion and consequently greater ground level impacts. For this reason, 2019 was chosen for the AQIA.

7.2.2 TAPM

In order to calculate all required meteorological parameters required by the dispersion modelling process, meteorological modelling using The Air Pollution Model (TAPM, v 4.0.4) has been performed. TAPM, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a prognostic model which may be used to predict three-dimensional meteorological data and air pollution concentrations. TAPM predicts wind speed and direction, temperature, pressure, water vapour, cloud, rainwater and turbulence. The model 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 TAPM model may assimilate actual local wind observations so that they can optionally be included in a model solution, aligning the predicted solution towards the observed values. However, observations from the nearest weather stations at Mandurah and Bunbury AWS are too distant to influence the model at the Proposal. Three-dimensional TAPM output was used as input to the CALMET model.

Table 15 outlines the input data used in the TAPM modelling.

Table 15 Meteorological Parameters Adopted (TAPM v 4.0.4)

Parameter	Data
Modelling Period	31 December 2018 to 1 January 2020
Centre of analysis	(373,687, 6,366,995) UTM zone 50
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Data assimilation	None
Terrain	AUSLIG 9 second DEM

7.2.3 CALMET

CALMET is a meteorological model that develops hourly wind and other meteorological fields on a three-dimensional gridded modelling domain that are required as inputs to the CALPUFF dispersion model. 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, sea breeze, 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. The final hourly varying wind field thus reflects the influences of local topography and land uses.

Three-dimensional meteorological data was generated for the modelling domain covering an area of 25 km × 25 km with a grid resolution of 500 m, centred on the Proposal. Data generated for this domain were used as input to a second nested inner grid of 5 km x 5km with a grid resolution of 100 m, the output of which was then used as input to the CALPUFF dispersion model.

Table 16 details the parameters used in the meteorological modelling to drive the CALMET model.

Table 16 Meteorological Parameters Adopted (CALMET v 6.1)

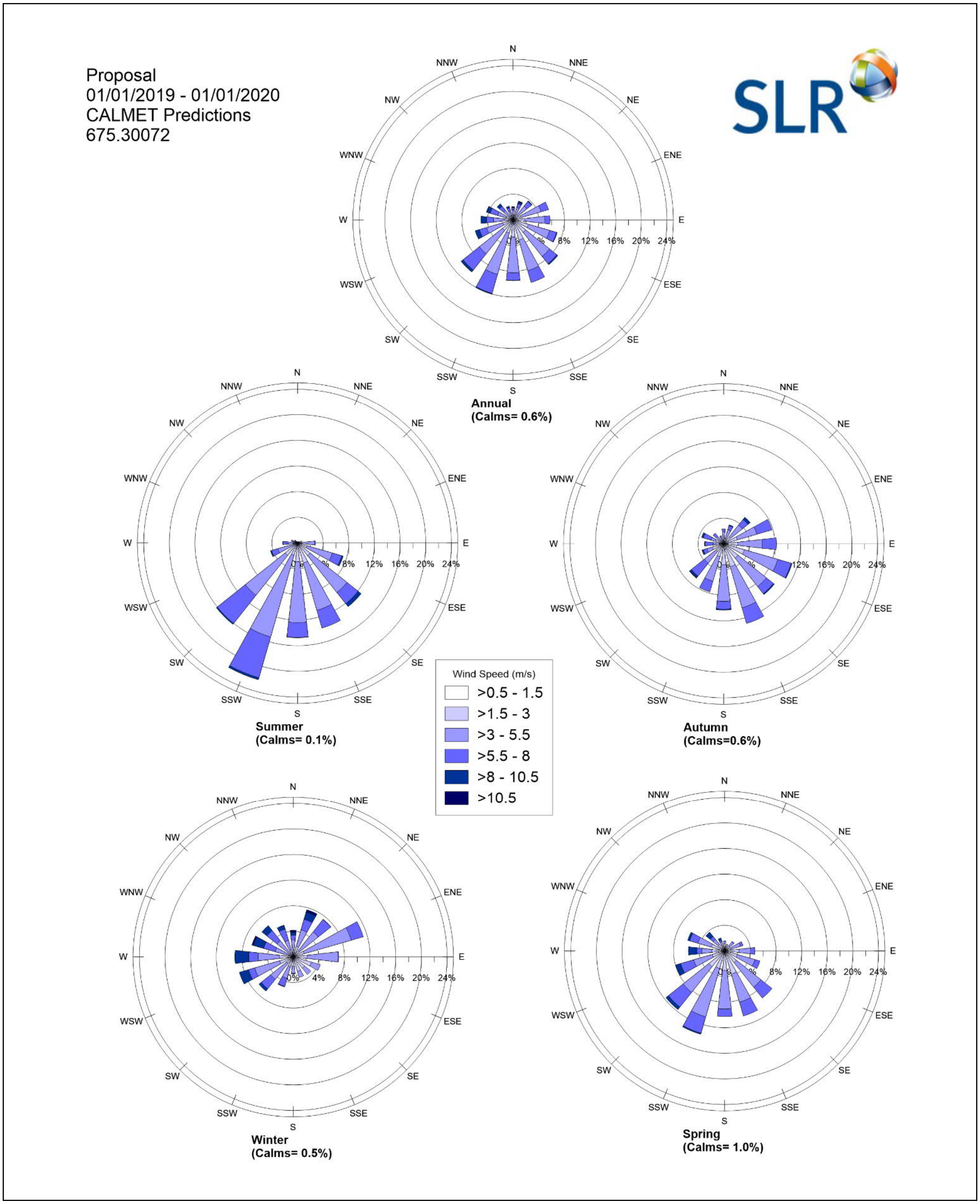
Parameter	Data
Meteorological grid	Outer: 25 km × 25 km Inner: 5 km x 5 km
Meteorological grid resolution	Outer: 0.5 km Inner: 0.1 km
Initial guess field	3D output from TAPM modelling
Data assimilation	None

7.2.4 Meteorological Data Used in the Dispersion Modelling

7.2.4.1 Wind Speed and Direction

Summaries of the annual wind behaviour predicted by CALMET for the Proposal location for the modelled year are presented as wind roses in Figure 11. These wind roses show that on an annual basis, the Proposal site is predicted to experience low to moderate winds, predominantly from the southern quadrants which aligns with the Mandurah BoM observations (Section 4.2.4). The winds are rarely from the north, especially in the summer months, which would otherwise tend to carry dust emissions from the site towards the identified sensitive receptors.

