Willatook Wind Farm

Air Quality Assessment

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Willatook Wind Farm Pty Ltd

Jacobs

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Contents

Executive Summary

Willatook Wind Farm Pty Ltd is proposing the development of a new wind farm, to be located between Orford and Hawkesdale in south-west Victoria. Approval being sought for the Proposal includes the construction and operation of a quarry to supply construction materials for the development of up to 59 wind turbine sites.

An air quality impact assessment for the quarry operations has been carried out to support the Environment Effects Statement (EES) for the Proposal. The key objective of the assessment is to address the EES Scoping Requirements (DELWP, 2019) in relation to air quality; specifically, the requirement to assess the potential dust impacts from the proposed on-site quarry. In addition, the assessment of the potential effects of construction, operation and decommissioning activities on air quality associated with the wider wind farm Proposal was undertaken.

Review of the proposed activities for the Willatook Wind Farm (WWF) and expected air quality emissions identified the quarry construction and operation as the most significant source of air emissions and potential air quality impact; the quarry emissions were the focus of the modelling study. The broader activities across the WWF site, outside of the quarry, were not expected to contribute significantly to the overall air emissions, largely due to the relatively short duration and small scale of individual activities, and were therefore considered qualitatively. The emissions across the wider site are expected to be effectively managed using dust mitigations targeted for each specific activity.

The assessment of the pollutants emitted to air due to the quarry activities was based on the use of Victoria's regulatory air dispersion model, AERMOD. The AERMOD predictions of pollutant concentrations were compared with ambient air quality standards to assess the effects that the Proposal may have on the existing air quality environment. The air quality standards applied for the project and the modelling methodology were in accordance with the State Environment Protection Policy (Air Quality Management) (Victoria Government, 2001), and consistent with the Protocol for Environmental Management (PEM) for Mining and Extractive Industries (EPA, 2007). (The PEM is a part of the SEPP AQM). In addition, consideration was given to new legislation which came in to effect on 1 July 2021 as part of the new EP Act (2017). A key component of the new legislation impacting the air quality assessment is EPA's draft *Guideline for assessing and minimising air pollution* (EPA, 2021a). This guideline provides air quality standards for pollutants in ambient air and also refers to requirements under the General Environment Duty (GED), a cornerstone of the new EP Act for the risk management of air quality impacts.

The GED requires risks of harm to human health and the environment from air emission activities to be eliminated so far as reasonably practicable. Where it is not reasonably practicable to eliminate such risks, they are required to reduce them so far as reasonably practicable. For this project, this involved comprehensive assessment of siting of the Project infrastructure in the planning and design process (outside of the current air quality assessment) to minimise the risks to sensitive areas. Dust mitigation measures were developed and included in the modelling assessment; these will be further developed in the site specific dust management plan.

Under the new legislation, the dispersion modelling is used as a tool to assist in understanding air pollution risks. Any model predicted exceedences of pollutant criteria help to identify an unacceptable level of risk; the pollutant criteria do not represent concentrations below which no action is required. It is acknowledged that modelling assessments should not be used to predict real impacts that will occur, but rather the assessment is intended to conservatively estimate the risks to ensure that adequate controls are implemented (EPA, 2021a).

The key air pollutants identified for air quality assessment of the quarry operations are:

- Particulate Matter 10 (PM_{10}); an assessment indicator used for the protection of human health.
- Particulate Matter 2.5 ($PM_{2.5}$); an assessment indicator used for the protection of human health.

Total suspended particulates (TSP) were included in the modelling for the assessment of deposited dust. Assessment of respirable crystalline silica (RCS) was carried out using $PM_{2.5}$ as a proxy indicator, as defined and required by EPA (2007). Emissions estimates were calculated using relevant, published emission factors for mining operations, including the effects of dust mitigation measures. The mitigation measures included watering

of unsealed haul routes within the quarry boundary and the use of water sprays on stockpiles and various quarrying activities. Hourly variable emission files were generated to reflect the intended operating hours for the quarry and to incorporate variable dust emission rates based on wind speeds for wind sensitive emission sources, e.g. wind erosion from exposed areas

The meteorological model input files were generated using local, i.e. site specific, wind observation data combined with prognostic model outputs. The simulated meteorological year, 2018, was selected based on analysis of wind observation data, and air quality monitoring data that best represented a typical year (some years being affected by bushfires etc.).

The dispersion modelling incorporated estimates for background air quality data, selected from EPA's Alphington monitoring station data, to provide the required 'cumulative' assessment. In the absence of site specific monitoring data available for the quarry location, the Alphington station data was considered to provide a conservative representation of background air quality. This was consistent with the assessment carried out for a similar quarry proposal for construction of a wind farm in rural Victoria (Jacobs, 2018).

Under EPA's draft guideline (EPA, 2021a), the air quality standards for pollutants with assessment averaging times of 24 hours or more apply at sensitive receptor sites. The closest receptor site, predicted by the model to experience the highest ambient pollutant levels arising from the quarry operations, is located approximately 1.4 km south east of the quarry boundary. The AERMOD model predicted no exceedences of the project air quality standards at any of the sensitive receptor sites, for all pollutants assessed. However, the model outputs demonstrated that elevated risk, especially for PM_{10} levels, was predicted for some areas beyond the quarry site boundary. These findings highlighted the importance of the implementation of industry standard dust mitigation measures to effectively manage emissions from the quarry operations and to minimise the risk of impact to surrounding sensitive areas. In addition, the provision of a dust management plan, which identifies appropriate and site specific risk controls to reduce risks so far as reasonably practicable, as outlined in the GED, will be important.

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to provide air quality assessment services in accordance with the scope of services set out in the contract between Jacobs and the Client, Willatook Wind Farm P/L (Willatook Wind Farm).

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report using various information sourced from Willatook Wind Farm and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

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This report has been prepared on behalf of, and for the exclusive use of Willatook Wind Farm and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and Willatook Wind Farm. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

Glossary

Abbreviation	Expansion / definition
AG	Australian Government
BESS	Battery Energy Storage System
BoM	Bureau of Meteorology
CEMP	Construction Environmental Management Plan
CO	Carbon monoxide
DELWP	Department of Environment, Land, Water and Planning (State of Victoria)
EES	Environment Effects Statement
EETM	Emissions Estimation Technique Manual
EP Act	Environment Protection Act (2017)
EPA	Environment Protection Authority (Victoria)
g/m^2/month	Grams per metre squared per month
GED	General Environmental Duty
GLC	Ground level concentration
GWh	Gigawatt hours (1 x 10^9 Watt hours)
Jacobs	Jacobs Group (Australia) Pty Ltd
L/m^2/hr	Litres per metre squared per hour
µg/m^3	Micrograms (1 x 10^{-6}) per cubic metre
NEM	National Electricity Market
NEPC	National Environment Protection Council
NEPM	National Environment Protection (Ambient Air Quality) Measure
NOx	Nitrogen oxides (nitric oxide and nitrogen dioxide)
NPI	National Pollution Inventory
PEM	Protocol for Environmental Management: Mining and Extractive Industries
$PM_{2.5}$	Particulate Matter 2.5 – mass concentration of particulate matter comprising particles with aerodynamic diameters less than or equal to 2.5 microns (2.5 µm).
PM_{10}	Particulate Matter 10 – mass concentration of particulate matter comprising particles with aerodynamic diameters less than or equal to 10 microns (10 µm).
RCS	Respirable crystalline silica
RH	Relative humidity
SEPP (AAQ)	State Environment Protection Policy (Ambient Air Quality)
SEPP (AQM)	State Environment Protection Policy (Air Quality Management)
SO_2	Sulphur dioxide
TSP	Total Suspended Particulates – mass concentration of particulate matter comprising particles with aerodynamic diameters less than or equal to approximately 50 microns (50 µm).
USEPA	United States Environmental Protection Agency
VG	Victoria Government
VOC	Volatile organic compound
WS	Wind speed
WWF	Willatook Wind Farm
WTG	Wind turbine generator

1. Introduction

Willatook Wind Farm Pty Ltd is seeking approval for the Willatook Wind Farm (WWF), the Proposal, to be located between Orford and Willatook in south-west Victoria. The Proposal will include construction and operation of a quarry to supply construction materials for the development of up to 59 proposed wind turbine sites.

This Air Quality Impact Assessment was prepared by Jacobs Group (Australia) Pty Ltd (Jacobs) on behalf of Willatook Wind Farm to support the Environment Effects Statement (EES) for the Proposal. The purpose is to address the EES Scoping Requirements in relation to air quality; i.e., (DELWP, 2019)

- *Assess the potential dust impacts from the proposed on-site quarry in accordance with the requirements of EPA Victoria's Protocol for Environmental Management: Mining and Extractive Industries (2007)*

- *Assess the potential effects of construction, operation, and decommissioning activities on air quality.*

The evaluation objective, as set out in the EES Scoping Requirements for amenity (Section 4.5 of DELWP 2019) is:

- *To minimise and manage adverse air quality and noise and vibration effects on residents and local communities as far as practicable during construction, operation and decommissioning having regard to applicable limits, targets or standards.*

Noise and vibration effects are considered elsewhere. The Air Quality Impact Assessment was undertaken in accordance with the *State Environment Protection Policy (Air Quality Management)* (Victoria Government, 2001), and is consistent with the EPA's Protocol for Environmental Management: Mining and Extractive Industries (EPA, 2007). Also, reference was made to EPA's new draft *Guideline for assessing and minimising air pollution in Victoria* (EPA, 2021a). Further, a review of Victoria Government's newly released Environmental Reference Standard (ERS) was undertaken to determine if any changes would be needed to the assessment methodology (VG, 2021). This new VG documentation led to some changes being required to the assessment; details are provided in Section 3.

The main objectives of this assessment were to identify the potential air quality issues and quantify the key potential air quality impacts by air dispersion modelling. The dust emissions from the quarry were the primary focus of the quantitative assessment. A qualitative assessment was undertaken for the effects of the wider wind farm construction, operation and decommissioning activities, i.e. outside of the quarry activities; refer Section 2.2.

The assessment was based on the use of Victoria's regulatory air dispersion model, AERMOD, used in accordance with EPA's guidelines: EPA (2014a) and EPA (2014b), to predict concentrations of substances emitted to air due to the quarry activities. The AERMOD predictions were compared with air quality standards to assess the effects that the Proposal may have on the existing air quality environment.

The structure of this air quality assessment report is by the following sections:

- Project description and air quality – Section 2
- Air quality standards – Section 3
- Existing air environment – Section 4
- Air emissions estimates – Section 5
- Assessment methodology – Section 6
- AERMOD results – Section 7
- Application of GED – Section 8
- Conclusions – Section 9

2. Project Description

2.1 Project Overview

Willatook Wind Farm Pty Ltd are proposing the construction of a new wind farm located between Orford and Hawkesdale in south-west Victoria. The project would include the implementation of up to 59 wind turbines which would operate for at least 25 years for the generation of more than 1,300 gigawatt hours (GWh) of renewable electricity provided to the National Electricity Market (NEM) each year. As part of this project, an on-site quarry would be developed to provide basalt resource for the construction of the wind farm, thereby reducing the need to source material from off site. This quarry construction, the Proposal, would provide approximately 450,000 m^3 of crushed rock product for the road network and for the supply of concrete.

The maximum disturbance area at the quarry is expected to be approximately 24.7 hectares (ha). Quarry activities at the site will include blasting and drilling, excavation works, crushing and screening, hauling of material by trucks and stockpiling of material. It is anticipated that the quarry will undergo significant activity in the early stages of the project as it produces road base material to construct access track infrastructure, then the hard stand areas at each wind turbine tower and will taper off as construction of the towers and associated infrastructure occurs.

The quarry is expected to have an extraction area of around 10 ha, with pit depth of up to 14 metres and approximately 1 million tonnes of basalt product generated over a period of around 2 years.

The layout diagrams for the proposed quarry and for the overall WWF site are provided in Appendix A.

There will be approximately 60 kilometres of access tracks (both new and existing) to provide access from the public road network to each wind turbine and supporting infrastructure. These access tracks provide access for project construction and maintenance vehicles and can be used by emergency vehicles and by landowners for their farming operations. Thirteen project access points are proposed from the Woolsthorpe-Heywood Road, Tarrone North Road, Riordan's Road and Old Dunmore Road to connect to the access tracks.

Other project infrastructure to be installed as part of the construction phase will include:

- A hardstand area at each wind turbine site
- The installation of underground cables connecting all wind turbines to the on-site substation
- A battery energy storage system (BESS) located immediately to the west of the substation
- An operations and maintenance facility consisting of site offices and amenities
- A central temporary construction compound located within the project site, and including office facilities, amenities and car parking
- Three concrete batching plants to supply concrete for the wind turbine foundations, the on-site substation and the BESS
- Four laydown areas for the storage of wind turbine components and other equipment
- The installation of up to three permanent meteorological masts, with associated single-lane access tracks

Overall, the project site encompasses an area of approximately 4,154 hectares of private and public land The construction footprint is expected to represent 5.4% of the total project site.

2.2 Air Quality Issues

The air quality issues described in this section arise when air pollutant emissions from an industry or activity lead to a deterioration in ambient (i.e. outdoor) air quality. Potential air quality issues were identified from a review of activities associated with construction, operation and decommissioning of the proposed WWF, with consideration given to the types of air emissions and the proximity of the activities to sensitive receptors such as residences.

2.2.1 Potential quarry issues

Air emissions from construction and operation of the proposed WWF quarry would be from a variety of activities including material handling, transport, and processing, some blasting, and wind erosion of stockpiles and exposed areas. These would include emissions of very small (inhalable) dust particles known as airborne particulate matter. These emissions will occur for an extended period, i.e. greater than 12 months, will involve intensive material movement, and are expected to represent the most significant source of air quality impact for the wind farm. A quantitative air quality impact assessment was considered warranted and was carried out for the construction and operation of the proposed quarry. The identification, quantification, and impact assessment of air emissions at the quarry are addressed in detail in this assessment report.

Key air quality indicators for assessment of particulate matter are set out in the Victorian Government (VG) State Environment Protection Policy (Air Quality Management) (VG, 2001), the Environment Protection Authority Victoria (EPA) *Protocol for Environmental Management – Mining and Extractive Industries* (EPA, 2007). They are also included in the new legislation under the umbrella of the updated Environment Protection Act 2017 (the EP Act) which was implemented in Victoria on 1 July 2021. These indicators are (see Glossary for more details):

- Particulate Matter 10 (PM_{10}); an assessment indicator used for the protection of human health.
- Particulate Matter 2.5 ($PM_{2.5}$); an assessment indicator used for the protection of human health.

Emissions estimates for Total Suspended Particulates (TSP) are used only to calculate, by modelling, estimates for deposited dust for the purpose of assessment of potential impacts on amenity. Estimates of emission rates for PM_{10}, $PM_{2.5}$ and TSP (for deposited dust) are provided in Section 5.

In addition to the emissions of particulates, there will be air emissions of gases at the quarry site, primarily from the combustion of diesel and blasting of explosives. The largest consumers of diesel at the quarry site during normal operation is expected to be the mobile fleet including heavy moving equipment (haul trucks, excavators, etc.), mobile processing plants, and light mobile equipment (utility vehicles, small trucks, forklifts, etc.). The air emissions from these sources will mainly be nitrogen oxides (NOx), carbon monoxide (CO) and volatile organic compounds (VOCs). Emissions during the blasting operations will be NOx, CO and sulphur dioxide (SO_2).

Due to the relatively small fleet of equipment, and short and periodic nature of the blasting operations, these gas emissions are expected to be insignificant for the proposed quarry site in relation to, for example, the emissions from all road vehicles used in a small town and were not included in the modelling.

To conclude, the key air quality issues identified for the proposed quarry construction and operation were those associated with dust emissions due to equipment use on unpaved roads and exposed working areas, and materials handling. As such the focus of this study was on the assessment of ground level concentrations of PM_{10} and $PM_{2.5}$, and deposited dust.

The procedures and air quality standards set out in VG (2001), EPA (2007) and ERS (2021), and the new draft guideline (EPA, 2021a), relevant to the assessment for the Proposal, are detailed in Section 3.

2.2.2 Potential wider wind farm issues

In addition to the quarry construction and operation, there will be various activities across the broader wind farm project during each of the construction, operation and decommissioning phases which may impact local air quality. The key activities expected to impact air quality for each activity phase are described below.

Construction phase

The construction of the WWF will occur over a period of approximately 24 months. Following the completion of the detailed engineering design, key site establishment activities and subsequent civil works, in addition to establishment and operation of the on-site quarry, will include:

- Delivery of key plant and construction vehicles

- Construction of accessways required for the delivery of materials and goods for construction
- Establishment of temporary concrete batch plants and temporary construction offices
- Construction of the wind turbine generator (WTG) hardstand areas and footing
- Installation of underground cables, installation of on-site substation and battery energy storage system (BESS)
- Maintenance of local road network in consultation with Regional Roads Victoria and the Moyne Shire, in accordance with the Traffic Management Plan

Towards the end of the 2 year construction phase, the following activities will be undertaken:

- Removal of all temporary infrastructure, including the on-site quarry infrastructure and construction compound, from the WWF site
- Rehabilitation of the on-site quarry area and the wider site

For the above activities, the main potential air quality impacts are expected to be:

- Dust generated during civil works, e.g. excavations, loading/unloading material, grading
- Wheel generated dust from unsealed roads; internal accessways will be constructed using compacted crushed rock aggregate. Dust emissions are expected to be highest for areas with the highest amount of traffic, e.g. access points, at the construction/maintenance compounds.
- Dust generated from wind erosion of exposed areas and material stockpiles
- Combustion engine emissions (NOx, VOCs, fine particulates) from mobile vehicles and stationary plant (e.g. power generation)

Importantly, it is anticipated that construction of each of the WTGs and associated infrastructure will occur progressively, i.e. construction will occur at different times for the various locations of the WTGs across the WWF site; refer Appendix A for the layout and extent of the WWF site. The WTG foundations will each have a footprint of approximately 27 x 27 metres, with total hardstand area of 6,500 m^2 for each wind turbine. Construction dust emissions for each site are expected to be significantly less than those for the quarry and will occur over relatively short periods for each site. Similarly, the construction of the on-site substation, battery energy storage system and temporary construction offices will have significantly lower dust emissions compared to the quarry site and will be of short duration.