Figure 11 Predicted Annual and Seasonal Wind Roses for the Proposal (2019)



7.2.4.2 Atmospheric Stability

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion, inhibiting or promoting pollutant dispersion, respectively. The Pasquill-Gifford-Turner (PGT) assignment scheme identifies six Stability Classes, A to F, to categorise the degree of atmospheric stability as follows:

- A = Extremely unstable conditions
- B = Moderately unstable conditions
- C = Slightly unstable conditions
- D = Neutral conditions
- E = Slightly stable conditions
- F = Moderately stable conditions

The meteorological conditions defining each PGT Stability Class are shown in Table 17.

Table 17 Meteorological Conditions Defining Each PGT Stability Classes

Surface Wind Speed (m/s)	Daytime Insolation			Night-Time Conditions	
	Strong	Moderate	Slight	Thin overcast or >4/8 cloud	<= 4/8 cloudiness
< 2	A	A - B	B	E	F
2 - 3	A - B	B	C	E	F
3 - 5	B	B - C	C	D	E
5 - 6	C	C - D	D	D	D
> 6	C	D	D	D	D

Notes:

a. Strong insolation corresponds to sunny midday in midsummer in England; slight insolation to similar conditions in midwinter.

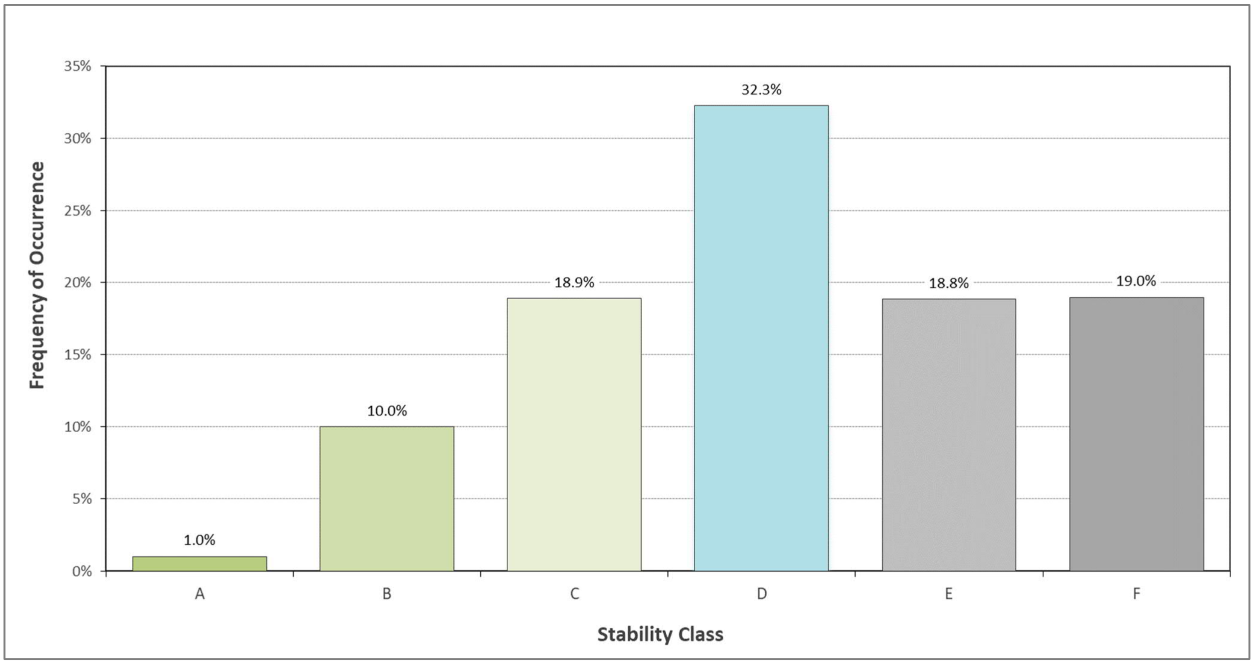
b. Night refers to the period from 1 hour before sunset to 1 hour after sunrise.

c. The neutral category D should also be used, regardless of wind speed, for overcast conditions during day or night and for any sky conditions during the hour preceding or following night as defined above.

Source: (NOAA, 2018)

The predicted frequency of each stability class at the Proposal site during 2019 is presented in Figure 12. The results indicate a high frequency of conditions typical to Stability Class D (Neutral), with a low frequency of very unstable conditions (Stability Class A). Stable conditions (Stability Classes E and F) also occur relatively frequently. Stable conditions occur during the night-time, under low wind speed conditions, which inhibit pollutant dispersion.

Figure 12 Predicted Stability Class Frequencies for Proposal Site (2019)

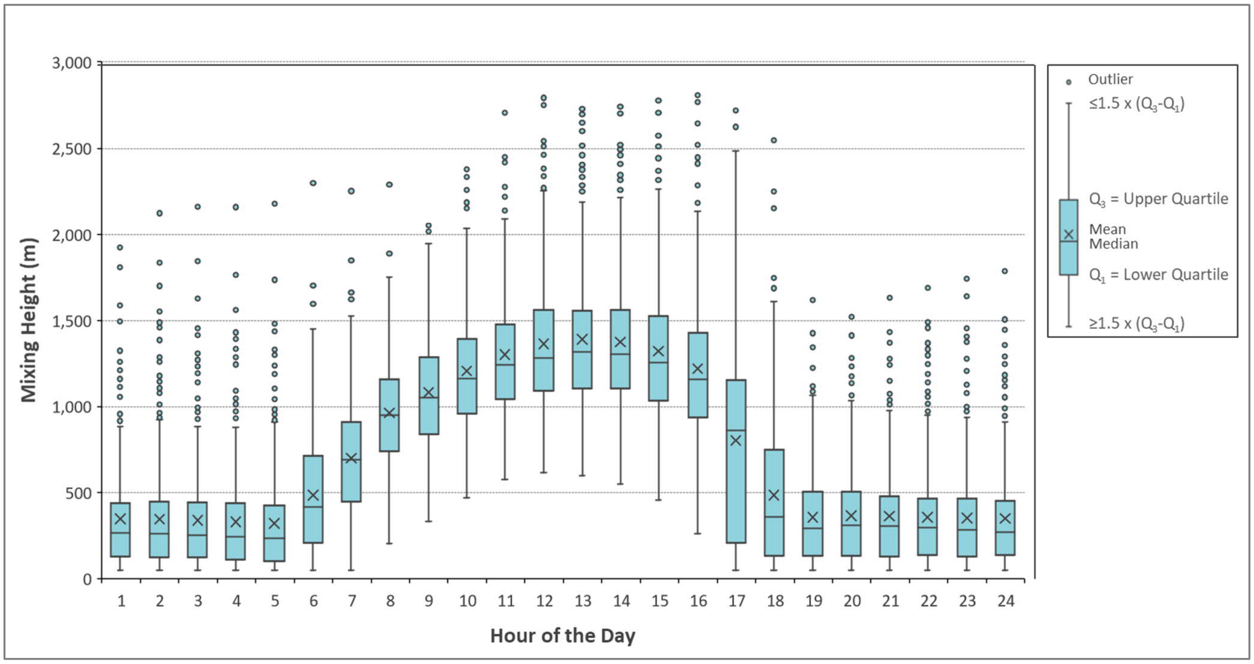


7.2.4.3 Mixing Heights

The mixing height is the height to which the atmosphere is uniformly mixed. Mixing heights have a diurnal variation and rapidly change after sunrise and at sunset. If a plume penetrates up through, or is released above, the mixing height, the pollutants will be trapped aloft, and their effect will not be observed at ground level. If a plume is trapped within a shallow mixed layer, the vertical dispersion will be limited and high ground-level concentrations are likely to occur.