It is anticipated there will be three concrete batch plants used for the construction of the individual wind turbine sites. The closest to the quarry will be located approximately 2 km north-west of the quarry boundary. The other two will be further away (greater than 4.5 km) to the east and north east. It is expected that the batching plants will be designed and operated to adequately control dust emissions, i.e. as per guidelines set out in EPA publication 1806 for reducing risks in the premixed concrete industry (EPA, 2019b). In terms of the cumulative impact, i.e. contribution to the impact from the quarry emissions, at the sensitive receptor predicted to experience the highest dust impact from quarry operations, the nearest concrete batch plant is 3.4 km from this key sensitive receptor and is unlikely to have any significant impact to ambient air quality at this key receptor location. For the other sensitive receptor locations, where the impact from the quarry operations is expected to be significantly lower, the shortest distance to any of the concrete batch plants is approximately 1.0 km. This is greater than the minimum separation distance of 100 metres for concrete plants under the guideline *Recommended separation distances for industrial residual air emissions* (EPA, 2013) which is applied to minimise off-site impacts arising from unintended, industry-generated dust emissions. Ambient air impact from the concrete batch plants is expected to be negligible as a result of the implementation of effective dust controls and the separation distances.

Operations phase

The operations phase of the project will include the testing and commissioning of the wind farm, following by ongoing operations and maintenance of the facility for the export of electricity. The operational life of the WWF is expected to be 25-30 years. There would be approximately 15 maintenance staff located at the WWF site as part of routine operations, maintenance and repair activities. Light vehicles and small trucks would travel from the site office and maintenance yard to individual WTGs and substation, mostly via internal roads. There may be occasional larger vehicles for the delivery of larger equipment items.

Overall, the emissions during this phase, specifically wheel generated dust from unsealed access roads and vehicle combustion emissions, are expected to be minor and of short duration.

Decommissioning and rehabilitation phase

The decommissioning and rehabilitation phase will be undertaken over a 12 month period and will involve removal of the wind turbines and all other above ground equipment and infrastructure. The wider WWF site will be restored in accordance with the Decommissioning Plan and in consultation with the relevant landowners and regulators. Alternatives to this approach which may be considered closer to the time, and depending on assessment of economic viability, include continuing the operation of the wind farm with potential refurbishment or replacement of the WTGs.

The main air emissions expected for this phase are wheel generated dust from vehicle movements on unsealed roads and combustion engine emissions, e.g. from transport vehicles, and the use of large equipment at site including cranes, excavators and graders. These emissions are expected to be minor compared to the construction and operation of the quarry.

Summary of wider wind farm issues

In conclusion, the emissions from the activities across the broader wind farm, outside of the quarry activities, are not expected to be significant contributors to the overall dust impact for the WWF; the focus of the assessment are the emissions from the quarry construction and operation. Imperative to the effective management of dust impact on site for all wind farm activities will be the implementation of the Construction Environmental Management Plan (CEMP) which will specifically address air quality emissions and mitigations. This document should align with the EPA publications:

- *Mining and quarrying – Guide to preventing harm to people and the environment* (EPA, 2021b)
- *Civil construction, building and demolition guide (EPA, 2020b)*

and requirements of the new Environment Protection Act 2017 (EP Act); refer Section 3.2 and Section 8.

Dust management and mitigations

Key dust mitigations to be incorporated in the dust management plan, a subset of the CEMP, and applicable to the winder wind farm area (as well as the quarry site) are shown in Table 2-1. In the generation of the plan, the overarching approach should be to prevent the generation of dust in the first instance, i.e. in lieu of applying dust suppression measures. For example, avoiding the installation of a stockpile where possible to minimise dust generation. This is consistent with the EP Act hierarchy of control as part of the GED requirements. Where prevention is not practicable, site-specific, best practice design controls and management practices should be implemented to minimise dust.

In addition to setting out the specific activity based mitigation measures in Table 2-1, the dust mitigation plan would include:

- Requirements to schedule dust generating activities by avoiding adverse weather conditions, such as during hot and dry periods, high winds and days with poor air quality

- Regular visual monitoring of dust, with results recorded in a dust management database
- Regular monitoring of the effectiveness of dust control measures. If dust controls are found to be ineffective, these would be reviewed (internally and / or by an external dust specialist, if required) and amended as necessary
- Any non-compliances with the Environmental Reference Standard relevant to the project would be reported to EPA Victoria and corrective action taken where necessary
- Dust management training would be undertaken for construction workforce as part of the site-specific induction, outlining controls to be implemented during construction to manage potential air quality impacts
- Procedures for monitoring of weather (e.g., wind speed, wind direction) and triggers to adjust or temporarily cease dust generating activities
- Monitoring of forecast and real time local wind parameters (e.g. wind speed, wind direction) and adjustment or temporary cessation of dust generating activities, as required, to reduce impact to sensitive receptors
- Complaint investigation and response plan.

Table 2-1: Summary of dust mitigation measures

Dust generating activity	Dust mitigation measure
General dust controls	Ensure the area of cleared land is minimised during the drier months of the year, when potential for dust generation is at its greatest.
	Rehabilitate and revegetate inactive stockpiles and disturbed areas to reduce wind erosion.
	Use water sprays to reduce wind erosion from exposed areas, i.e. in addition to unsealed haul roads and access tracks.
	If additives in the water are used to increase its dust suppression properties, the chemical should have no adverse environmental impacts.
	Ensure that smooth surfaces are deep ripped and left rough and cloddy to reduce the wind velocity at the soil surface.
	Construct wind fences wherever appropriate, e.g. install shade cloth as a wind break.
	Suppress dust during concrete cutting and construction and demolition activities
Haul/access roads, material handling and transport	Use stabilised materials in high traffic areas.
	Implement watering of unsealed haul roads and access tracks to reduce wheel generated dust. The frequency of watering will be determined by weather conditions and the erodibility of the soil. Ideally, watering rates will be greater than 2 $L/m^2/hr$ to maximise dust suppression. Particular attention is to be paid to minimising dust by water application at higher traffic areas, e.g. site access points, at construction/maintenance compound sites.
	Vehicle movements restricted to defined areas
	Minimise traffic speed and movement during dry and warm conditions.
	Use wheel wash facility to minimise transfer of dusts from site

Dust generating activity	Dust mitigation measure
	Minimise drop height for unloading operations
	Use water sprays for material transfer operations
Management of stockpiles and batters	Minimise the number of stockpiles, and the area and the time stockpiles are exposed.
	Locate stockpiles where they will be least susceptible to wind erosion.
	Construct the stockpile with no slope greater than 2:1 (horizontal to vertical). A less steep slope may be required where the erosion risk is high.
	Stabilise stockpiles and batters that will remain bare for more than 28 days by covering with mulch or anchored fabrics or seeding with sterile grass.
	Use water sprays to suppress dust on stockpiles and batters.
	Finish and contour any stockpiles located on a floodplain so as to minimise loss of material in a flood or rainfall event.
Equipment and infrastructure	Select equipment, e.g. concrete batching plants, which have integrated best practice dust control features.
	Design and operation of concrete batching plants to adequately control dust emissions, as per guidelines set out in EPA publication 1806 – *Reducing risk in the premixed concrete industry* (EPA, 2019b)
	Use on-tool dust extraction and/or enclosures on equipment during construction activities such as rock breaking and drilling.

Importantly, and as outlined in EPA (2020c), air quality impact risks from dust are to be managed such that risks of harm to people or the environment are eliminated or reduced as far as reasonably practicable. This means that proportionate controls must be used to mitigate or minimise the risk of harm. This is to be documented to demonstrate consideration of available options and selection of suitable controls.

3. Air Quality Standards

3.1 Overview

This section reviews Victoria's ambient air quality standards relevant to the Proposal and sets out the standards used for assessment.

3.2 Victorian Policy and Guidelines

The policies and guidelines which are used to evaluate air quality impacts are in a transition phase, with the new Environment Protection Act 2017 (EP Act) and subordinate legislation recently coming into effect (1 July 2021). Currently, air quality in Victoria is evaluated using processes and criteria set out in Victoria's State Environment Protection Policy (Ambient Air Quality) (VG, 1999; VG, 2016) and VG (2001). The current and new legislation relevant to the air quality assessment for this Project are described below.

3.2.1 Current legislation

Victoria's State Environment Protection Policy (Ambient Air Quality) (VG, 1999; VG, 2016), sets out ambient air quality standards for 'criteria' air pollutants. These were based on national standards set by the National Environment Protection Council of Australia (NEPC) as part of the National Environment Protection (Ambient Air Quality) Measure (NEPM) (NEPC, 2016). It is noted a new NEPM was registered on 26 May 2021, but with no changes to the standards for particulate matter (NEPC, 2021).

The EPA has established a network of monitoring stations across Victoria, with annual reports testing the state's compliance with the air quality standards. The NEPM has recently been updated however there are no changes to the standards for PM_{10} and $PM_{2.5}$.

VG (2001) sets out design criteria for many air pollutants for use in modelling assessments, including for the indicators PM_{10} and $PM_{2.5}$. However, the design criteria for PM_{10} and $PM_{2.5}$ are specified for point sources, which are not applicable to dust emissions sources identified for this Proposal. In this case the EPA (2007) guidance must be used, EPA (2007) being a part of VG (2001).

While VG (1999) and VG (2016) are not intended to be used for modelling assessments, review of EPA (2007) indicates there is potential for the new PM_{10} and $PM_{2.5}$ standards set out in VG (2016) to apply to this Proposal. As such, under current legislation, the VG (2016) objectives for particulate matter and the EPA (2007) maxima for deposited dust would be appropriate standards for this assessment.

In addition to VG (1999) and VG (2016), an environment effects statement (EES) is to be provided for the Project. Assessment of air quality is identified as a requirement to be addressed under 'Amenity'. Specifically, the EES scoping document (DELWP, 2019) outlines the requirement for assessment of potential dust impacts from the proposed on-site quarry in accordance with EPA (2007).

The former guideline *Best Practice Environmental Guidelines for Major Construction Sites* (EPA, 1996) was replaced by the Civil Construction, Building and Demolition Guide (EPA, 2020b) in November 2020. This new guideline provides information regarding activities which may lead to the generation of dust and potential impacts. It outlines controls that can be implemented to minimise the generation and transport of dust.

Also relevant to the quarry Proposal is the EPA publication *Mining and quarrying – Guide to preventing harm to people and the environment* (EPA, 2021b). This guide outlines how to manage risks, and requirements under the general environment duty (GED), and addresses managing risks from dust. The *Dust Management Guideline* prepared by the Construction Material Processors Association (CMPA, 2016) provides practical guidelines, including various mitigation options, for the effective management of airborne dust arising from extractive industries.

Finally, the Mineral Resources (Sustainable Development) (Mineral Industries) Regulations 2019 (VG, 2019) under the Mineral Resources (Sustainable Development) Act 1990, set out the requirements relating to declared mines including royalties, fees, setting out of licence areas, and infringement offences.

3.2.2 New legislation to be implemented 1 July 2021

The new EP Act incorporates legislation which focusses on preventing waste and pollution impacts, rather than managing the impacts after they have occurred. The cornerstone of the new EP Act is the GED. The GED requires anyone engaging in any activity that poses risks of harm to human health or the environment from pollution or waste to minimise those risks, so far as reasonably practicable. This requires such risks to either be eliminated, or if it is not reasonably practicable to eliminate such risks, to be reduced so far as reasonably practicable.

The EP Act's environment protection framework includes the new ERS, (VG, 2021). These identify environmental values, air indicators and objectives that set the benchmark for the quality of the air environment needed to protect the environmental values. The ERS is a reference standard, not a compliance standard for business. The ERS, combined with a new guideline released by EPA (2021), will replace the SEPP (AQM) and generally adopts the objectives in the NEPM (AAQ) with some modifications. It is noted the (national) NEPM (AAQ) was updated on the same day as VG's ERS was published (26th May 2021), and the expectation is the ERS ambient air quality standards will now be updated to reflect the new NEPM standards. However no further changes are anticipated that would affect the outcomes of this assessment.

EPA's draft *Guideline for assessing and minimising air pollution* (EPA, 2021a) was released for comment in May 2021. This presents air quality assessment criteria for the assessment and management of air emissions. The criteria will supercede those in VG (2001) and EPA (2007). For dust assessment, the criteria in the guideline for PM_{10} and $PM_{2.5}$ refer to the ERS. These values are the same as those for the recently issued NEPM (AAQ) (AG, 2021) with the exception of the annual PM_{10} standard of 25 µg/m^3 compared to the ERS standard of 20 µg/m^3. For pollutants with averaging times of 24 hours or greater, which is applicable for the current dust assessment, the guideline criteria apply at discrete sensitive receptors.

Under the draft guideline, dispersion modelling and monitoring of deposited dust are not supported by EPA as tools to demonstrate that risk of dust is acceptable. However, these tools are identified in the guideline as being able to provide useful information to characterise temporal or spatial trends and identify key sources, sensitive receptors and appropriate risk control measures. The guideline will be finalised and published in late 2021. The new EP Act and the draft guideline (EPA, 2021a) were released after the initiation of the air quality assessment for the wind farm project, and before its completion.

3.2.3 Project Assessment Standards

The current and proposed legislation as detailed in the above sections has been used to compile the air quality standards suitable for the Project air quality assessment. The general approach applied was to adopt the lowest, i.e. most conservative, assessment standards from current and new legislation. These standards are presented in Table 3-1.

Table 3-1: Air Quality Standards Relevant for Assessment

Substance/Indicator	Averaging Time	Standard (Maximum)#	Reference
PM_{10}	24 hours	50 µg/m^3	ERS (VG, 2021)
	Annual	20 µg/m^3	ERS (VG, 2021)
$PM_{2.5}$*	24 hours	25 µg/m^3	ERS (VG, 2021)
	Annual	8 µg/m^3	ERS (VG, 2021)
Respirable crystalline silica	Annual	3 µg/m^3	EPA (2021)
Deposited dust	Monthly	2.0 g/m^2/month (maximum)	EPA (2007)
	Monthly	4.0 g/m^2/month (max. total including background)	EPA (2007)

'Maximum' means no model-predicted exceedences are allowed.
*Modelling assessment based on current values of $PM_{2.5}$ standards. In 2025 these will be reduced to 20 µg/m^3 (maximum 24-hour average) and 7 µg/m^3 (annual average).

The modelling assessment determined the potential for air quality impacts due to the Proposal by the level of compliance with the standards listed in Table 3-1. These standards apply to sensitive receptors such as residences, schools, and hospitals (EPA, 2021a; EPA, 2007). The standards relate to total air pollutant concentrations; i.e., including background (non-Proposal) levels.

4. Existing Environment

4.1 Overview

This section reviews the local meteorology and existing air quality of the study area for the Proposal. The review considers meteorological and air quality data from a variety of sources. The objectives were to identify any existing air quality issues and the meteorological conditions that influence local air quality.

4.2 Geographical Setting

4.2.1 Site Location

The proposed WWF is located in a rural district in south-west Victoria, between Orford and Hawkesdale townships. It is approximately 250 km west of Melbourne and approximately 22 km north north-west of Port Fairy.

The location of the wind farm area (light blue region) and the quarry area (orange boundary within the wind farm region) is shown in the processed Google Earth image shown in Figure 4-1.

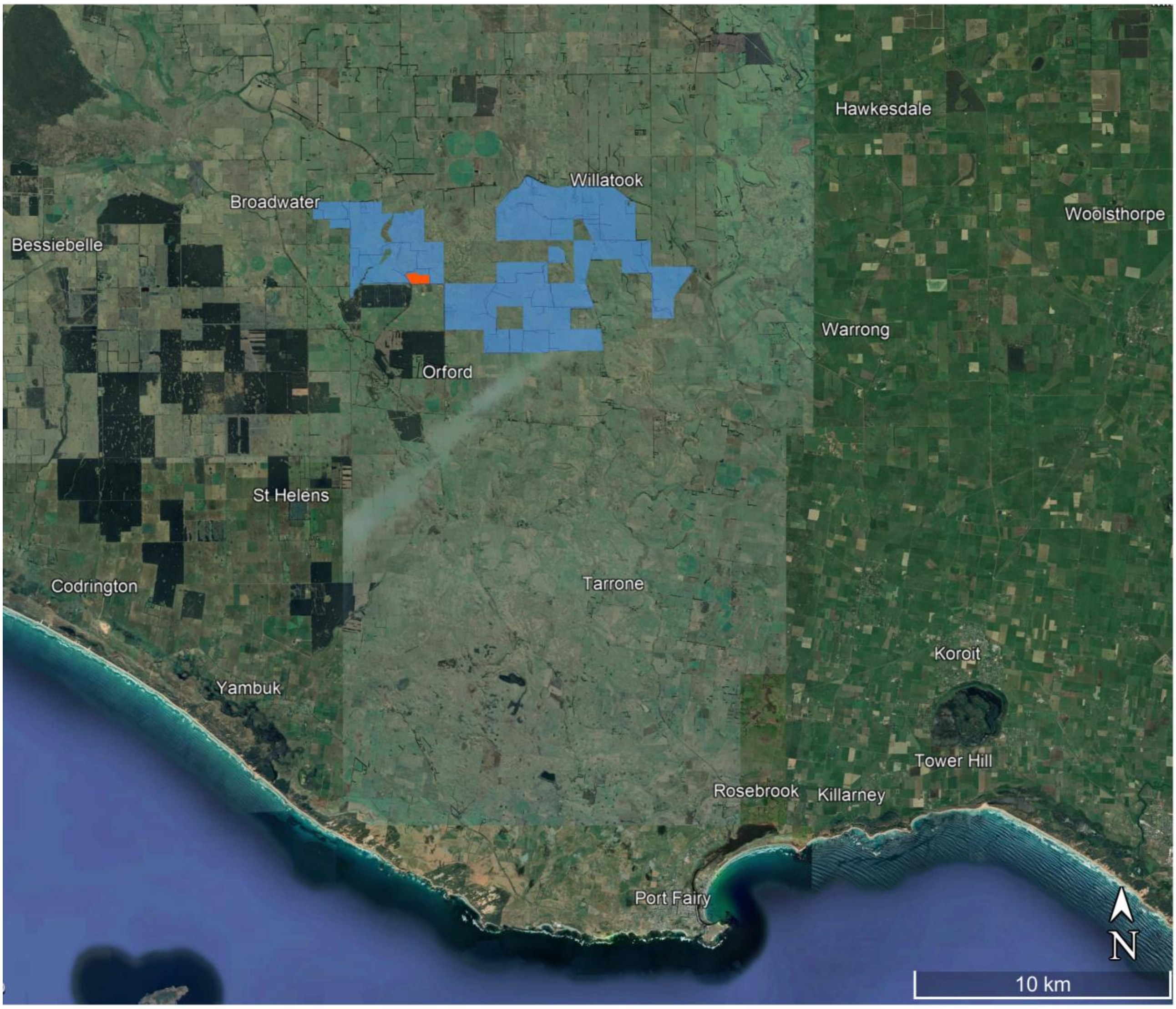


Figure 4-1: Proposed WWF location

4.2.2 Topography and Sensitive Receptors

The quarry and surrounding areas are relatively flat, with elevations varying between 60 and 125 metres above sea level across the study domain; refer Figure 4-2. In relation to the proposed quarry area, there are some slightly elevated areas approximately 4 km north-west of the site, with some depressions to the south of the site. These are not considered to have a significant impact on the air quality assessment.