Diurnal variations in maximum and average mixing depths predicted at the Proposal site during 2019 are illustrated in Figure 13. As would be expected, an increase in the mixing depth 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 growth of the convective mixing layer.

Figure 13 Predicted Mixing Heights at Proposal Site (2019)



7.3 Additional Model Parameters and Options

A summary of additional CALPUFF modelling options and parameters used for the assessment is provided in Table 18.

Table 18 Model Parameters

Parameter	Option
Calculation Type	Concentration and dry deposition rate
Plume Rise Method	NA
Building Downwash	NA
Gridded Receptors	Cartesian 5.5 km x 7.5 km; 100 m spacing; 0 m AGL centred on Proposal
Discrete Receptors	Camp site: 375,381, 6,365,120 Preston Beach residence (Parorama Drive): 374,311, 6,362,050; 0 m AGL Preston Beach residence (Lakeside Terrace): 374,532, 6,361,728; 0 m AGL Preston Beach residence (Preston Beach Road): 375,018, 6,361,242; 0 m AGL

AGL Above ground level

7.4 Dispersion Model Configuration

7.4.1 PM_{10} and $PM_{2.5}$ Modelling Methodology

Emissions from the site were represented by a series of volume sources, except for wind erosion from the exposed areas, which was represented by area sources.

The estimated particulate emissions were modelled as:

- Fine Particulates (FP < 2.5 µm)
- Course Matter (2.5 µm < CM < 10 µm)
- Remainder (RE > 10 µm).

These parameters were then grouped within the CALPUFF model to predict $PM_{2.5}$ and PM_{10} concentrations at surrounding receptor locations. This approach provides the most realistic treatment of the differing size fractions, with the lighter, finer particulate matter being dispersed further than the heavier size fraction that settles out of the air more rapidly.

Based on the sensitivity of each activity to wind speed, hourly varying emission files representing hourly FP, CM and RE emissions for each source were generated for each model scenario based on the annual average emission rates estimated for each activity. Details of the algorithm used to generate the variable emission files are presented in Appendix A.

In addition to the above, the following operating conditions were also incorporated in the variable emission files:

- Wind erosion occurs every hour of the year adjusted for windspeed (refer Appendix A).
- Dust generating activities (excluding wind erosion) will not occur between May and November.
- Dust generating activities (excluding wind erosion) will occur for a period of 16 weeks per annum between December and April. To be conservative the modelling assumed that activities occurred over five months from beginning of December to end of April.
- Dust generating activities (excluding wind erosion) will occur between 7:00 am and 6:00 pm 7 days per week (December to April).

8 Assessment of Impacts

8.1 PM_{10}

The predicted maximum 24-hour and annual average PM_{10} concentrations at discrete receptors are presented in Table 19. The cumulative concentrations include the estimated background concentrations (Section 4.4.3) and indicate that there are no exceedances of the 24-hour or annual average PM_{10} criteria for both the controlled and uncontrolled emission scenarios. There is no increase in incremental impacts at the sensitive receptors from the operations at the quarry site under the uncontrolled scenario conditions when compared with the controlled scenario because impacts from the Site at the sensitive receptors are negligible.

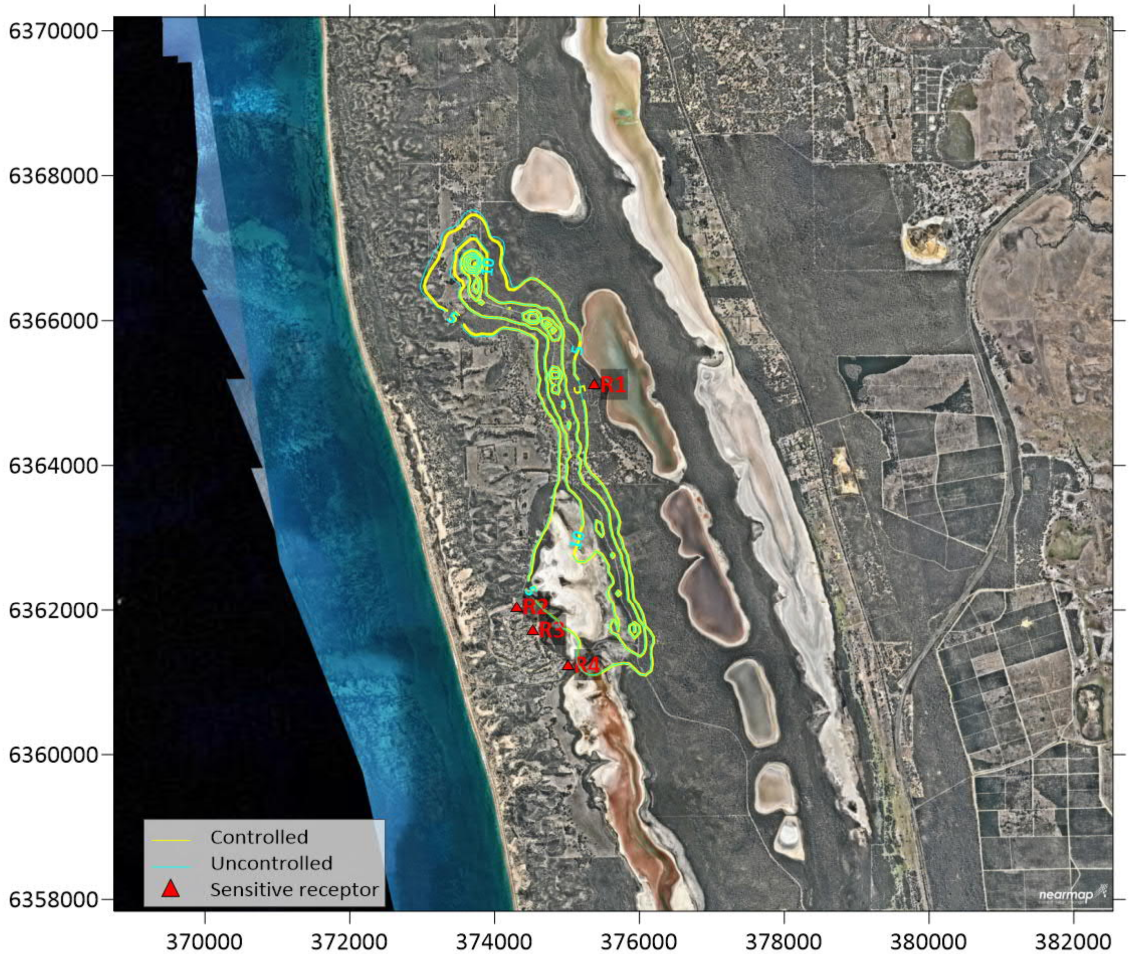
Only impacts from sales truck wheel generated dust along Preston Beach Road North are predicted at the sensitive receptors and no controls on the haul road wheel generated dust were assumed for both scenarios in this regard, due to the low level of frequency of trucks. The incremental impacts are predicted to be low relative to the estimated background concentrations and therefore it is unlikely there would be any significant elevation in ambient PM_{10} concentrations due to the Proposal.

Isopleths of the predicted incremental 24-hour average and annual average dust deposition rates for the controlled and uncontrolled scenarios are presented in Figure 14 and Figure 15.

Table 19 Predicted Incremental and Cumulative 24-Hour and Annual Average PM_{10} Concentrations

Scenario	Receptor ID	Increment (µg/m³)		Cumulative (µg/m³)	
		Maximum 24-Hour	Annual	Maximum 24-Hour	Annual
Controlled	R1	3.5	0.21	23	17
	R2	2.4	<0.1	22	17
	R3	2.2	<0.1	21	17
	R4	4.3	0.10	23	17
Uncontrolled	R1	3.5	0.21	23	17
	R2	2.4	<0.1	22	17
	R3	2.2	<0.1	21	17
	R4	4.3	0.10	23	17
			Criteria	50	25

Figure 14 Incremental 24-Hour Average PM_{10} GLCs



Lvl11, 176 Wellington Parade
East Melbourne
VIC 3002
T: +61 3 9249 9400
www.slrconsulting.com

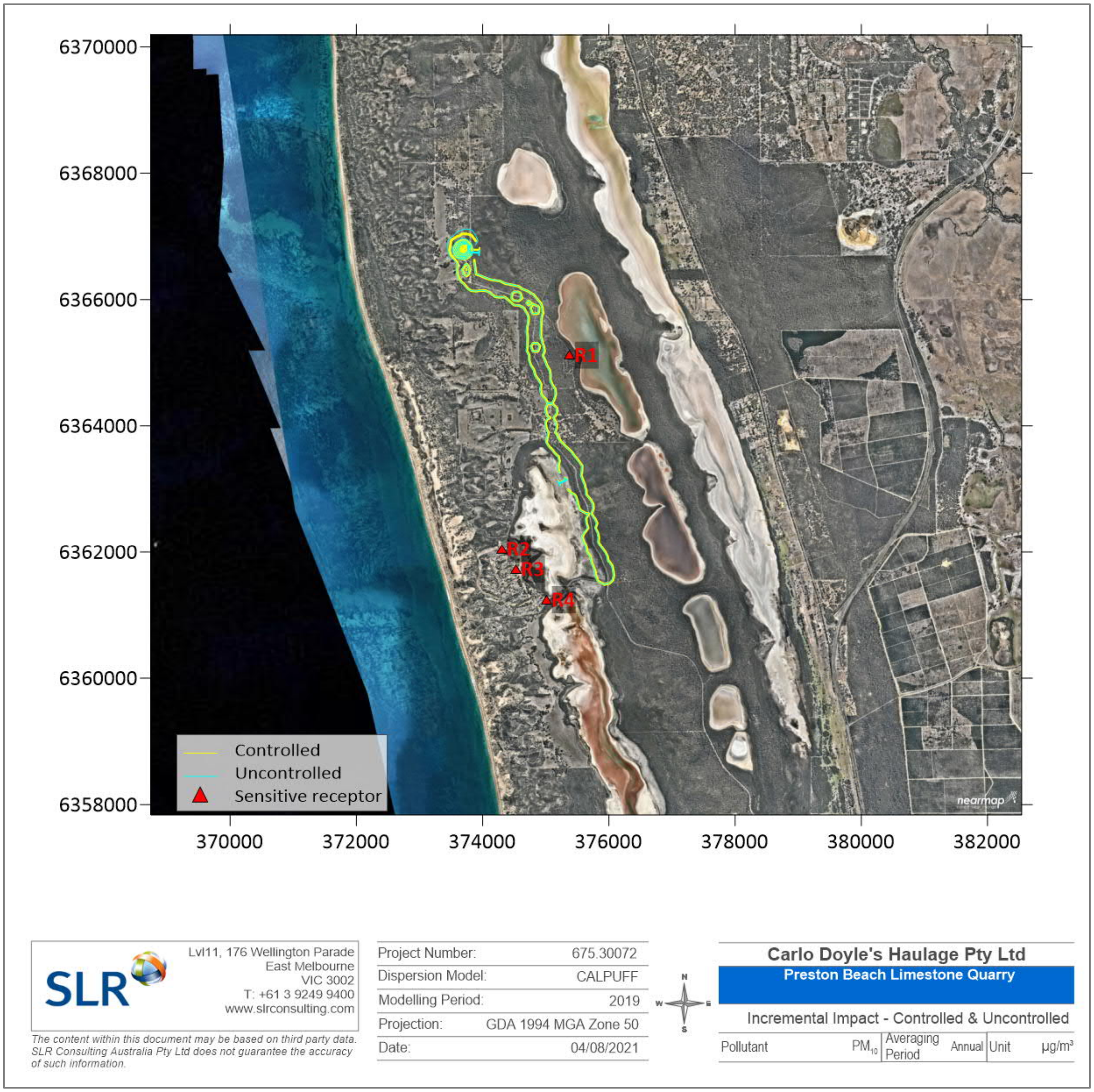
The content within this document may be based on third party data. SLR Consulting Australia Pty Ltd does not guarantee the accuracy of such information.