The nearest sensitive receptor site (pink triangles in Figure 4-2) to the quarry is located approximately 1.4 km south-east of the quarry boundary. This is an isolated residential dwelling and a participating land owner. This distance is greater than the minimum separation distance of 500 metres for a quarry (with blasting) under the guideline *Recommended separation distances for industrial residual air emissions* (EPA, 2013) which is applied to minimise off-site impacts arising from unintended, industry-generated dust emissions.

There are several other isolated sensitive receptor sites, all being residential properties, especially along the Hamilton-Port Fairy Road approximately 3 km south-west of the quarry site, and along Woolsthorpe-Heywood Road approximately 3 km north of the quarry site.

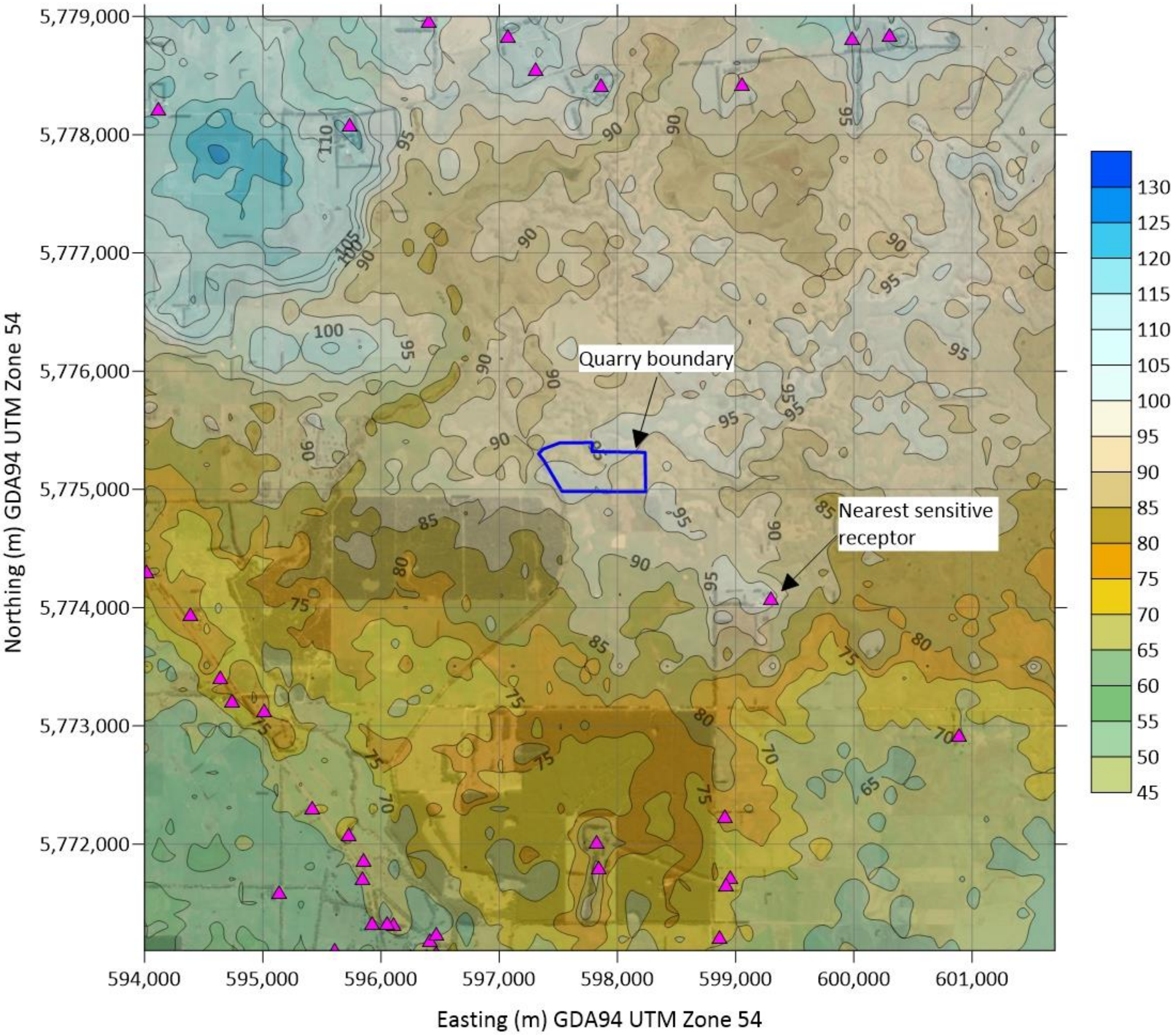


Figure 4-2: Terrain elevations (metres) above sea level for study domain

4.2.3 Land Use

The proposed wind farm site and surrounding area is predominantly cleared land used for cattle and sheep farming although some of the properties are also used for dairy farming and cropping. There are large areas of forest plantations located to the south-west of the wind farm, which can be seen on Figure 4-1. There are various small water bodies within the study area, including Shaw River located to the west of the quarry site and Cockatoo Swamp to the north.

Significant transport routes in the region are the Hamilton-Port Fairy Road to the west and Woolsthorpe-Heywood Road to the north of the study domain.

There are no other significant industries within the vicinity of the proposed quarry site that would affect local air quality. The Holcim Tarrone quarry is located approximately 11 km south east of the quarry site and is not expected to have any significant effects on sensitive receptors in the study area at the same time as effects due to the proposed quarry.

Air quality in the study area is expected to be affected primarily by emissions from fires, wind-blown dusts due to forestry and agricultural activity, vehicles on unpaved roads (such as Old Dunmore Rd to the west of the proposed quarry site and Riordans Road to the south), and wind erosion of exposed soils.

4.3 Local Meteorology

4.3.1 Overview

For air quality assessments, meteorological conditions are crucially important for determining the direction and rate at which air pollutant emissions from a source will disperse. Typically, meteorological parameters used for modelling assessments include: wind speed and wind direction, temperature, humidity, rainfall, atmospheric stability, and mixing (or boundary) layer height. This section provides climatological summaries of local conditions representative of the WWF site, based on the nearest representative, long-term, Bureau of Meteorology (BoM) observations as well as local wind observations collected near the proposed wind farm location.

The closest weather station to the proposed wind farm location is the Warrnambool Airport NDB, approximately 33 km south east of the quarry location and 8 km from the coast. This station is located close to the coast and is expected to be heavily influenced by coastal effects (e.g. sea breezes). The nearest inland weather station is the Mortlake Racecourse (BoM station number 090176, latitude 38.07° south, longitude 142.77° east, elevation 130m above mean sea level). Mortlake Racecourse is located approximately 58 km east north-east of the quarry site; refer Figure 4-3. The similar land use and terrain means Mortlake Racecourse climatology should be reasonably representative of the quarry site. Differences would include, for example, sea breezes being weaker and arriving later at Mortlake.

Wind speed and wind direction monitoring data are collected at the proposed wind farm site by a station located approximately 5 km east of the quarry and approximately 20 km north of the coast; refer Figure 4-3. To assess the validity of this observation data, comparisons with the long term Mortlake Racecourse and Warrnambool Airport NBD is provided in Section 4.3.4.

Figure 4-3: Quarry location relative to Mortlake Racecourse and Warrnambool Airport NDB weather stations

4.3.2 Temperature

Monthly means for daily minimum and maximum temperatures for BoM Mortlake Racecourse over 1991-2021 are shown in Figure 4-4. These temperature statistics are expected to be similar for the Willatook quarry site.

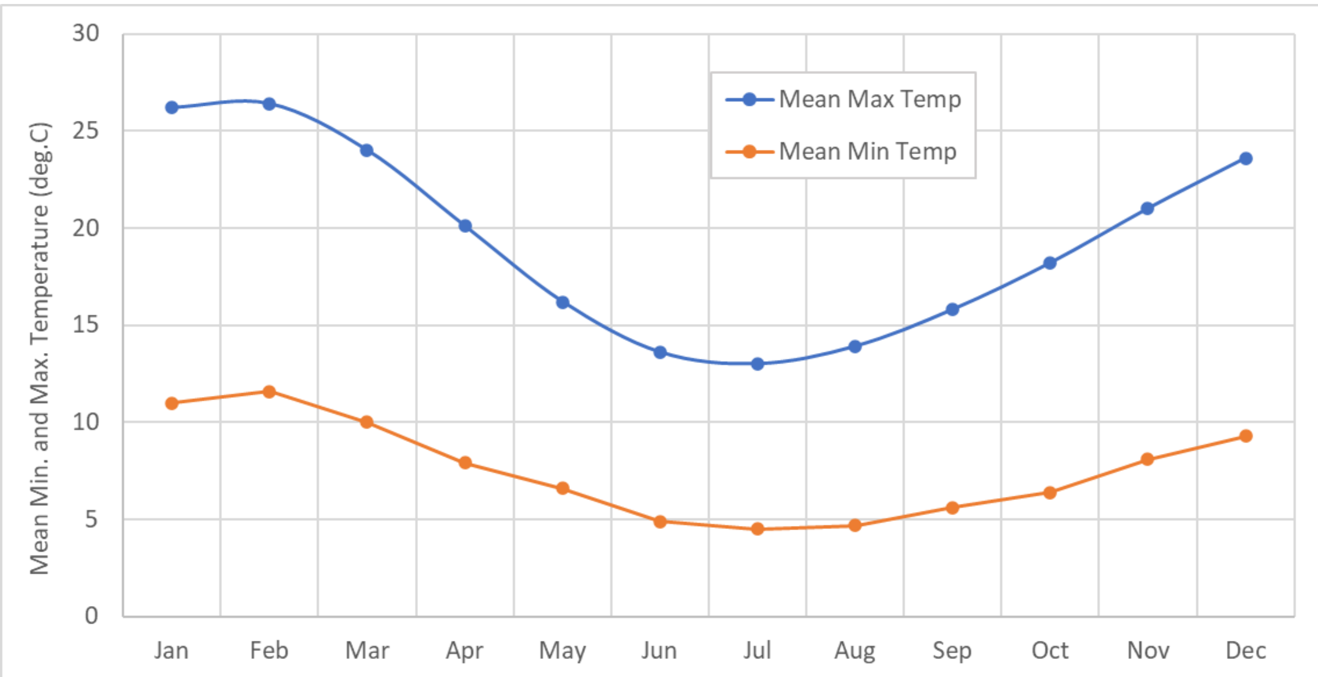


Figure 4-4: Mean minimum and maximum temperatures – Mortlake Racecourse 1991-2021

4.3.3 Rainfall and Humidity

Monthly mean 9am and 3pm relative humidity (%) for BoM Mortlake Racecourse over 1991-2010 are shown in Figure 4-5. The Willatook quarry's relative humidity statistics are expected to be slightly higher than Mortlake's given the shorter distance from the coast. Monthly mean and highest rainfall (millimetres) for Mortlake Racecourse over 1994-2021 are shown in Figure 4-6.

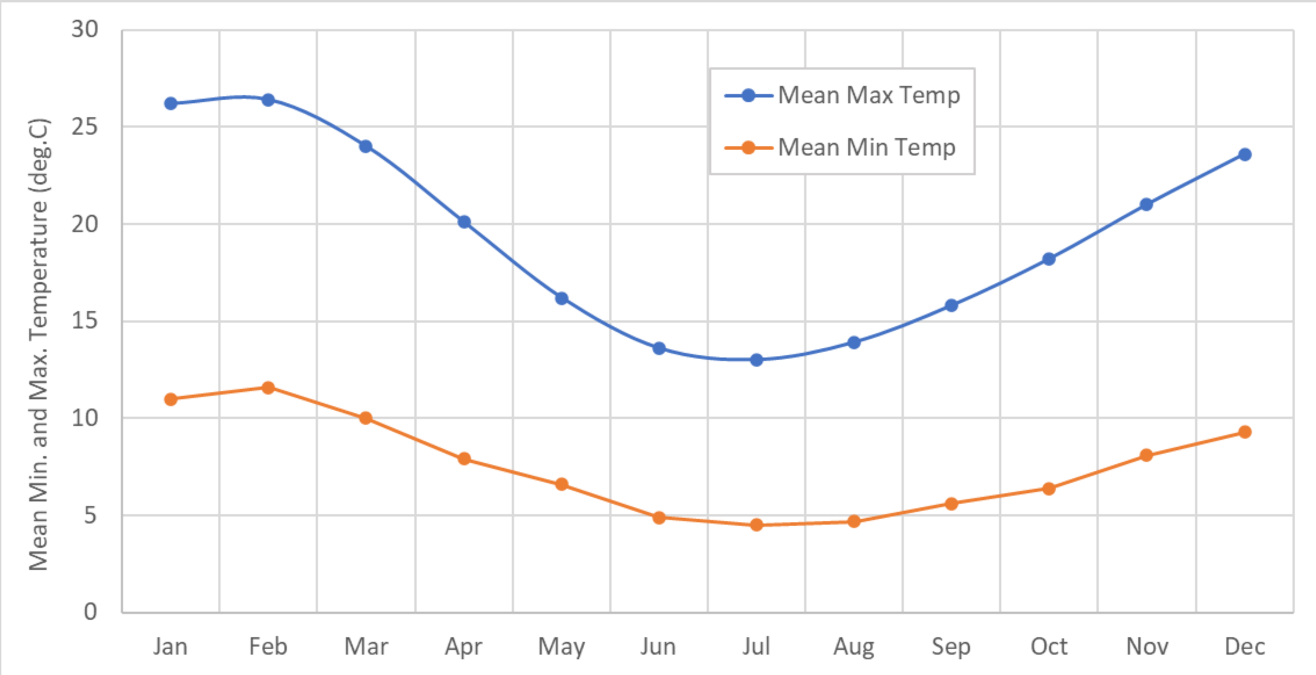


Figure 4-5: Mean 9am and 3pm relative humidity – Mortlake Racecourse 1991-2010

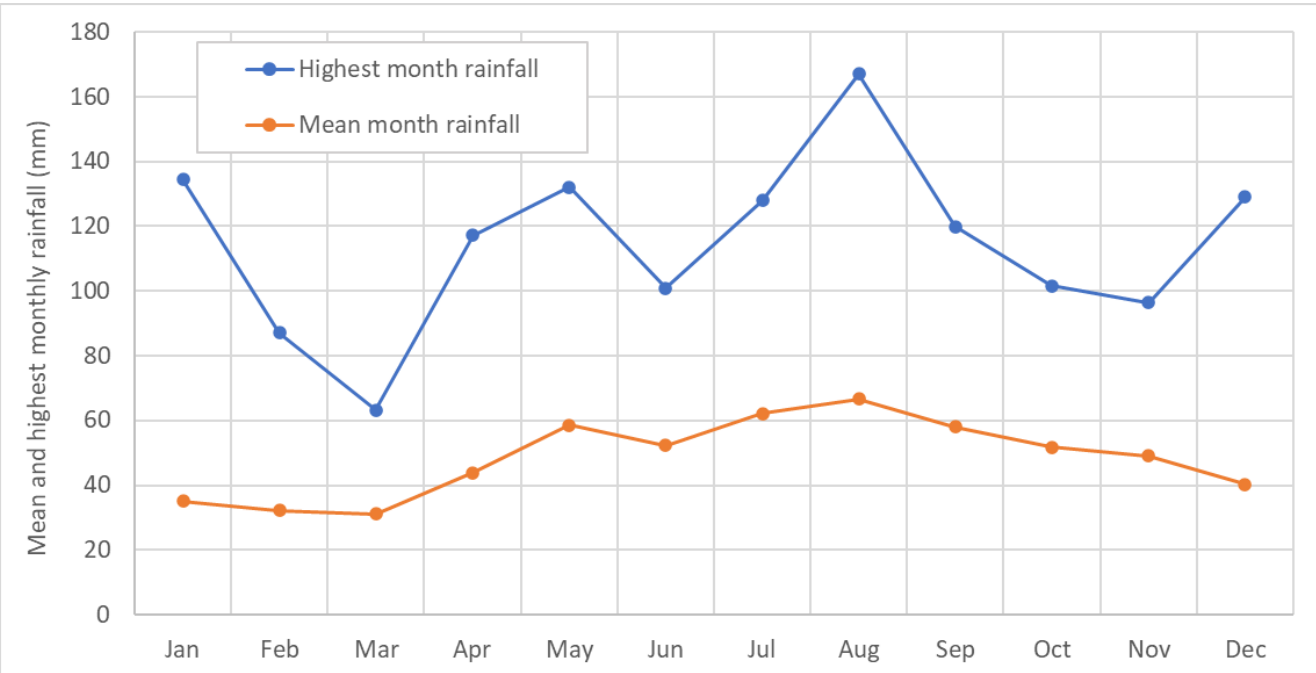


Figure 4-6: Mean and highest monthly rainfall – Mortlake Racecourse 1994-2021

4.3.4 Wind Parameters

Monthly mean wind speed (m/s; 2003-2021) and maximum wind gusts (m/s; 2003-2021) for BoM Mortlake Racecourse are shown in Figure 4-7. The annual average wind speed was 3.9 m/s (2003 – 2021). Wind speeds could be expected to be slightly higher at the quarry site due to it being slightly closer to the coast.

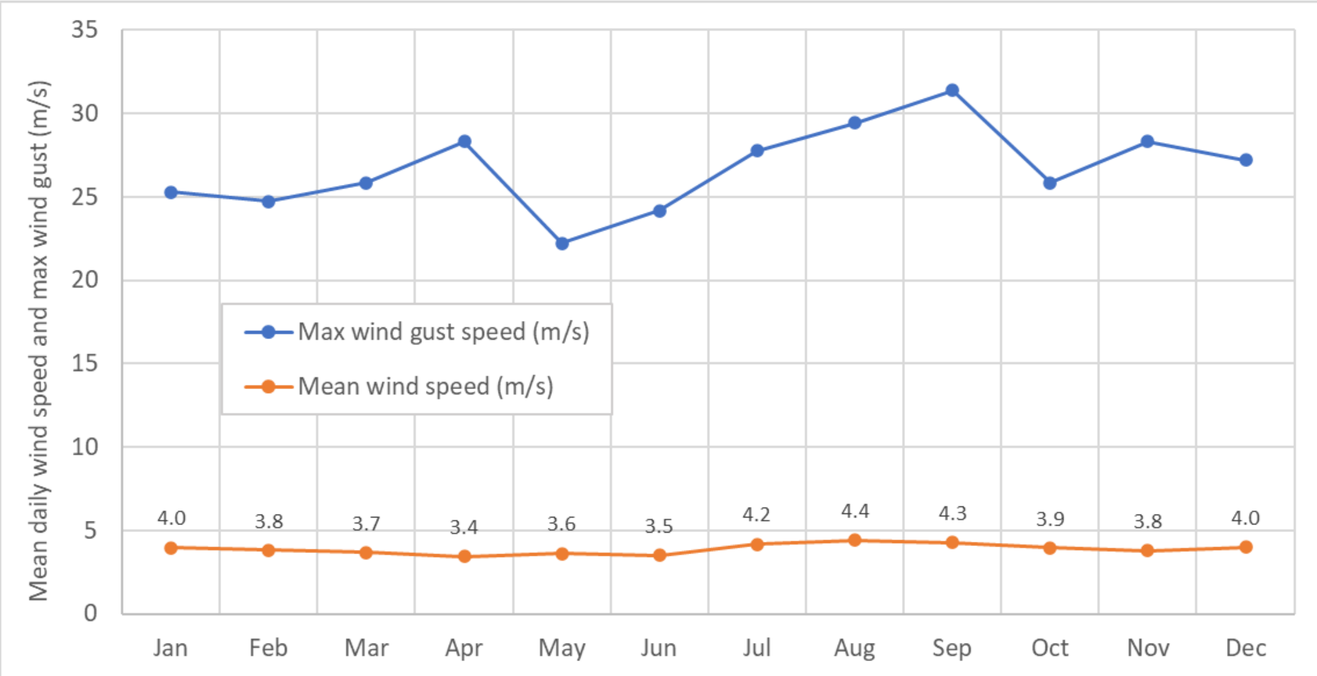


Figure 4-7: Mean wind speed and maximum wind gusts – Mortlake Racecourse 2003-2021

To assess the validity of the local observation data collected at the proposed wind farm site, for the purposes of meteorological modelling, comparisons have been made with the long term wind parameters for each of the BoM stations: Mortlake Racecourse and Warrnambool Airport NDB. Comparisons were made with the local observation data for model year 2018 (refer Section 6.3). A summary of the wind pattern comparison is provided in Figure 4-8 and the wind speeds in Table 4-1. The following conclusions are made:

- The long term wind patterns for Warrnambool Airport NDB and Mortlake Racecourse are similar at 9am. However, at 3 pm, stronger and more frequent southerly winds are observed at Warrnambool. This is likely to include a sea breeze component given Warrnambool's proximity to the coast.
- The local wind farm area wind pattern at 9 am is similar to that of the BoM stations, however has more frequent north westerly winds. This is comparable with Warrnambool's long term wind pattern and suggests the WWF area experiences similar patterns as Warrnambool in the mornings. This is reasonable as the 9 am wind patterns are generally reflective of synoptic effects, whereas the 3 pm observations are often influenced by surface effects, e.g. sea breezes.
- The 3 pm wind pattern for the local wind farm area aligns more closely with the Mortlake Racecourse BoM long term data, with a high frequency of south westerly winds at this time. This is expected due to the influence of surface effects in the afternoon, as discussed above.
- The average wind speeds measured at the wind farm location align more closely with the Warrnambool Airport NBD BoM long term data, than for the Mortlake Racecourse station. This suggests the quarry area is influenced by coastal wind effects.
- Overall, comparison of the wind farm wind observation data for 2018 with the data from the closest BoM stations indicates that the local observation data is comparable with the long term wind speeds and patterns and is suitable for input to the meteorological modelling (see Section 6.3).

Table 4-1: Comparison of wind speeds at BoM stations and local wind farm area observations

Monitoring location	9 am average wind speed (m/s)	3 pm average wind speed (m/s)	Annual average wind speed (m/s)
Mortlake Racecourse BoM, 1991-2010	4.7	6.1	3.9
Warrnambool Airport NDB BoM, 1998-2010	5.3	6.9	4.7
Local wind farm area observations, 2018	5.7	6.7	5.2

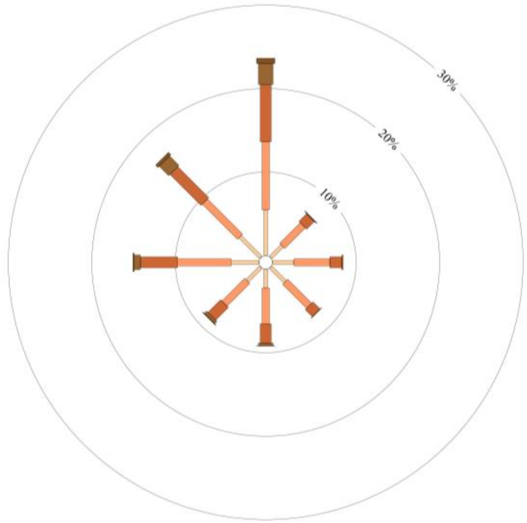
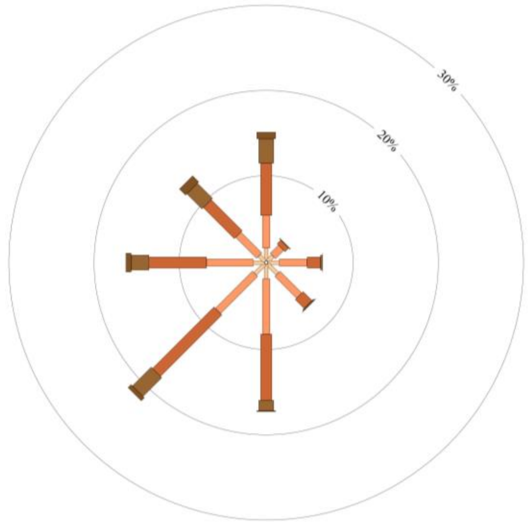
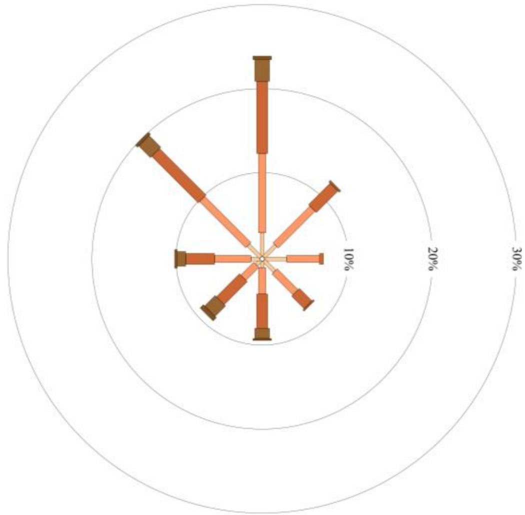
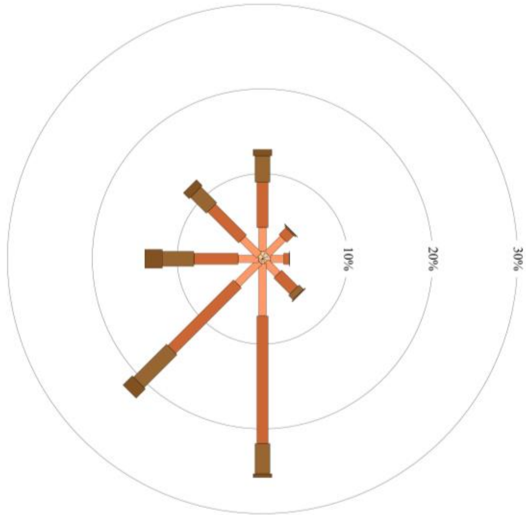
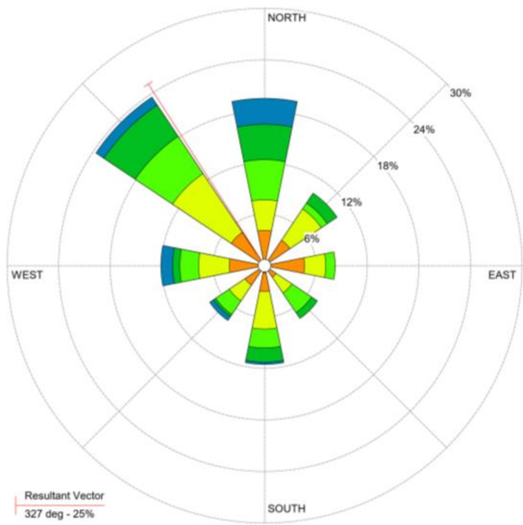
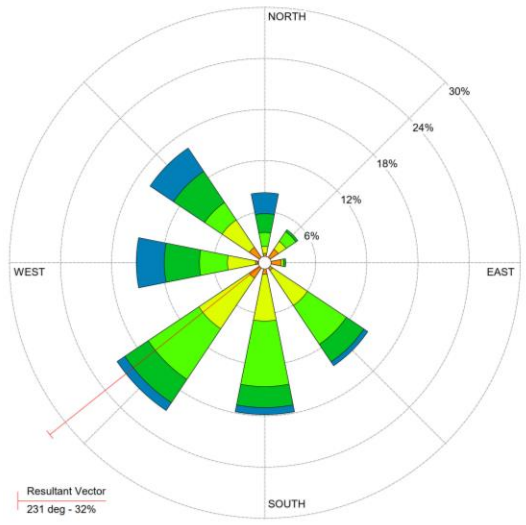
Wind station	9 am wind rose	3 pm wind rose
Mortlake Racecourse BoM, 1990-2020		
Warrnambool Airport NDB BoM, 1998-2020		
Local wind farm area observations, 2018		

Figure 4-8: Comparison of wind parameters for long term BoM stations and local wind farm observations

4.4 Existing Air Quality

4.4.1 Overview

Although the regional air quality is not currently extensively monitored across regional Victoria, some campaign monitoring has been undertaken in the past (EPA, 2018). For the monitoring data (PM_{10}, ozone and visibility) collected for Warrnambool, located approximately 35 km south east of the WWF, the air quality was impacted on isolated days due to wood fire smoke (in winter) and bushfires, however the measured air quality parameters were noted to be comparable with other parts of Victoria. Overall, the air quality across the region of the proposed wind farm is expected to be good in comparison to that of urban areas and the Melbourne-Geelong Airshed, which are subject to elevated concentrations of gaseous and particulate pollutants from road vehicles.

4.4.2 Airborne Particulate Matter

Historical EPA monitoring data for ambient air levels of PM_{10} and $PM_{2.5}$ from various stations are available across the Port Phillip and Latrobe Valley regions. For $PM_{2.5}$, continuous data are available for Alphington, Footscray, Geelong and Traralgon stations. Of these stations, Alphington was selected to represent background air quality for the WWF region. While Alphington's air quality is influenced by urban road traffic, in general the particulate matter levels there are not as affected by wind-blown dust as they are at Footscray and Geelong; e.g. EPA (2020). The particulate matter levels measured in the Latrobe Valley (Traralgon), would be associated with brown coal-fuelled electricity production such as open cut mining.

The long term trends for PM_{10} and $PM_{2.5}$ for the Alphington monitoring station are provided in Figure 4-9 and Figure 4-10. Two major bushfires in eastern Victoria in 2019 contributed to the elevated $PM_{2.5}$ levels in 2019. The elevated PM_{10} levels for this year were attributed to windblown dust due to the lower than average rainfall (EPA, 2020a).

In 2018, the elevated $PM_{2.5}$ levels in 2018 were influenced by urban sources such as domestic wood heating on cold, still nights. Land burns also contributed to the higher $PM_{2.5}$ levels.

Overall, the long term typical PM_{10} and $PM_{2.5}$ 70th percentile ambient concentrations for EPA Alphington station are approximately 20 µg/m^3 and 8 µg/m^3, respectively.

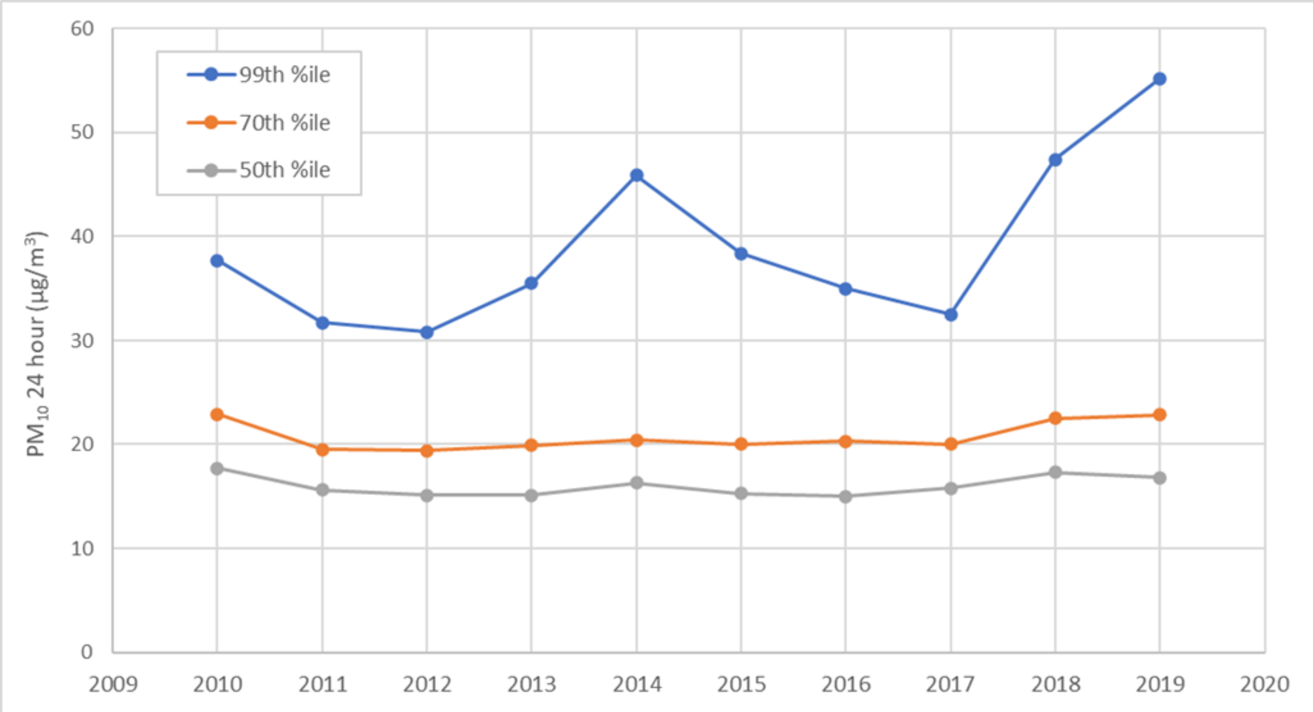


Figure 4-9: EPA (2020, 2016) 24-hour average PM_{10} at Alphington monitoring station

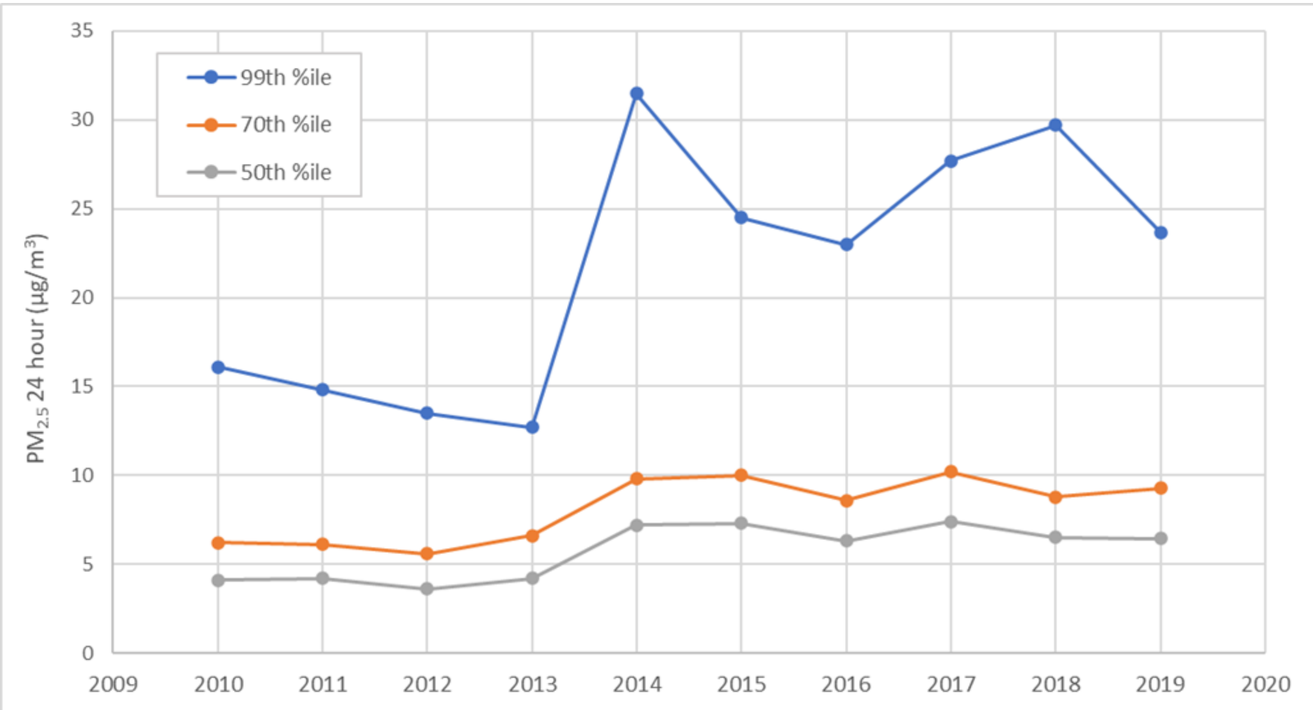


Figure 4-10: EPA (2019 and 2015) 24-hour average $PM_{2.5}$ at Alphington monitoring station

4.4.3 Other Air Pollutants

Respirable crystalline silica (RCS) is created during activities such as cutting, grinding, and drilling of materials such as stone, rock, concrete and mortar. There are no known activities in the study area which would generate RCS dust, as such it is expected that concentrations of RCS are negligible at the quarry site.

4.4.4 Summary

There were no air quality monitoring data available in the Project air quality study area; in this situation VG (2001) requires addition of "the 70th percentile of one year's observed hourly concentrations as a constant value to the predicted maximum concentration from the model simulation." Also VG (2001) states, "In cases where a 24-hour averaging time is used in the model, the background data must be based on 24-hour averages". In the absence of site specific monitoring data, the particulate levels in the Port Phillip region, and specifically at the EPA Alphington monitoring station as discussed above, were considered to adequately represent the background dust levels. The air quality at the WWF site is expected to be comparable to other sites across Victoria including the Port Phillip region, as supported by the EPA summary of regional air quality (EPA, 2018).