Project Number:	675.30072
Dispersion Model:	CALPUFF
Modelling Period:	2019
Projection:	GDA 1994 MGA Zone 50
Date:	04/08/2021

Carlo Doyle's Haulage Pty Ltd
Preston Beach Limestone Quarry
Incremental Impact - Controlled & Uncontrolled

Pollutant	PM_{10}	Averaging Period	24-Hour	Unit	µg/m³

Figure 15 Incremental Annual Average PM_{10} GLCs



8.2 $PM_{2.5}$

The predicted maximum 24-hour and annual average $PM_{2.5}$ concentrations at discrete receptors are presented in Table 20. The cumulative concentrations include the estimated background concentrations (Section 4.4.3) and indicate that there are no exceedances of the 24-hour average $PM_{2.5}$ criterion. As with PM_{10}, there is no increase in incremental impact at the sensitive receptors under the uncontrolled scenario conditions when compared with the controlled scenario because impacts from the Site at the sensitive receptors are negligible. The incremental impacts are predicted to be low relative to the estimated background concentrations and therefore there is unlikely to be any significant elevation in ambient $PM_{2.5}$ concentrations due to the Proposal.

Isopleths of the predicted incremental 24-hour average and annual average dust deposition rates for the controlled and uncontrolled scenarios are presented in Figure 16 and Figure 17.

Table 20 Predicted Incremental and Cumulative 24-Hour and Annual Average $PM_{2.5}$ Concentrations

Scenario	Receptor ID	Increment (µg/m³)		Cumulative (µg/m³)	
		Maximum 24-Hour	Annual	Maximum 24-Hour	Annual
Controlled	R1	0.37	<0.1	10	<8.6
	R2	0.25	<0.1	9.9	<8.6
	R3	0.24	<0.1	9.8	<8.6
	R4	0.45	<0.1	10	<8.6
Uncontrolled	R1	0.37	<0.1	10	<8.6
	R2	0.25	<0.1	9.9	<8.6
	R3	0.23	<0.1	9.8	<8.6
	R4	0.45	<0.1	10	<8.6
			Criteria	25	8

Figure 16 Incremental 24-Hour Average $PM_{2.5}$ GLCs

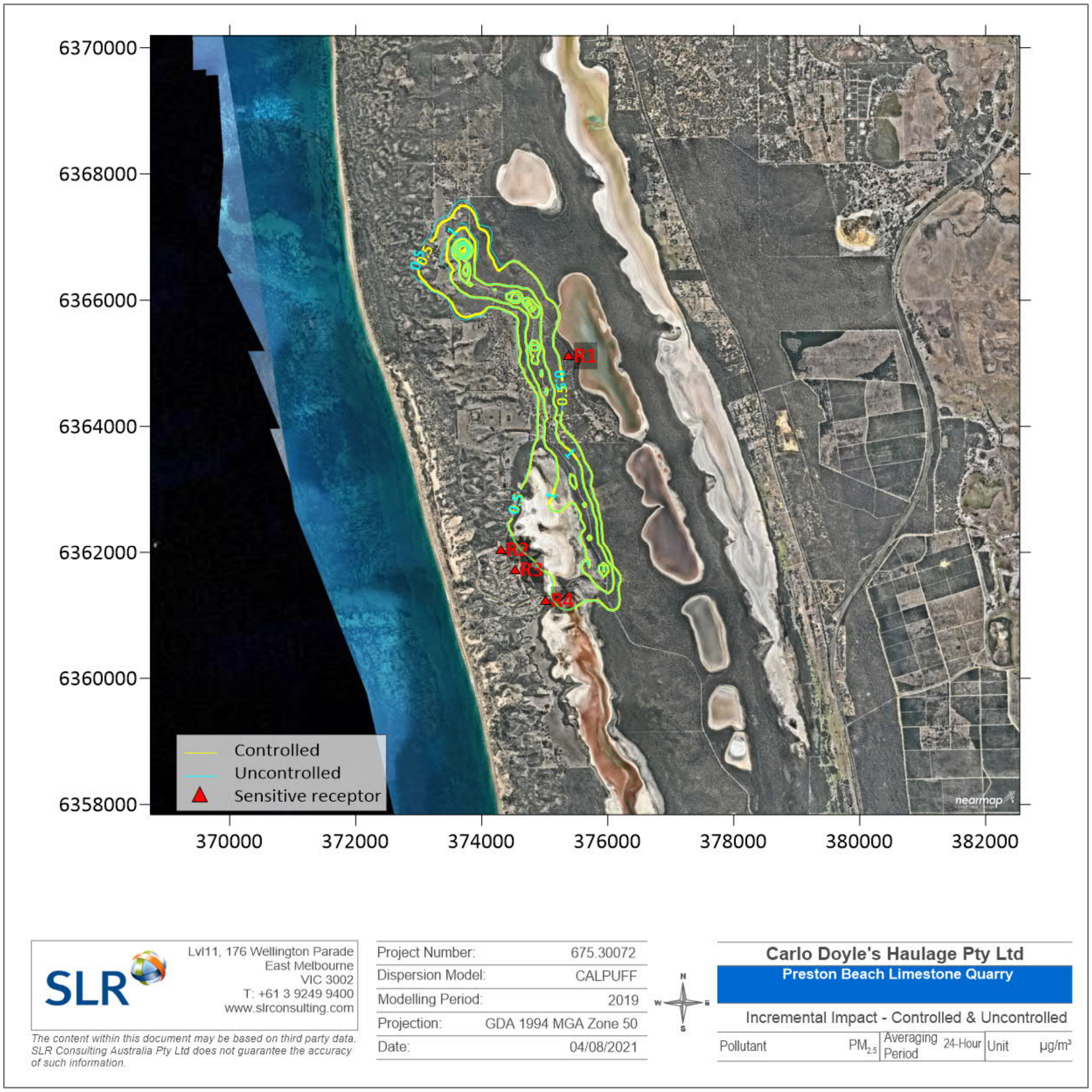
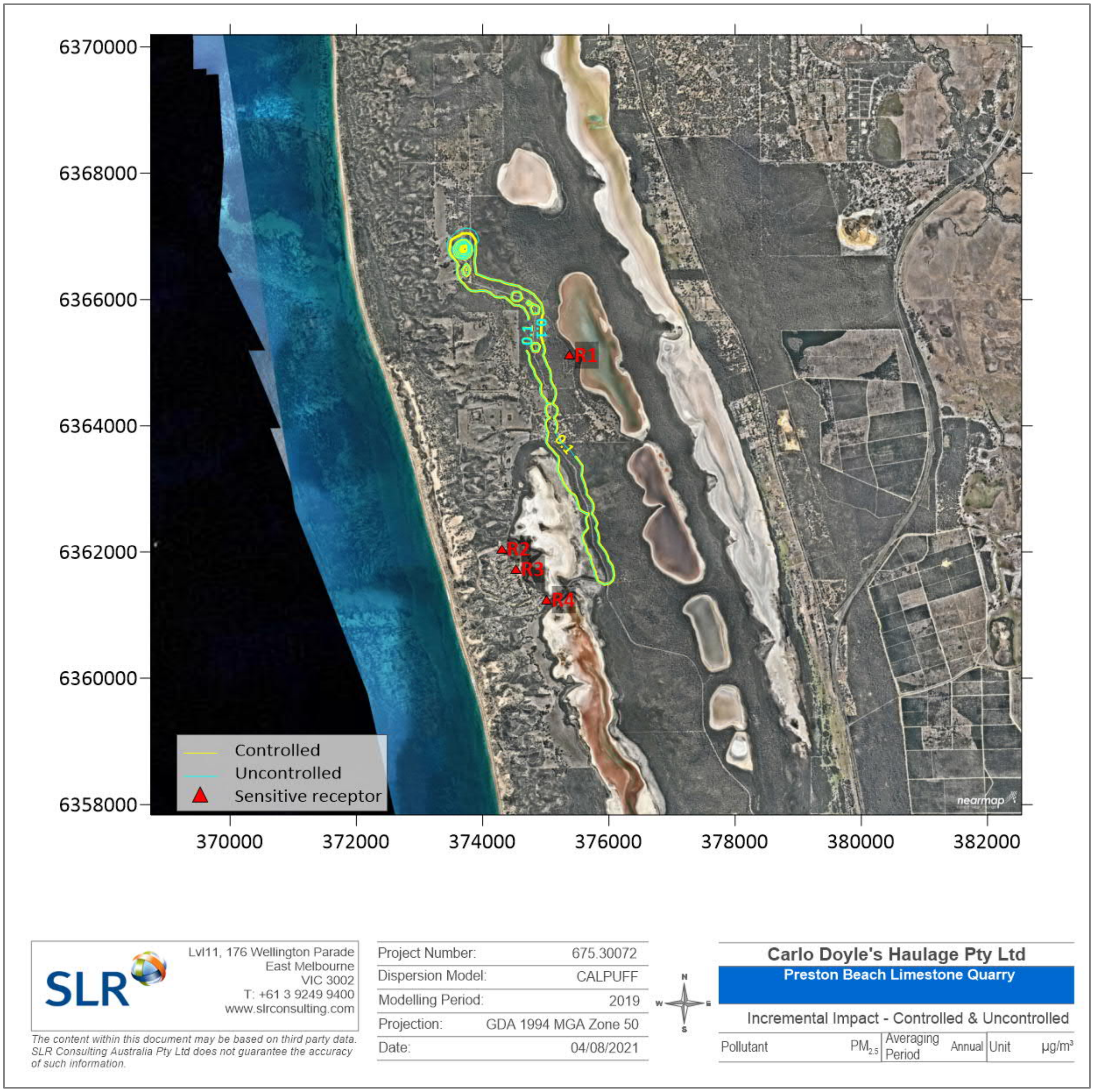