The 70th percentile 24-hour average raw monitoring data for the EPA station were used to calculate the background PM_{10} and $PM_{2.5}$ concentrations for use in this assessment, for the meteorological case study year 2018. The calculated 50th percentiles (i.e. medians) were used to estimate annual average background concentrations.

For background deposited dust, a constant level of 2.0 g/m^2/month was applied, based on the EPA (2007) standards for deposited dust.

A summary of the background levels for PM_{10}, $PM_{2.5}$, deposited dust and RCS used in the assessment are provided in Table 4-2.

Table 4-2: Background pollutant levels applied for Project assessment

Pollutant	Averaging time	Background level	Notes
Particulate matter (PM_{10})	24-hour	19.7 µg/m^3	70th percentile from Alphington (EPA, 2019a)
Particulate matter (PM_{10})	Annual	14.8 µg/m^3	50th percentile from Alphington (EPA, 2019a)
Particulate matter ($PM_{2.5}$)	24-hour	8.0 µg/m^3	70th percentile from Alphington (EPA, 2019a)
Particulate matter ($PM_{2.5}$)	Annual	6.4 µg/m^3	50th percentile from Alphington (EPA, 2019a)
Deposited dust	Month	2.0 g/m^2/month	Worst case estimate based on EPA (2007) standards for background deposited dust
RCS	Annual	0 µg/m^3	No known sources of RCS in model region.

5. Air Emissions Estimates

The key air emissions resulting from the operation of the proposed quarry will be dust emissions from the following activities:

- excavation works
- material handling
- material movement, i.e. truck hauling,
- crushing and screening operations
- wind erosion – from active stockpiles and from general exposed areas, and
- drilling and blasting operations.

The dust emission inventory was informed by the proposed project description for the quarry (WWF, 2021a). This details the key activities and schedule of operations, and equipment information. The location of the activities and main features of the quarry are set out in the 'Site Layout Plan', as provided in Appendix A.

The dust emission rates were generally determined using published emission factors obtained from the following sources:

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

The key emission factor equations applied are provided in Appendix C. Other input information included estimates for expected haul road distances and routes, truck sizes, soil moisture content and activity operating hours.

The scenario modelled and presented in this report represents the worst-case expected dust emissions, whereby the material excavation and movement rates are peak rates expected over the life of the quarry operation, and the stockpiles are at the maximum extent expected.

A summary of the key inputs representing the modelled scenario, i.e. peak production, are shown in Table 5-1.

Table 5-1: Quarry dust emission estimate input parameters

Quarry model parameter	Value
Quarry lifetime production	1 million tonnes
Peak annual production rate	600,000 tonnes per year
Maximum disturbance area	20 ha (area subject to wind erosion, i.e. excluding footprint area of dams)
Crushed rock product stockpile area	4.0 ha
Topsoil stockpile area	0.45 ha
Overburden stockpile area	2.0 ha
Raw product stockpile area	1.5 ha
Blast frequency	1 or less per week, 40 – 50 per year
Blast area	1,000 m^2 (approximately)
Holes drilled per blast	150 holes per blast
Number of crushing/screening trains	2

Quarry model parameter	Value
Crushing and screening rate	600,000 tonnes per year
Haul route distances	Approximately 1 km
Moisture content of excavated material	2% by mass
Operating hours	7 am – 6 pm Monday to Friday 7 am – 1 pm Saturday 365 days per year*

** Model inputs conservatively assume 365 operating days per year. In practice, will be less than this due to no activity on Sundays and holidays.*

For the purposes of the assessment the RCS emissions are assumed to be the same as the $PM_{2.5}$ fraction, as set out in the PEM (2007). Although the composition of the $PM_{2.5}$ dust fraction is not known, in practice, it is expected that the RCS will be less than 100% of the $PM_{2.5}$. The proportion of RCS in the $PM_{2.5}$ will be dependent on the soil types disturbed and the depth of the excavation. For this site, RCS is not expected to be an issue based on geotechnical information provided by the quarry designers (BCA Consultants) which indicates that silica would not typically be expected in the quarry basalt material. However, for the purposes of the modelling assessment, RCS has been assessed as 100% of the $PM_{2.5}$ in accordance with the PEM.

The calculated annual dust emission estimates as TSP, PM_{10} and $PM_{2.5}$ for the proposed operations are shown in Table 5-2. The highest emission rates are attributed to dust generated during the hauling of material by trucks over unsealed roads. The next highest emissions are expected for the cumulative loading and unloading operations, i.e. to trucks, stockpiles. Drilling and blasting activities are the smallest contributors to the total dust emissions.

Table 5-2: Estimated dust emissions from the quarry activities

Quarry Activity	Annual emissions (kg/year)		
	TSP	PM_{10}	$PM_{2.5}$
Excavators loading overburden to trucks	3,032	1,434	152
Hauling overburden to dumps	30,183	8,919	1,509
Unloading overburden to dumps	12,144	4,352	607
Drilling rock	1,328	698	66
Blasting rock	348	180	17
Excavators loading shot rock to trucks	1,798	850	90
Hauling shot rock to raw product stockpiles	17,895	5,288	895
Loading raw product stockpiles	1,200	510	60
Loading shot rock to mobile crusher	1,798	850	90
Primary crushing	3,000	1,200	150
Secondary crushing	9,000	3,600	450
Screening	9,000	3,000	450
Loading crushed product to stockpiles via conveyor	1,798	850	90
Loading crushed product to trucks	2,400	1,020	120
Hauling crushed product off-site	21,086	6,231	1,054

Quarry Activity	Annual emissions (kg/year)		
	TSP	PM_{10}	$PM_{2.5}$
Wind erosion from exposed areas / dumps	10,862	5,431	815
Wind erosion from active stockpiles	3,329	1,664	250
Total	**130,200**	**46,078**	**6,865**

Dust mitigation measures will be implemented at the quarry site to minimise dust emissions during the various operational activities. Further discussion of the mitigation measures in relation to the PEM (EPA, 2007) and GED is provided in Section 8.

The reduction in the dust emissions is estimated using published control factors in the NPI EETM (NPI, 2012). A summary of the reductions incorporated in the model inputs is provided in Table 5-3. The pit retention factor reduces emissions for sources which are located within the quarry pit owing to the lower expected release rate above the surface level of the pit. A 5% reduction is incorporated for PM_{10} emissions and 50% for TSP, as set out in the NPI EETM for Mining (AG, 2012).

Table 5-3: Applied dust mitigation controls

Quarry Activity	Applied control *
Excavators loading overburden to trucks	-
Hauling overburden to dumps	75% - level 2 water (> 2 L/m^2/hr)
Unloading overburden to dumps	-
Drilling rock	70% - water sprays
Blasting rock	-
Excavators loading shot rock to trucks	-
Hauling shot rock to raw product stockpiles	75% - level 2 water (> 2 L/m^2/hr)
Loading raw product stockpiles	50% - water sprays
Loading shot rock to mobile crusher	-
Primary crushing	50% - water sprays
Secondary crushing	50% - water sprays
Screening	50% - water sprays
Loading crushed product to stockpiles via conveyor	-
Loading crushed product to trucks	-
Hauling crushed product off-site	75% - level 2 water (> 2 L/m^2/hr)
Wind erosion from exposed areas / dumps	-
Wind erosion from active stockpiles	50% - water sprays
Pit retention	TSP: 50% reduction PM_{10}: 5% reduction

** The applied control represents the percentage reduction of emissions when the mitigation control is implemented*

6. Assessment Methodology

6.1 Overview

The air quality impact assessment was undertaken in accordance with the State Environment Protection Policy (Air Quality Management), (VG, 2001), and consistent with the EPA's Protocol for Environmental Management: Mining and Extractive Industries (EPA 2007). EPA (2007) is a part of VG (2001). The modelling components of the assessment were undertaken in accordance with the EPA's requirements for the use of AERMOD (EPA, 2014a; EPA, 2014b). Also, consideration was given to the EPA's new draft guideline for air quality assessment (EPA, 2021a); see Section 3.

As detailed in Section 2.2, the focus of the quantitative air quality assessment were the dust emissions from the proposed quarry construction and operation, with emission rates as set out in Section 5.

6.2 Geographical Data

The model inputs incorporated the terrain at the site and the current land use, e.g. vegetation types, roads/transport, water bodies. These are described in Section 4.2.

6.3 Meteorological Modelling

The AERMOD dispersion model inputs used surface and upper air meteorological data files generated for each hour of the model year generally in accordance with EPA (2014a).

The EPA AERMET guideline (2014a) requires site specific input data to be used which is defined as being within a 25 km radius of the site. As there was no BoM station within this radius, the input data were generated by the use of the prognostic model, TAPM, in conjunction with surface hourly average wind speed and wind direction observation data measured near the proposed quarry site at height of 11 metres and collected between 2018 and 2020, inclusive. The location of the observation station in relation to the quarry is shown in Figure 4-3.

The 'Guidance notes for using the regulatory AERMOD air pollution model' (EPA, 2014b) states that a period of 5 years of meteorological data should be used for AERMOD dispersion modelling assessments, although this requirement may be relaxed in special cases, subject to justification. For this project, on-site meteorological data for the 5 year period 2016 – 2020 were analysed. The data for 2016 and 2017 were not used due to anomalies in the collected data. The final application of 3 years of hourly meteorological data was judged to be more than satisfactory as an input for the air quality assessment, as determined by:

- Comparing the selected 2018 – 2020 site data to long term historical data to show the data were representative of typical conditions, and covered nearly all possible hourly conditions for the location. Comparison of the site observations with the long term data from the nearest BoM stations supported the use of the local data (refer Section 4.3).
- Using site specific data collected from a local observation station near the quarry as input to the generation of the meteorological modelling files.
- Selecting and assessing the model year with wind patterns expected to present the highest risk to sensitive receptors.

All upper air data was generated using TAPM.

The meteorological model incorporated land use and terrain data for the region. Land use within the model domain was defined for 12 sectors, centred on the quarry centre, using NLCD92 Land Cover Classes and established using vertical imagery.

The modelled annual wind patterns and average speeds for the 3 years, 2018 – 2020, are similar, as shown in Figure 6-1 and Figure 6-2, and any of these years were considered suitable to represent the wind conditions at the wind farm location.

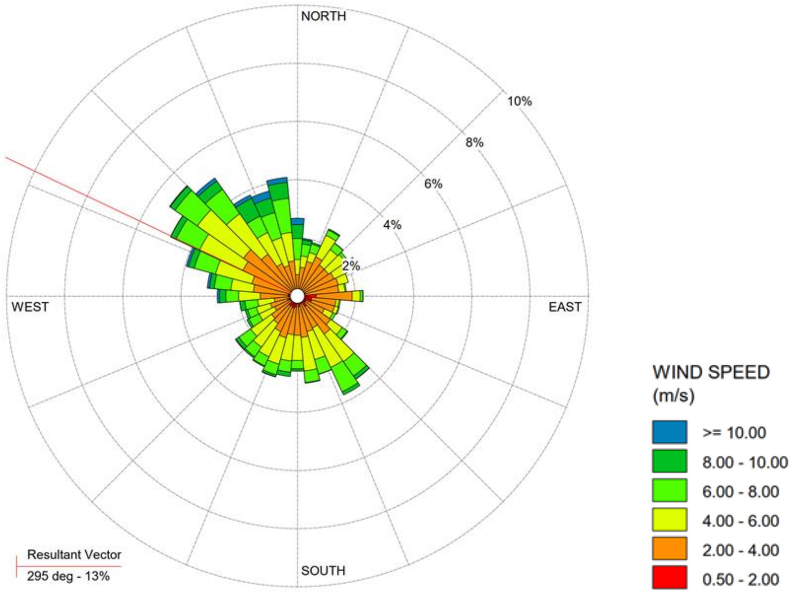


Figure 6-1: Model output, 2018 wind rose (average wind speed = 4.3 m/s)

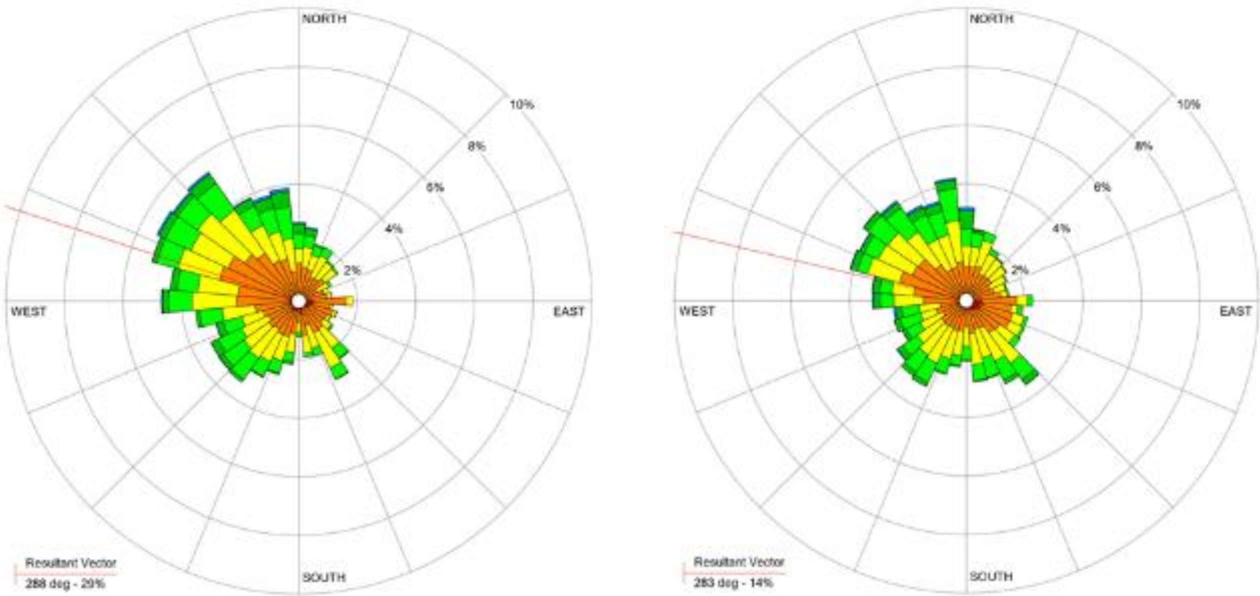


Figure 6-2: Model outputs: 2019 wind rose, avg WS = 4.3 m/s (left), and 2020 wind rose, avg WS = 4.4 (right)

Of these 3 years, 2018 was selected as the model year for the following reasons:

i. The ambient background air quality data for this year was considered to be most representative of typical conditions. Year 2019 background data was characterised by two major bushfires in Victoria which result in high levels of $PM_{2.5}$ and higher than typical PM_{10} levels due to occurrences of wind blown dust related to lower than average rainfall, as well as some exceedences due to bushfires. In addition, the $PM_{2.5}$ dataset for 2019 was incomplete, with the fourth quarter data not provided due to errors in the monitoring equipment (EPA, 2020a). Published background data for 2020 was not available at the time of the assessment.

ii. Analysis of the wind observation data at the quarry site showed that the percentage of strong winds, i.e. higher than 6 m/s, blowing towards the direction of the nearest sensitive receptor site (located 1.4 km south east of the quarry location) was highest for year 2018.

The seasonal wind pattern model outputs for year 2018 are provided in Figure 6-3. The seasonal wind pattern model outputs for years 2019 and 2020 are provided in Appendix B. The annual wind rose is compared with the observation data in Figure 6-4.

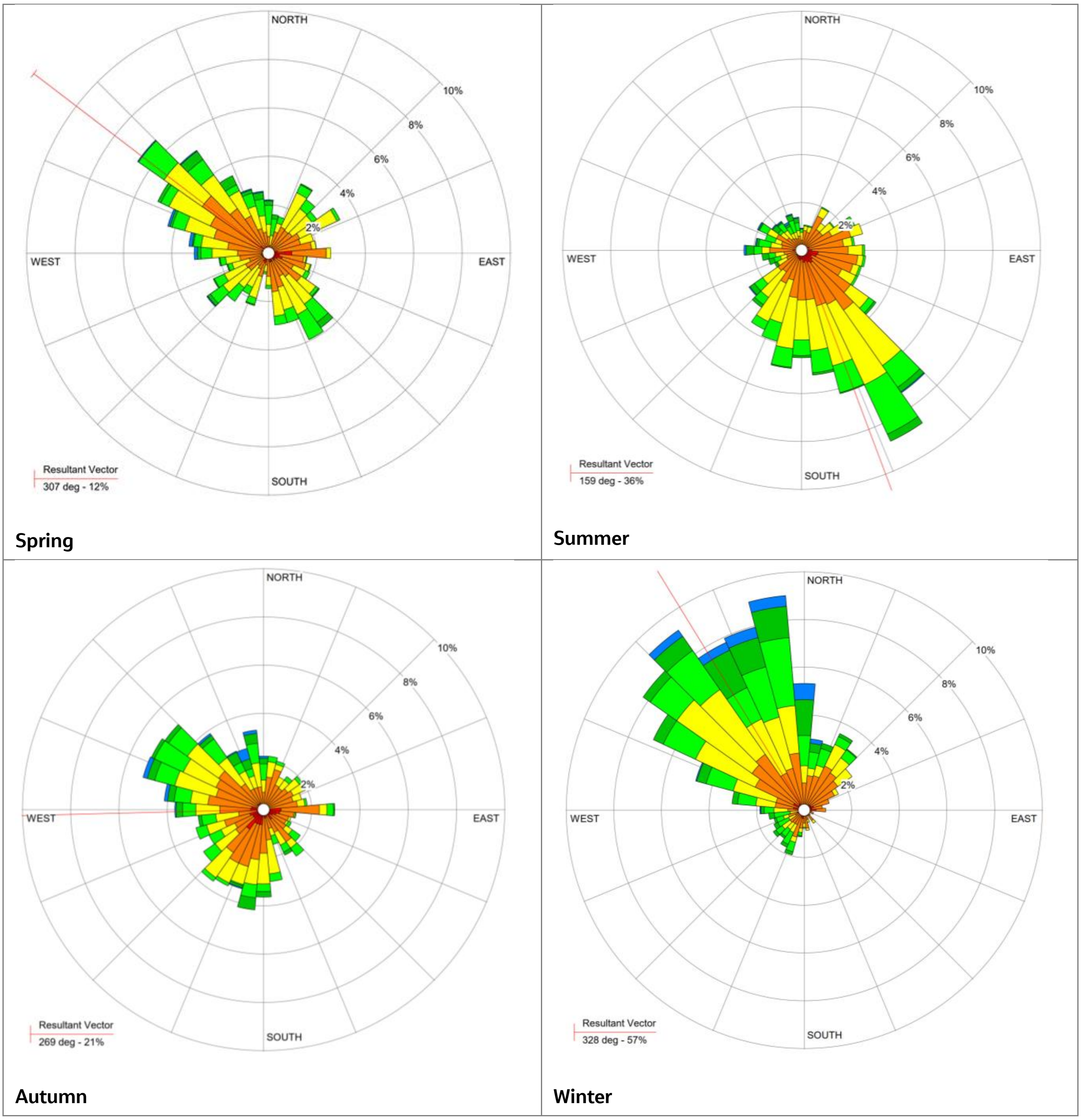


Figure 6-3: Modelled seasonal wind roses, year 2018, at proposed quarry site

The seasonal wind patterns indicate that the highest wind speeds occur in winter and are predominantly from the north-west, i.e. towards the closest sensitive receptor site which is located approximately 1.4 km south-east of the quarry. This suggests that this receptor site would be most impacted by ambient dust (attributable to the quarry) during the winter months. During the summer months, when conditions are drier and managing dust emission sources becomes more challenging, the predominant wind direction is from the south-east, i.e. blowing away from the closest sensitive receptor site.