Figure 17 Incremental Annual Average $PM_{2.5}$ GLC



8.3 RCS

The predicted maximum annual average RCS concentrations (as a fraction of $PM_{2.5}$) at discrete receptors are presented in Table 21. The cumulative concentrations include the estimated background concentration (Section 4.4.3) and indicate that there are no exceedances of the criterion. The incremental impacts are predicted to be low relative to the estimated background concentrations and therefore there is unlikely to be any significant elevation in ambient RCS concentrations due to the Proposal.

Table 21 Predicted Incremental and Cumulative Annual Average RCS Concentrations

Scenario	Receptor ID	Increment (µg/m^3)	Cumulative (µg/m^3)
Controlled	R1	<0.1	<0.4
	R2	<0.1	<0.4
	R3	<0.1	<0.4
	R4	<0.1	<0.4
Uncontrolled	R1	<0.1	<0.4
	R2	<0.1	<0.4
	R3	<0.1	<0.4
	R4	<0.1	<0.4
		Criteria	3

8.4 Dust Deposition

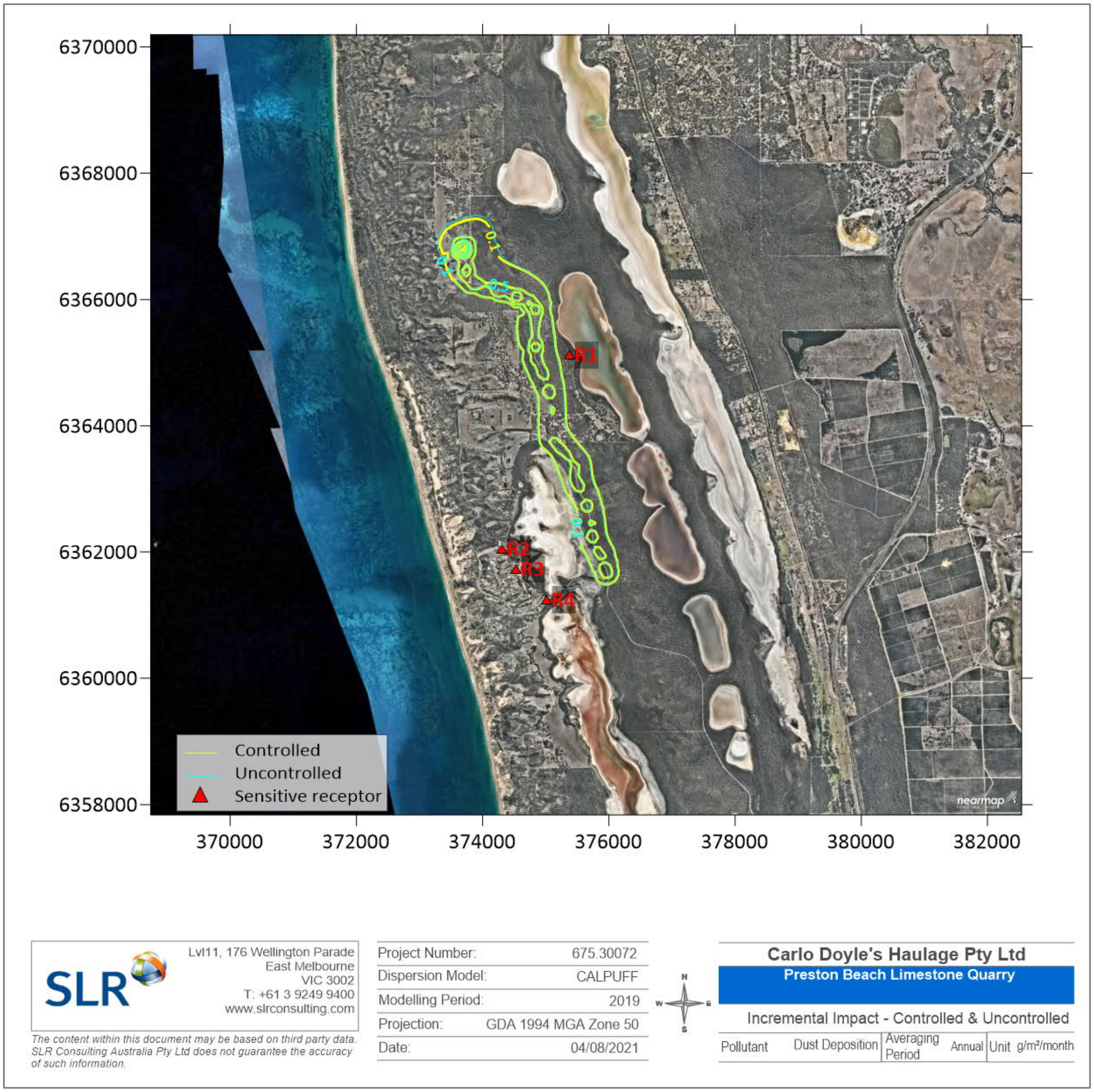
The predicted annual average dust deposition rates at discrete receptors are presented in Table 22 and indicate that there are no exceedances of the criterion. There is unlikely to be any significant dust deposition resulting from the Proposal at the sensitive receptors.