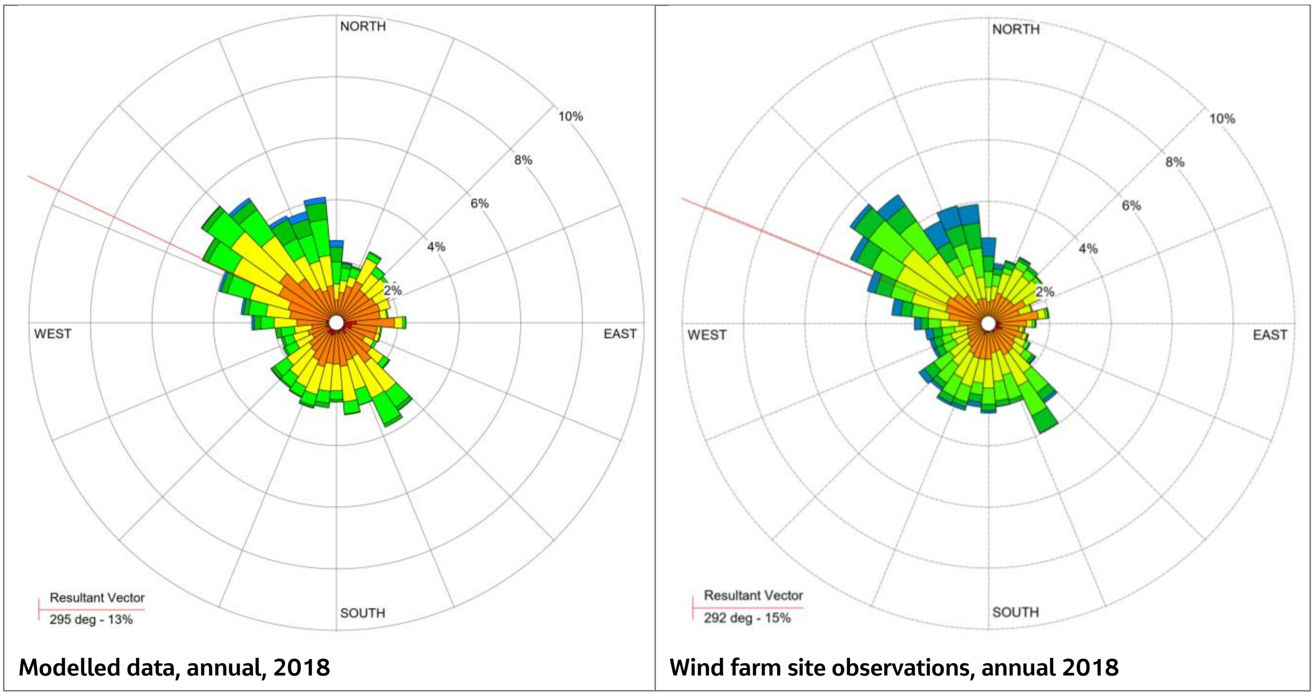


Figure 6-4: Annual wind rose at quarry site; modelled (left) and observations (right)

6.4 Air Dispersion Modelling

The Victorian regulatory air dispersion model AERMOD was used to predict ground-level concentrations (GLCs) and dust deposition levels resulting from the estimated dust emissions set out in Section 5. The resulting GLCs were compared with the air quality standards for the Project as set out in Section 3.

Modelling was undertaken using the meteorological data files generated for model year 2018 as described in Section 6.3. The dispersion modelling was undertaken in accordance with the EPA guideline for AERMOD (EPA, 2014b). A summary of the AERMOD settings is provided in Table 6-1.

Table 6-1: Summary of AERMOD model parameter settings

AEMOD parameter	Settings
AERMOD version	Version 19191 *
Terrain	Digital Terrain Model created using the 1 second (approximately 30 metre) Shuttle Radar Topography Mission elevation data provided by USGS.
Model domain	121 x 121 grid points; 12.0 km x 12.0 km (total 14,641 grid receptors)
Grid receptor spacing	100 meters
Discrete receptors	Total 73 discrete receptors
Land use	Rural
Wake/downwash effects	None
Meteorological data	One year of hourly meteorological data using TAPM generated prognostic data from and site observations (11m height) for year 2018, processed as input files for use with AERMOD in accordance with EPA (2014a).

** A new version of AERMOD was released by US EPA on 22 April 2021. Sensitivity testing indicated no change to model results with the application of the new model.*

Quarry operations were represented by a series of volume sources located according to the location of activities for each modelled scenario. Figure 6-5 shows the location of the modelled sources where the emissions from the dust generating activities listed in Table 6-2 were assigned to one or more of these source locations.

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

a) Wind insensitive sources, where emissions do not vary with wind speed (for example, mobile crusher).

b) 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.

c) 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, and exposed areas, 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.

Quarry operating activities were assumed in the modelling to occur over the period 7 am to 6 pm.

Figure 6-5: Location of dust emission sources

Table 6-2: Emission source location and activity key

Emission source ID	Description	Activities
1,2	Overburden dump	Hauling overburden to dumps, unloading overburden, wind erosion from active stockpiles
7, 8, 9	Stockpiles – topsoil	Wind erosion from active stockpiles
10, 12	Stockpiles – product	Loading crushed product to stockpiles, loading crushed product to trucks, wind erosion from active stockpiles
3 – 6, 11, 16 - 22	Quarry	Excavators loading overburden to trucks, hauling overburden, drilling and blasting, excavators loading shot rock to trucks, hauling shot rock to stockpiles, wind erosion from exposed areas
13, 14	Mobile crusher and screens, material stockpiles	Loading raw material stockpiles, loading raw material to mobile crusher, crushing and screening, loading crushed product to stockpiles, loading crushed product to trucks, wind erosion from active stockpiles
15	Haul road	Hauling to raw material stockpiles, wind erosion from exposed areas
23 - 25	Haul road	Hauling of overburden to overburden dumps, wind erosion from exposed areas
26 - 31	Haul road	Hauling of crushed product

7. AERMOD Results

7.1 Overview

This section provides the results of the AERMOD dispersion modelling assessment for the proposed quarry dust emissions.

Dispersion modelling results are set out in accordance with EPA (2014b). Model outputs are provided for:

- PM_{10}: Maximum predicted grid GLC, 24 hour average (µg/m^3)
- PM_{10}: Predicted grid GLC, annual average (µg/m^3)
- $PM_{2.5}$: Maximum predicted grid GLC, 24 hour average (µg/m^3)
- $PM_{2.5}$: Predicted grid GLC, annual average (µg/m^3)
- RCS: Predicted grid GLC, annual average (µg/m^3)
- Dust deposition: Predicted grid dust deposition, maximum monthly (g/m^2/month)

Background concentrations for PM_{10}, $PM_{2.5}$ and deposited dust as described in Section 4.4 were applied.

7.2 Maximum 24-Hour Average PM_{10} Concentrations

The AERMOD results for maximum 24-hour average PM_{10} GLCs, using hourly 2018 meteorological data as input, are provided in Figure 7-1. There were no predicted exceedences of the standards at any of the discrete receptors. The orange contour represents the Project standard of 50 µg/m³.

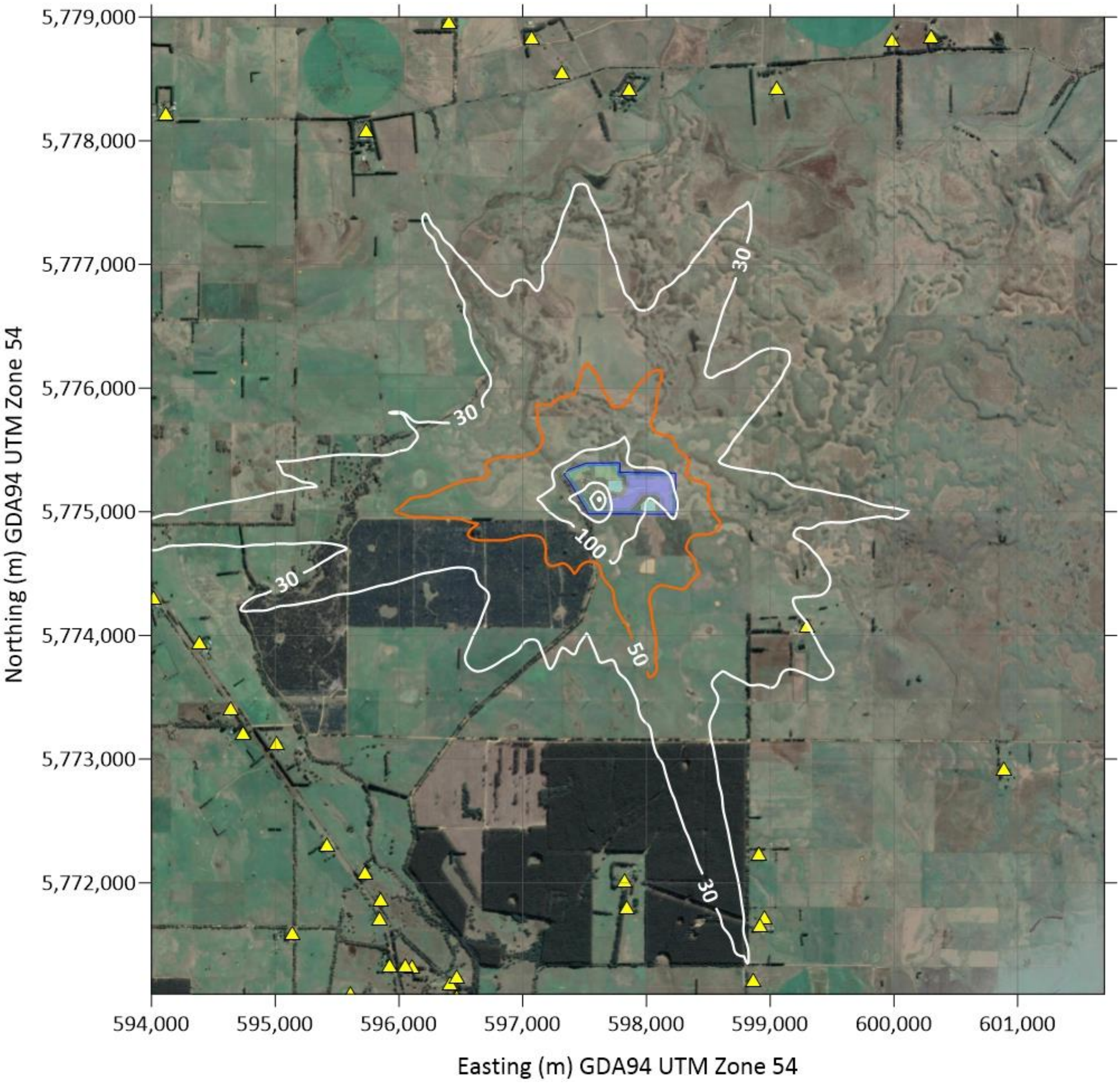


Figure 7-1: Maximum PM_{10} GLCs 24 hour average (µg/m³)

The PM_{10} 24 hour average concentration time series for the closest sensitive receptor site (as identified in

Figure 4-2) is provided in Figure 7-2. The highest PM_{10} concentrations are predicted by the model to occur in the winter months, i.e. June through to August. The maximum contribution above background level is approximately 10 µg/m³. In the figure, the contributions from the quarry are shown clearly superimposed on the fixed estimate for the background PM_{10}. For most of the year the background level is the more significant component.

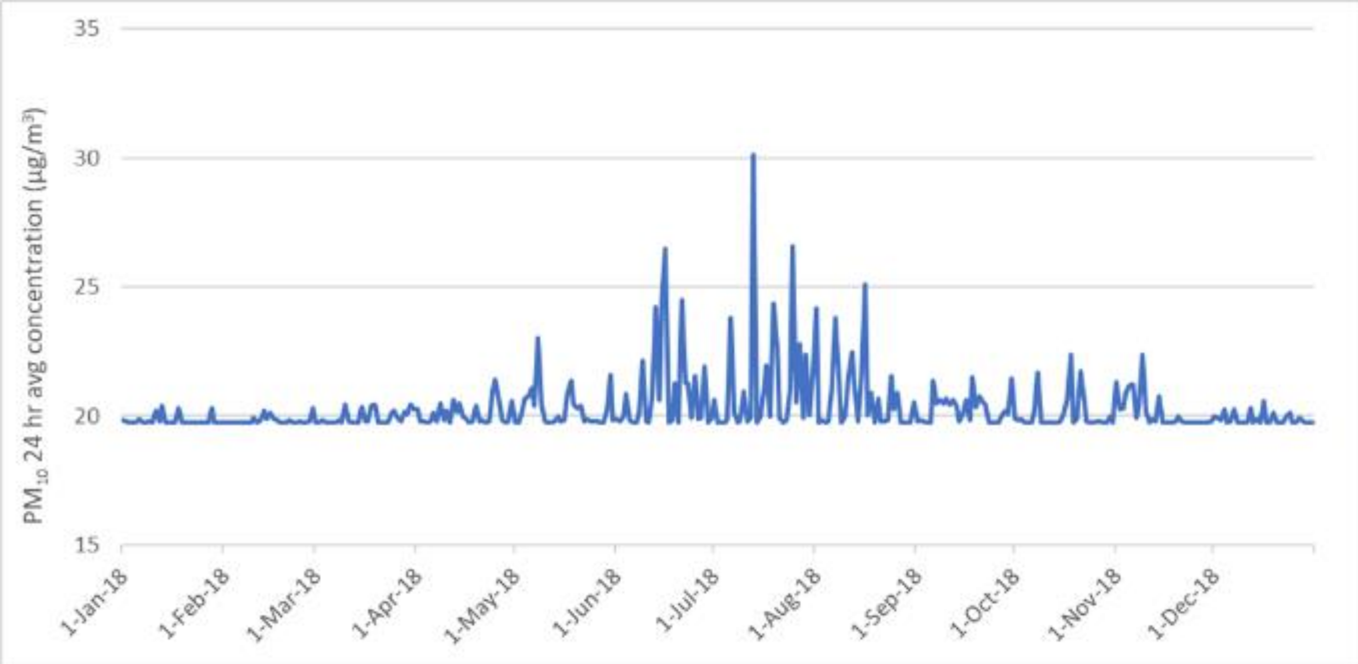


Figure 7-2: PM_{10} 24 hour average GLC (μg/m^3) at nearest sensitive receptor – time series

7.3 Annual Average PM_{10} Concentrations

The AERMOD results for the annual average PM_{10} GLCs, using hourly 2018 meteorological data as input, are provided in Figure 7-3. There were no predicted exceedences of the standards at any of the discrete receptors. The orange contour represents the Project standard of 20 µg/m³.

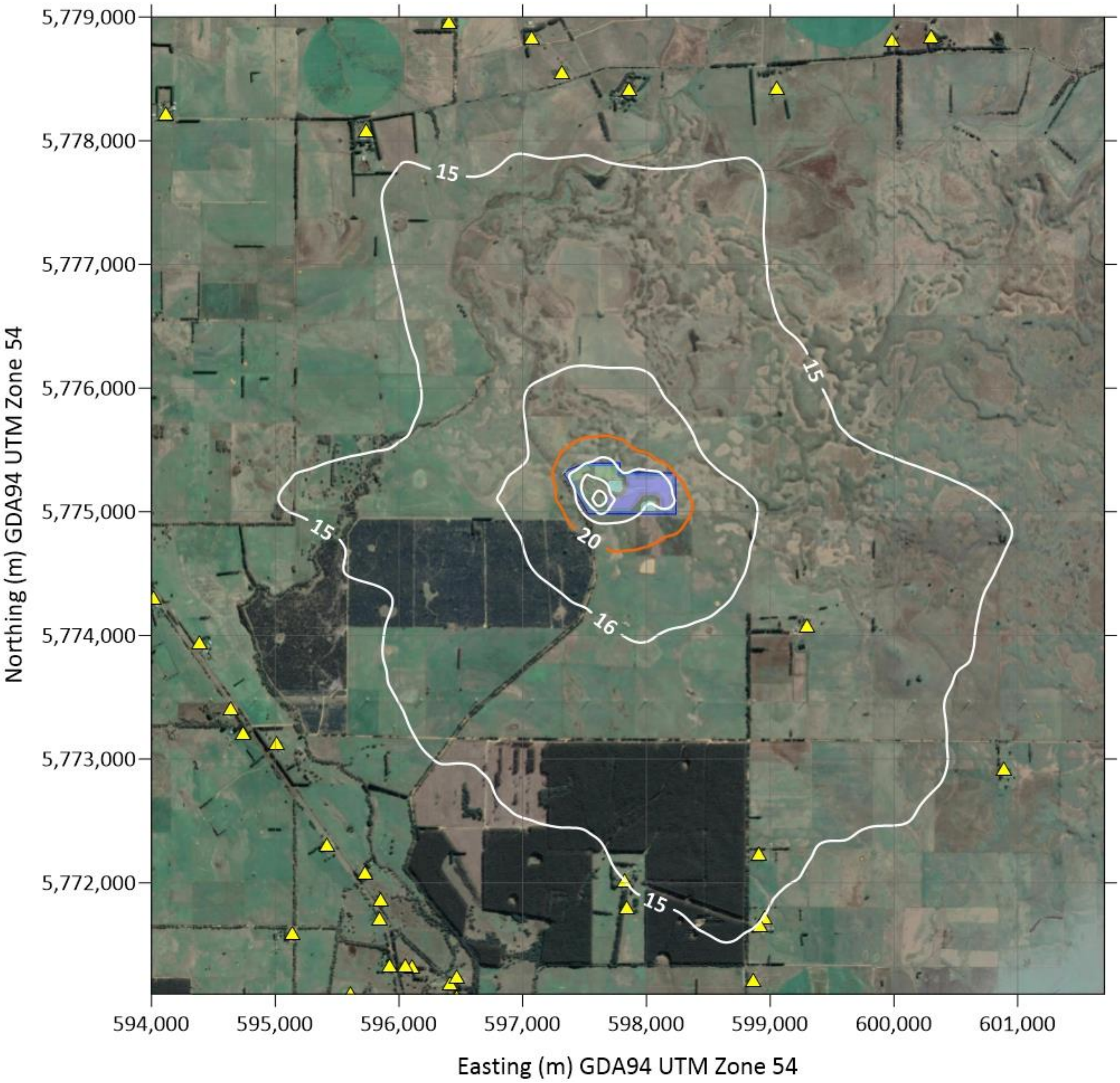


Figure 7-3: PM_{10} GLCs, annual average (µg/m³)

7.4 Maximum 24-Hour Average $PM_{2.5}$ Concentrations

The AERMOD results for maximum 24-hour average $PM_{2.5}$ GLCs, using hourly 2018 meteorological data as input, are provided in Figure 7-4. There were no predicted exceedences of the standards at any of the discrete receptors. The orange contour represents the Project standard of 25 µg/m^3.