Isopleths of the predicted incremental annual average dust deposition rates for the controlled and uncontrolled scenarios are presented in Figure 18.

Table 22 Predicted Incremental and Cumulative Annual Average RCS Concentrations

Scenario	Receptor ID	Deposition Rate (g/m^2/month)
Controlled	R1	<0.1
	R2	<0.1
	R3	<0.1
	R4	<0.1
Uncontrolled	R1	<0.1
	R2	<0.1
	R3	<0.1
	R4	<0.1
	Criteria	4

Figure 18 Incremental Annual Average Dust Deposition Rate



9 Management and Mitigation

All off-site cumulative 24-hour and annual average ground level PM_{10}, $PM_{2.5}$ and (RCS as $PM_{2.5}$) concentrations are predicted to comply with the adopted criteria at the nearest sensitive receptors, or (as in the case of the annual average $PM_{2.5}$ concentrations) that the incremental impact predicted for the quarry operations is negligible compared to the assumed background levels. Dust deposition rates are also predicted to comply with the criterion at the nearest sensitive receptors.

Due to the distance between the Site and the sensitive receptors, there is negligible difference in the predicted impacts at the sensitive receptors when the Proposal is modelled with and without dust emission controls. Only impacts due to wheel generated dust along Preston Beach Road North are predicted at the sensitive receptors.

Nevertheless, the following management practices are recommended to minimise dust emissions from the Proposal:

- Include methods for the management of dust emissions into site inductions, training and daily toolbox meetings.
- Perform daily inspections of visible dust emissions to identify whether dust is travelling off-site and where the main sources of dust are so that action can be taken to mitigate any impacts (i.e. additional watering etc).
- Site staff should determine the frequency of water cart passes required, based on the following:
  - weather conditions
  - volume of traffic on exposed or dusty surfaces
  - extent of stripped area
  - extent of unprotected areas.
- Reduce dust production on-site by scheduling work into stages to minimise land disturbance in the planning and design stage, including scheduling installation of control measures for dust prevention, while having regard for seasonal dryness.
- Retain as much vegetative screening between the Proposal and the nearest sensitive receptors as possible.
- Limit vehicle movements to designated haulage routes and parking areas.
- Use cattle/shaker grids and wheel wash in order to reduce the tracking of mud off-site if appropriate.
- Keep the areas of land cleared to a minimum, and the period of time areas remain cleared to a minimum.
- Rehabilitate cleared areas promptly.
- Minimise the size of and locate stockpiles in areas that are protected from wind where possible and/or away from sensitive receptors.

In line with good practice for any operations with dust emitting activities, a dust management plan (DMP) should be prepared outlining responsibilities of on-site personnel including employees and manager in minimising generation of dust from any on-site activities.

10 Conclusions

The results of this modelling study concluded the following:

- The prevailing wind conditions during the summer months when the Proposal will be operating are generally from the southern directions meaning the nearest sensitive receptors will rarely be down wind of the Proposal and therefore unlikely to be impacted by dust emissions.
- For the controlled and uncontrolled scenarios, no exceedances of the cumulative 24-hour or annual average PM_{10} guideline are predicted at any off-site receptor. The predicted maximum incremental 24-hour and annual average PM_{10} concentrations at the surrounding sensitive receptors are low compared to the estimated background levels.
- For the controlled and uncontrolled scenarios, no exceedances of the 24-hour average $PM_{2.5}$ guidelines are predicted at any off-site receptor. Exceedances of the annual average $PM_{2.5}$ guideline are predicted at all receptors, however, this is due to the high background concentration adopted for this study, which exceeds the criterion before the Proposal contribution is added. The maximum increment from the proposed operation at the nearest sensitive receptors is less than 0.1 µg/m³, which is approximately 1% of the predicted cumulative concentration and less than 1.3% of the relevant guideline. The likelihood of an exceedance of the annual average $PM_{2.5}$ criterion at the nearest sensitive receptors as a result of emissions from the Proposal is considered very low.
- For the controlled and uncontrolled scenarios, no exceedances of the cumulative 24-hour or annual average RCS guideline are predicted at any off-site receptor. The predicted incremental 24-hour and annual average RCS concentrations at the surrounding sensitive receptors are minimal compared to the estimated background levels.
- For the controlled and uncontrolled scenarios, no exceedances of the dust deposition annual average criterion are predicted at any off-site receptor. The predicted incremental annual average dust deposition rates at the surrounding sensitive receptors are negligible.
- Due to the distance between the Site and the nearest sensitive receptors, only sales truck wheel generated dust from Preston Beach Road North is predicted to marginally impact air quality at the nearest sensitive receptors.

Given that minimal off-site impacts have been predicted at the nearest sensitive receptors, no instrument-based air quality monitoring programs are recommended. In line with DMP requirements regular inspections of visible dust emissions from the Proposal should be performed by site personnel to ensure that mitigation measures are being appropriately implemented, and any complaints received regarding air quality issues appropriately addressed and documented.

11 References

ACARP. (2015). *Development of Australia-Specific PM10 Emission Factors for Coal Mines.* Australian Coal Association Research Program.

Air & Waste Management Association. (2000). *Air Pollution Engineering Manual 1st Edition.*

BoM. (n.d.). *Average annual, monthly and seasonal evaporation*. Retrieved February 8, 2021, from http://www.bom.gov.au/jsp/ncc/climate_averages/evaporation/index.jsp?period=an#maps

DSEWPC. (2012). NPI Emission Estimation Technique Manual for Mining. *Version 3.1*. Australia: Department of Sustainability, Environment, Water, Population and Communities.