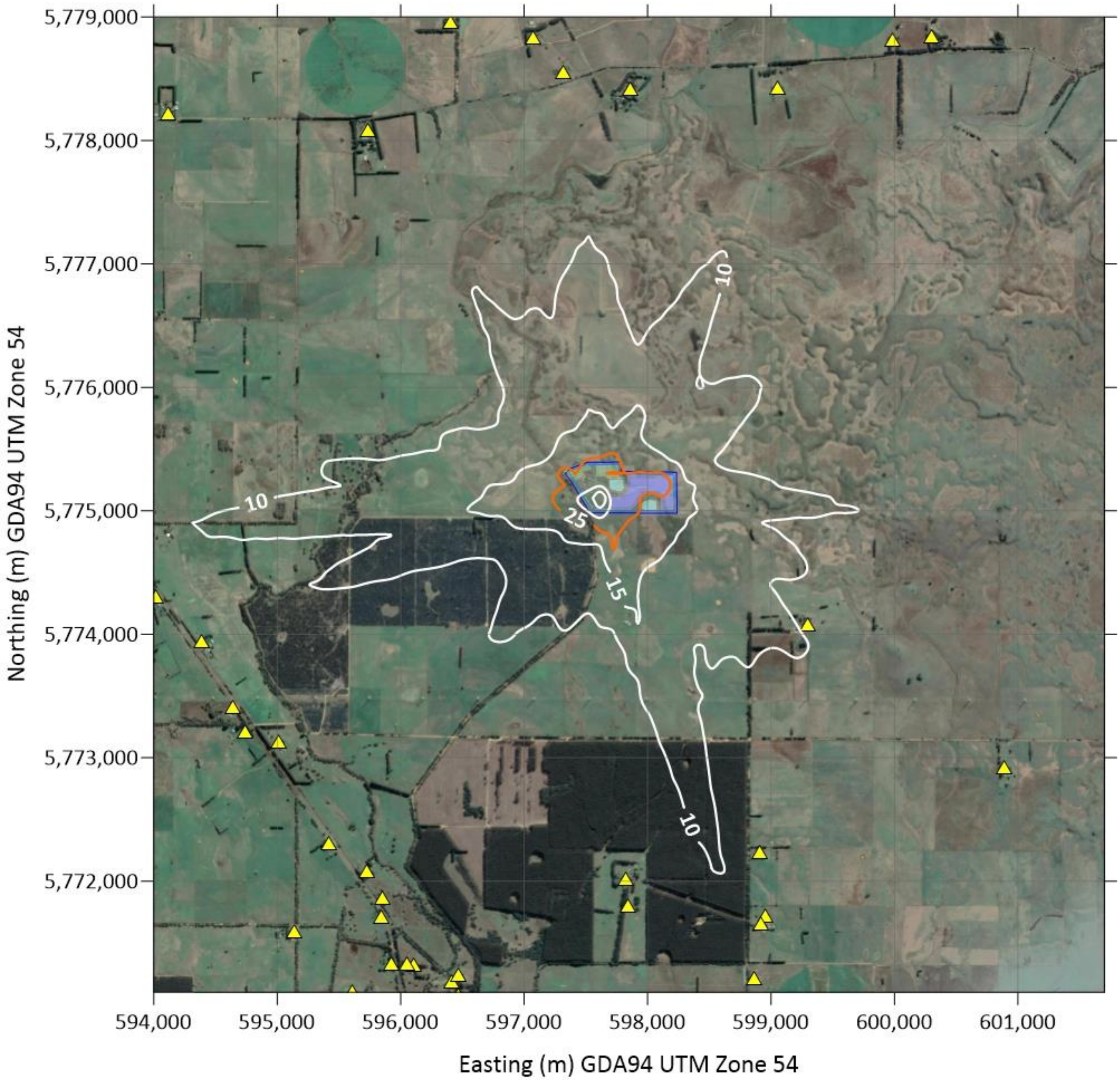


Figure 7-4: Maximum $PM_{2.5}$ GLCs 24 hour average (µg/m^3)

The $PM_{2.5}$ 24 hour average concentration time series for the closest sensitive receptor site (as identified in

Figure 4-2) is provided in Figure 7-5. As for the PM_{10} time series, the most significant $PM_{2.5}$ concentrations are predicted by the model to occur in the winter months, i.e. June through to August. The maximum contribution above background level is approximately 1.6 µg/m^3.

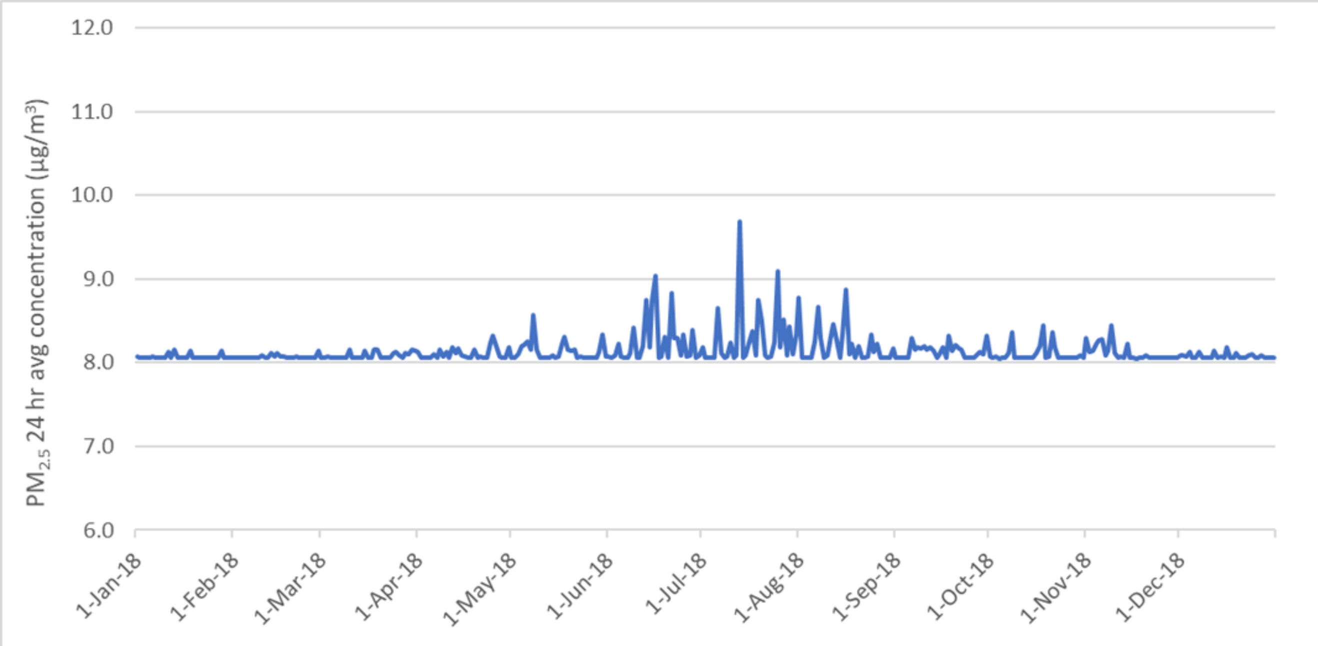


Figure 7-5: $PM_{2.5}$ 24 hour average GLC (µg/m^3) at nearest sensitive receptor – time series

7.5 Annual Average $PM_{2.5}$ Concentrations

The AERMOD results for the annual average $PM_{2.5}$ GLCs, using hourly 2018 meteorological data as input, are provided in Figure 7-6. There were no predicted exceedences of the standards at any of the discrete receptors. The orange contour represents the Project standard of 8 µg/m³.

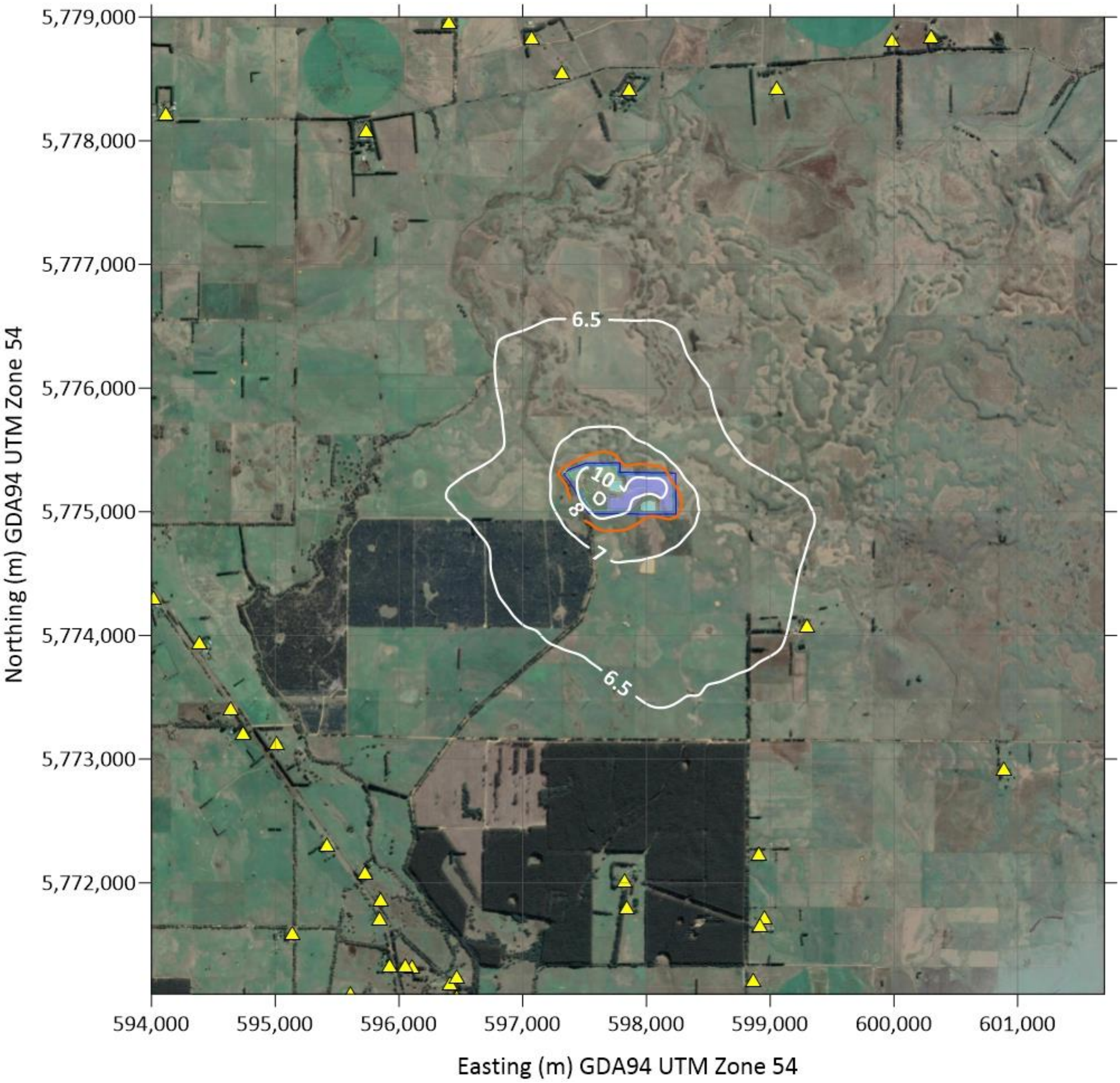


Figure 7-6: $PM_{2.5}$ GLCs, annual average (µg/m³)

7.6 Annual Average Respirable Crystalline Silica Concentrations

The AERMOD results for the annual average RCS GLCs, applying $PM_{2.5}$ as a proxy (conservative), using hourly 2018 meteorological data as input, are provided in Figure 7-7. The assessment of RCS was based on the emissions estimates for $PM_{2.5}$ in accordance with the PEM, although RCS is not expected to be an issue for this site (see Section 5).

There were no predicted exceedences of the standards at any of the discrete receptors. The orange contour represents the Project standard of 3 µg/m³.

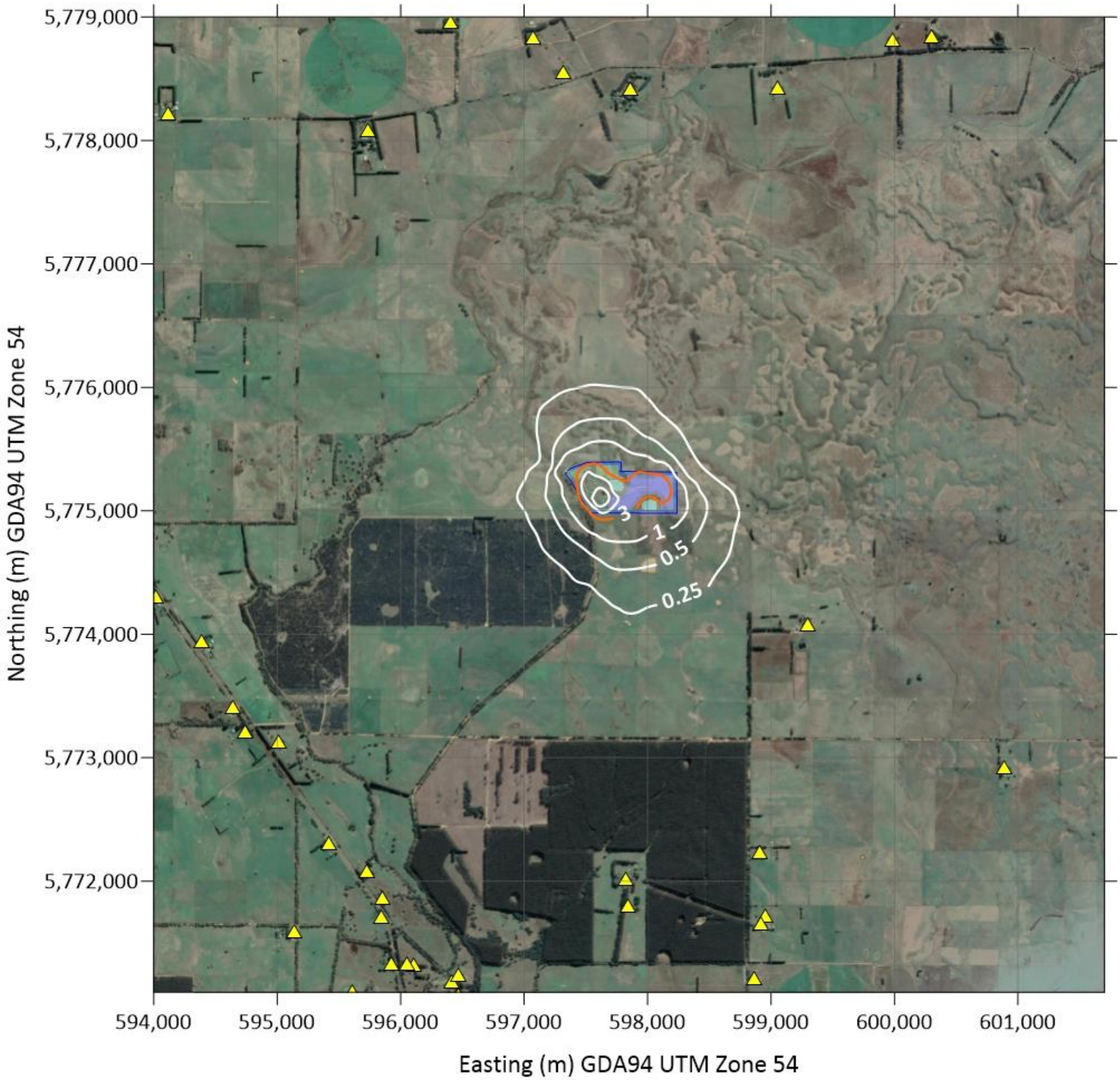


Figure 7-7: Respirable Crystalline Silica GLCs, annual average (µg/m³)

7.7 Deposited Dust

The AERMOD results for maximum monthly average dust deposition GLCs, using hourly 2018 meteorological data as input, are provided in Figure 7-8. There were no predicted exceedences of the project air quality standard at any of the discrete receptors. The orange contour represents the Project standard of 4 g/m^2/month.