DSITIA. (2009). *Mount Cotton Quarry Dust Investigation: December 2008 to December 2009.* Department of Science, Information Technology, Innovation and the Arts.

DWER. (2019). *Guideline: Air Emissions (Draft).* Perth: Department of Water and Environmental Regulation.

EPAV. (2021). *Guideline for assessing and minimising air pollution in Victoria (DRAFT).*

EPAWA. (2016). *Environmental Factor Guideline – Air Quality.* Perth: Environmental Protection Authority Western Australia.

EPAWA. (2018). *Statement of Environmental Principles, Factors and Objectives.* Perth: Environment Protection Authority Western Australia.

NEPC. (2016). *National Environment Protection (Ambient Air Quality) Measure.* Canberra: National Environment Protection Council.

NOAA. (2018, February 14). *National Oceanic and Atmospheric Administration*. Retrieved from Pasquill Stability Classes: https://www.ready.noaa.gov/READYpgclass.php

NSW EPA. (2017, January). *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales.* New South Wales Environment Protection Authority.

Oke, T. R. (2002). *Boundary Layer Climates.* Routledge.

Peters, S., Vermeulen, R., Fritschi, L., Musk, A., Reid, A., & Klerk, N. (2017). Trends in exposure to respirable cristalline silica (1986-2014) in Australian Mining. *American Journal of Industrial Medicine*, 673-678.

SPCC. (1986). *Particle size distributions in dust from open cut coal mines in the Hunter Valley.*

Stacey, P., Butler, O., Thorpe, A., & Roberts, P. (2018). Determination of respirable-sized crystalline silica in different ambient environments in the United Kingdom with a mobile high flow rate sampler utilising porous foams to achieve the required particle size selection. *Atmospheric Environment*, 51-57.

USEPA. (2006 and Updates). *Emission Factors & AP42, Compilation of Air Pollutant Emission Factors.* US Environmental Protection Agency.

APPENDIX A

Variable Emission File Configuration

VARIABLE EMISSION FILE – CALCULATION STEPS

A brief summary of the steps used in calculating the hourly varying emission rates for each source are presented below.

Step 1: Calculate daily/weekly/annual average emission rate (kg/year) for FP, CM and RE

$FP = PM_{2.5}$	(FP) Fine Particulate – particulate of size less than 2.5 µm
$CM = PM_{10} – PM_{2.5}$	(CM) Coarse Particulate – particulate of size between 10 µm and 2.5 µm
$RE = TSP - PM_{10}$	(RE) Rest Particulate – particulate of size greater than 10 µm

Step 2: Identify the operating hours for each activity

Step 3: Classify the sensitivity of each type of activity to wind speed

- Wind insensitive: activities with emission factor that is independent of wind speed (e.g. blasting)
- Wind sensitive: activities with emission factor that is a function of (wind speed/2.2)$^{1.3}$ (e.g. loading (not ACARP))
- Wind erosion: emission from exposed areas/stockpiles

Step 4: Identify the number of sources associated with each activity

Step 5: Calculate the hourly average emission rate for each activity per source

$$FP_{AC,i,h} = \frac{FP_i \times 1000}{N_{days} \times OH_i \times 3600 \times N_{s,i}} \times WSFactor_{i,h}$$

$$CM_{AC,i,h} = \frac{CM_i \times 1000}{N_{days} \times OH_i \times 3600 \times N_{s,i}} \times WSFactor_{i,h}$$

$$RE_{AC,i,h} = \frac{RE_i \times 1000}{N_{days} \times OH_i \times 3600 \times N_{s,i}} \times WSFactor_{i,h}$$

For wind insensitive activities

$$WSFactor_{i,h} = 1$$

For wind sensitive activities

$$WSFactor_{i,h} = \frac{\left(\frac{WS_h}{2.2}\right)^{1.3}}{\frac{\sum_{j=1}^{n}\left(\frac{WS_j}{2.2}\right)^{1.3}}{n}}$$

For wind erosion activities

$$WSFactor_{i,h} = \frac{(WS_h)^3}{\frac{\sum_{j=1}^{n}(WS_j)^3}{n}}$$

Where:

$FP_{AC,i,h}$- Fine particulates emission rate for Activity i (g/s) at hour h
$CM_{AC,i,h}$- Fine particulates emission rate for Activity i (g/s) at hour h
$CM_{AC,i,h}$- Fine particulates emission rate for Activity i (g/s) at hour h
OH_i-daily Operating hours (1- 24) for Activity i
N_{days} -Number of days in the meteorological data file
$N_{s,i}$ -Number of sources associated with Activity i
WS_h-Wind speed at the hour
n -number of hours in the meteorological data file

Note: If the activity was modelled as area source, the equation on the left column of the table needs to be divided by the area of that activity.

Step 6: Calculate hourly average emission rate for each source

To calculate the emission rate for a particular source for a particular hour, add up the calculated emission rate for each activity associated with source. For example, if Source 1 is associated with Activity 1, Activity 2 and Activity 3, then:

- $ER_{S1,h,FP} = FP_{AC,1,h} + FP_{AC,2,h} + FP_{AC,3,h}$
- $ER_{S1,h,CM} = CM_{AC,1,h} + CM_{AC,2,h} + CM_{AC,3,h}$
- $ER_{S1,h,RE} = RE_{AC,1,h} + RE_{AC,2,h} + RE_{AC,3,h}$

ASIA PACIFIC OFFICES

BRISBANE
Level 2, 15 Astor Terrace
Spring Hill QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

CANBERRA
GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

DARWIN
Unit 5, 21 Parap Road
Parap NT 0820
Australia
T: +61 8 8998 0100
F: +61 8 9370 0101

GOLD COAST
Level 2, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516

MACKAY
21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

MELBOURNE
Level 11, 176 Wellington Parade
East Melbourne VIC 3002
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

NEWCASTLE
10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

NEWCASTLE CBD
Suite 2B, 125 Bull Street
Newcastle West NSW 2302
Australia
T: +61 2 4940 0442

PERTH
Ground Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901

SYDNEY
Tenancy 202 Submarine School
Sub Base Platypus
120 High Street
North Sydney NSW 2060
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

TOWNSVILLE
12 Cannan Street
South Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

WOLLONGONG
Level 1, The Central Building
UoW Innovation Campus
North Wollongong NSW 2500
Australia
T: +61 2 4249 1000

AUCKLAND
Level 4, 12 O'Connell Street
Auckland 1010
New Zealand
T: 0800 757 695

NELSON
6/A Cambridge Street
Richmond, Nelson 7020
New Zealand
T: +64 274 898 628