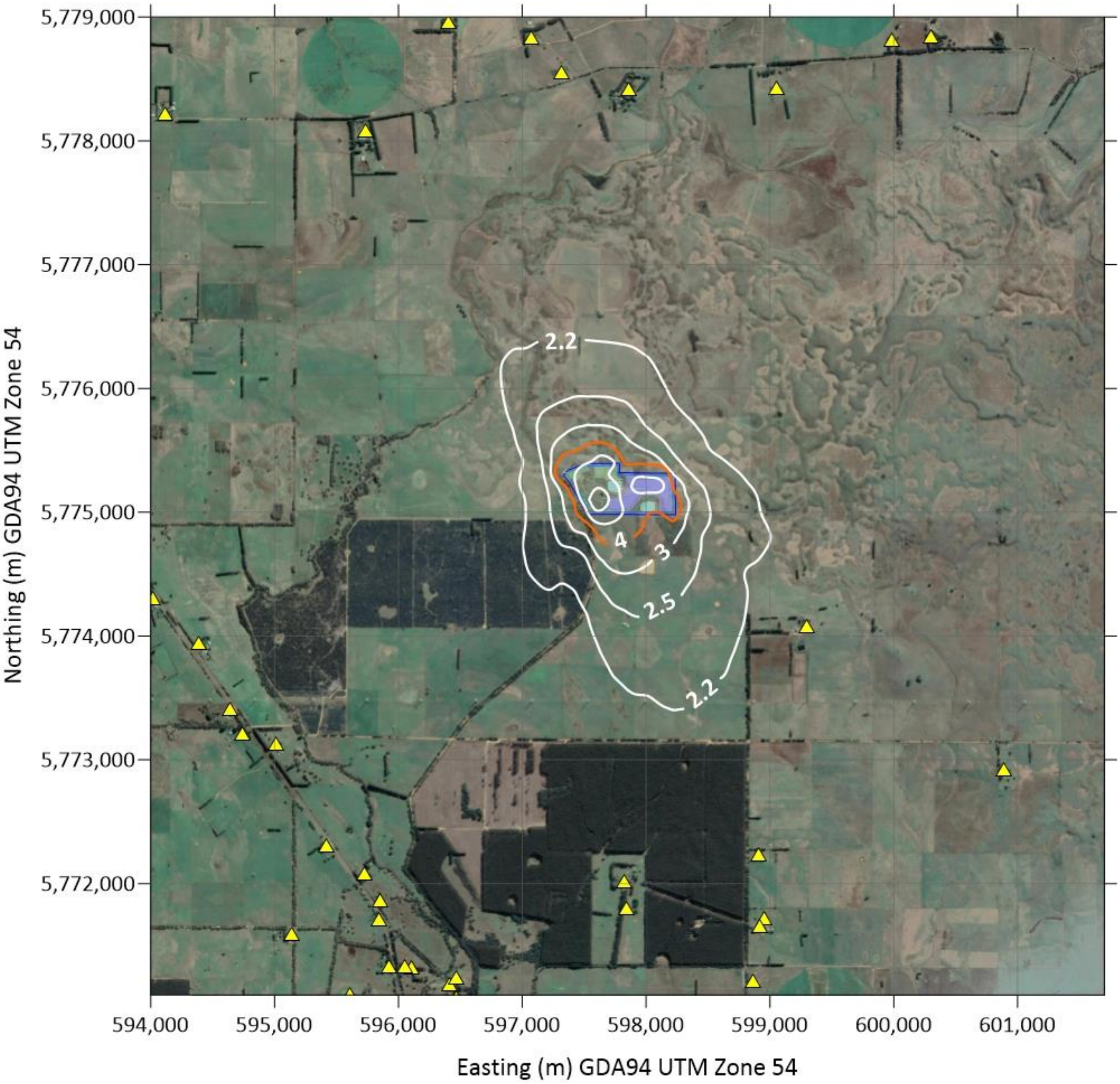


Figure 7-8: Maximum monthly dust deposition GLCs (g/m^2/month)

7.8 Summary of Model Results

A summary of the maximum predicted ambient GLCs for all grid points in the model domain, and the maximum result predicted across all sensitive receptor sites, is provided in Table 7-1. The air quality standards are also shown.

Each model result includes background levels, as set out in Section 4.4.

Table 7-1: Summary of AERMOD model results

Assessment parameter	Units	Project standard	Modelled Result	
			Maximum grid GLC	Maximum SR GLC *
PM_{10} 24-hour average	µg/m^3	50	802	**30**
PM_{10} annual	µg/m^3	20	161	**15**
$PM_{2.5}$ 24-hour average	µg/m^3	25	112	**9.7**
$PM_{2.5}$ annual average	µg/m^3	8.0	26	**6.5**
RCS annual average	µg/m^3	3.0	20	**0.1**
Dust deposition	g/m^2/month	4.0	63	**2.1**

** For each model, the highest predicted GLC at a sensitive receptor occurs for the nearest receptor site located approximately 1.4 km south east of the quarry development area boundary (see Section 4.2.2).*

The Project standards apply at the sensitive receptor sites; refer Section 3.2. The maximum model results at the identified sensitive receptor sites predict no exceedences of the project standards. This indicates a low risk of adverse air quality impact for PM_{10} and $PM_{2.5}$ dust emissions, and for deposited dust. Similarly, the risk of impact of RCS is also predicted to be low by the model outputs at the sensitive receptors.

It is noted that, although compliance with the Project standards was predicted at the sensitive receptor locations in accordance with the Project assessment requirements, the model outputs demonstrated that elevated risk, especially for PM_{10} levels, was predicted for some areas beyond the quarry site boundary, with the PM_{10} 24 hour average contour extending to approximately 1.4 km beyond the boundary.

8. Application of GED

Under the new EP Act, the quarry operation and wider wind farm construction works will need to address requirements of the GED to minimise risks of dust emissions. Although it is not within the scope of the air quality assessment to evaluate different risk mitigation options for dust emissions from the quarry and wider wind farm site (this would be done as part of the generation and implementation of a dust management plan), general information is provided here regarding the expected requirements of the new EP Act and GED, as well as references to high level dust mitigation measures which would need to be implemented as part of the GED.

Under the GED, persons who engage in activities that involve air emissions are required to eliminate risks of harm to human health and the environment from those emissions so far as reasonably practicable. Where it is not reasonably practicable to eliminate such risks, they are required to reduce them so far as reasonably practicable. Duty holders will need to clearly document how the existing or proposed risk controls meet the requirement to minimise risks so far as reasonably practicable.

For proposed risk controls, duty holders must have regard for six considerations when making decisions on proposed risk controls:

- Eliminate first
- Likelihood of harm
- Degree of harm
- The duty holder's knowledge about the risks
- Availability and suitability of technology
- Costs

The duty holder should evaluate multiple risk control options and document the decision process.

During the development of the WWF, a comprehensive range of environmental, social and infrastructure elements and associated constraints which influence the siting of the Project infrastructure were assessed as part of the planning and design process. With respect to air quality, this included the following criteria in the site selection process:

- Relatively low density of dwellings
- Away from coastal areas (high amenity value and usually higher population density)
- Potential project size

In many cases, buffers were applied to known or modelled sensitive areas. For individual dwellings (sensitive sites), the Victorian Planning Provisions prevents WTGs being sited within 1 km of a dwelling without the written consent of the owner of the dwelling. The Project has applied a buffer of at least 1.5 km to most non-participating dwellings and a buffer of 2 km to some non-participating dwellings in response to feedback from Project stakeholders. For townships, a 3km buffer was applied to all Township Zones as defined in the Victorian Planning Provisions to minimise potential impacts to township residents. The purpose of incorporating these constraints and buffers into the planning process was to ensure that potential impacts could either be avoided or minimised whilst achieving the desired project outcomes. This approach aligns with the GED requirements whereby the primary focus is to eliminate or avoid the risk where practicable.

With regard to nuisance dust for the proposed WWF design, i.e. with a potential to create a visible dust issue, the new, draft *Guideline for assessing and minimising air pollution* (EPA, 2021a) indicates the implementation of risk-based dust management plans. The purpose of the plan should be to assess the risk of potential and existing dust sources, and implement site-specific, best practice design controls and management practices to minimise dust. It involves:

- Source identification
- Pathway analysis

- Receptor identification
- Risk assessment
- Implementation of controls
- Monitoring and review

The expected dust mitigation controls for the WWF site are detailed in Section 2.2.2. Specific and additional mitigation controls for the quarry area are:

- Watering of haul roads to minimise wheel generated dust. Water application rate of greater than 2 $L/m^2/hr$ (Level 2)
- Application of water sprays when drilling rock
- Application of water sprays when loading excavated materials and product to stockpiles
- Application of water sprays at crushing and screening operations
- Application of water sprays to control wind erosion from active stockpiles

These quarry dust mitigation controls have been applied in the modelling.

9. Conclusions

An air quality impact assessment was carried out for the proposed quarry at the WWF to support the EES for the Project. The key requirements, as set out in the EES Scoping Requirements document (DELWP, 2019), were to:

- Assess the potential dust impacts from the proposed on-site quarry in accordance with the requirements of the Protocol for Environmental Management: Mining and Extractive Industries (EPA, 2007), and
- Assess the potential effects of construction, operation and decommissioning activities on air quality associated with the wider wind farm Proposal.

As part of the assessment, consideration was given to proposed legislation which came in to effect on 1 July 2021 as part of the new EP Act (2017), with a key component of the new legislation impacting the air quality assessment being EPA's draft *Guideline for assessing and minimising air pollution* (EPA, 2021a). This guideline provides air quality standards for pollutants in ambient air, with reference to the (also new) ERS (VG, 2021), referring to requirements under the General Environment Duty (GED), which Victoria Government describes as a cornerstone of the new EP Act for the risk management of air quality impacts. Under the new legislation, dispersion modelling is used as a tool to help understand the air quality risks, notwithstanding the overall GED requirement to reduce risks to human health and the environment as far as reasonably practicable.

Review of the proposed activities for the WWF and expected air quality emissions identified the quarry construction and operation as the most significant source of air emissions and potential air quality impact; the quarry emissions were the focus of the modelling study.

It is anticipated that there will also be dust generated at locations across the broader WWF site due to activities associated with the construction of the individual wind turbine sites, use of the access tracks, operation of the concrete batching plants, and other activities. These broader activities across the WWF site, outside of the quarry, will be of relatively short duration and small scale (i.e. with lower dust generation intensity) compared to the quarry operations. As a result, the activities were not expected to contribute significantly to the overall air emissions and were therefore considered qualitatively. It is expected that these emissions can be effectively managed using dust mitigations targeted for each specific activity.

It is acknowledged that the wind farm construction, involving both the quarry operations and the wider site, is a significant infrastructure development with the use of heavy vehicles and movement of large quantities of earth and rock materials which will result in dust emission sources. It will be important to ensure that requirements to monitor emissions and modify activities accordingly, as set out in the dust mitigation plan, are implemented to avoid nuisance dust impacts off site. It is noted that nuisance dust complaints were experienced for the construction of the Macarthur wind farm (commissioned in 2013) located near Hamilton in western regional Victoria. This highlights the importance of proactive and effective management.

For the quarry construction and operation, the study involved a dispersion modelling assessment of air emissions at the quarry site using AERMOD, in accordance with EPA's guidelines, as far as practicable. Key air emissions attributed to the quarry operation were expected to be TSP, PM_{10} and $PM_{2.5}$. The study included the assessment of deposited dust and RCS. For this site, RCS is not expected to be an issue based on geotechnical information provided by the quarry designers (BCA Consultants). However, for the purposes of the modelling assessment, RCS was assessed as 100% of the $PM_{2.5}$, i.e. $PM_{2.5}$ was used as a proxy indicator, in accordance with the PEM.

Emission rate estimates were based on preliminary design information for the quarry and the use of emission factors from the NPI EETM for Mining (AG, 2012) and US EPA (1985 and updates). Hourly variable emission files were applied in the model for each pollutant. The emissions estimates incorporated the expected impact of dust mitigation measures, specifically watering of unsealed haul roads and use of water sprays on stockpiles, crushing, screening and drilling activities.

The meteorological input data were specific to the quarry site, generated using wind data collected from a local observation station near the quarry and prognostic modelling using TAPM. Comparison of the site observations with the long term data from the nearest BoM stations supported the use of the local data. Analysis of the available site observations data, i.e. for years 2018, 2019 and 2020, indicated similar wind direction patterns. With little to distinguish between the meteorological parameters annually, the year 2018 was selected as the model year, based on that year's more typical air quality (unaffected by severe bushfires) and the slightly higher percentage of strong winds blowing towards the closest sensitive receptor.

The air dispersion modelling for the Project predicted the highest risk of ambient air quality impact was for PM_{10} emissions, on both a 24-hour average and annual average basis. Although AERMOD predicted elevated levels well beyond the site boundary (i.e. the PM_{10} 24 hour average contour extends to approximately 1.4 km beyond the boundary), the predicted GLC at the nearest sensitive receptor site, located approximately 1.4 km south east of the quarry boundary, demonstrated compliance with the Project PM_{10} standard. Analysis of the predicted PM_{10} concentration at this receptor indicated highest levels would occur in the winter months. This aligned with the meteorological model outputs (and local wind observation data), which showed a higher frequency of winds from the north-west during winter.

The model outputs for $PM_{2.5}$ also indicated elevated risk levels beyond the site boundary, but to a significantly lower extent than that for PM_{10}. Similarly, risk levels for RCS and deposited dust were confined mainly to areas outside but close to the quarry site boundary.

There were no model-predicted exceedences of the Project standards at the sensitive receptors for all air pollutants emitted from the quarry operations. Although this indicated that unacceptable risks were not identified by the modelling at these sites, minimising risks by the development of a detailed and site specific dust management plan, as well as implementation of the recommended dust controls applied in the dispersion modelling assessment, will be key to minimising risks as far as practicable and satisfying GED requirements.

As with any dispersion modelling study, there were various uncertainties associated with the assessment. These included:

- The estimates of emissions are based on emission factors determined using knowledge and experience from other, similar mining and quarrying activities.
- The model inputs assume that emissions occur for 11 hours per day, 7 days of the week, and 365 days per year (providing conservative results). In practice, emissions will occur on 5 and a half days per week.
- The model does not incorporate any potential reduction of emissions resulting from rainfall events during the year (conservative).
- The inputs assume that the peak quarry rock movement rates occur for each day of the year. In practice, it is expected there will be fluctuations in the movement rates, however, as a conservative approach, the peak rate was incorporated in the model.
- The emissions estimates assume RCS emission rate is the same as the $PM_{2.5}$ emission rate. Although the composition of the $PM_{2.5}$ dust fraction is unknown, in practice, it is expected that the RCS will be less than 100% of the $PM_{2.5}$. The RCS model results are therefore considered to be conservative (high).
- The background ambient air particulate concentrations are not site-specific; refer Section 4.4. Although considered unlikely, there is potential for the background levels to be higher than the applied model data. In this case, the model may under-predict the actual ambient dust concentrations arising from the quarry operation. The highest risk of exceedence of ambient air quality criteria at a sensitive receptor site is for PM_{10} with 24 hour averaging period. If the background 24 hour average PM_{10} concentration applied was the 90^{th} percentile from the Alphington data set, i.e. 29 $\mu g/m^3$ (instead of the 70^{th} percentile of 19.9 $\mu g/m^3$), the maximum PM_{10} concentration predicted at the nearest sensitive receptor is approximately 39 $\mu g/m^3$. This is still lower than the ambient criterion of 50 $\mu g/m^3$.
- Hourly meteorological data for 3 years were applied for the assessment, which was judged to be satisfactory as an input for the assessment. Selection of the meteorological data for assessment was determined by: incorporation of site specific observation data in the model inputs, showing that the three years of meteorological data were representative of long term historical data, and focussing the assessment on the model year with wind patterns expected to present the highest risk to sensitive receptors.

The study results demonstrate that dust mitigation measures will be critical in effectively managing emissions from the quarry operations and minimising the risk of impact to surrounding sensitive receptors. In addition, the provision of a dust management plan, which identifies appropriate and site specific risk controls to reduce risks so far as reasonably practicable, as outlined in the GED, will be important.

10. References

AG (2012): Australian Government, National Pollutant Inventory, *Emission Estimation Technique Manual for Mining*, Version 3.1, January 2012

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Appendix A. Willatook Wind Farm Site Layout Diagrams

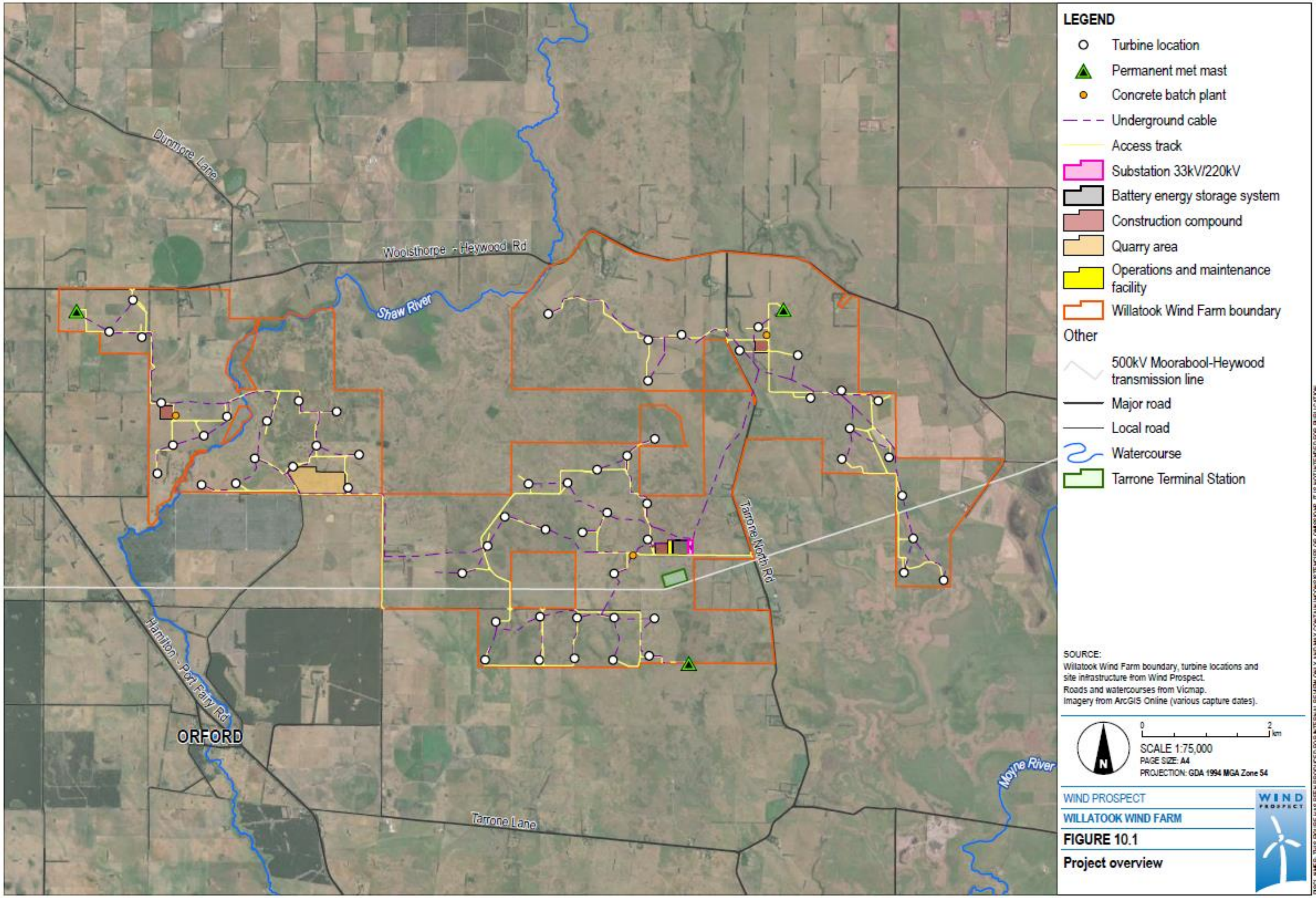

Figure 10-1: WWF Project – site overview

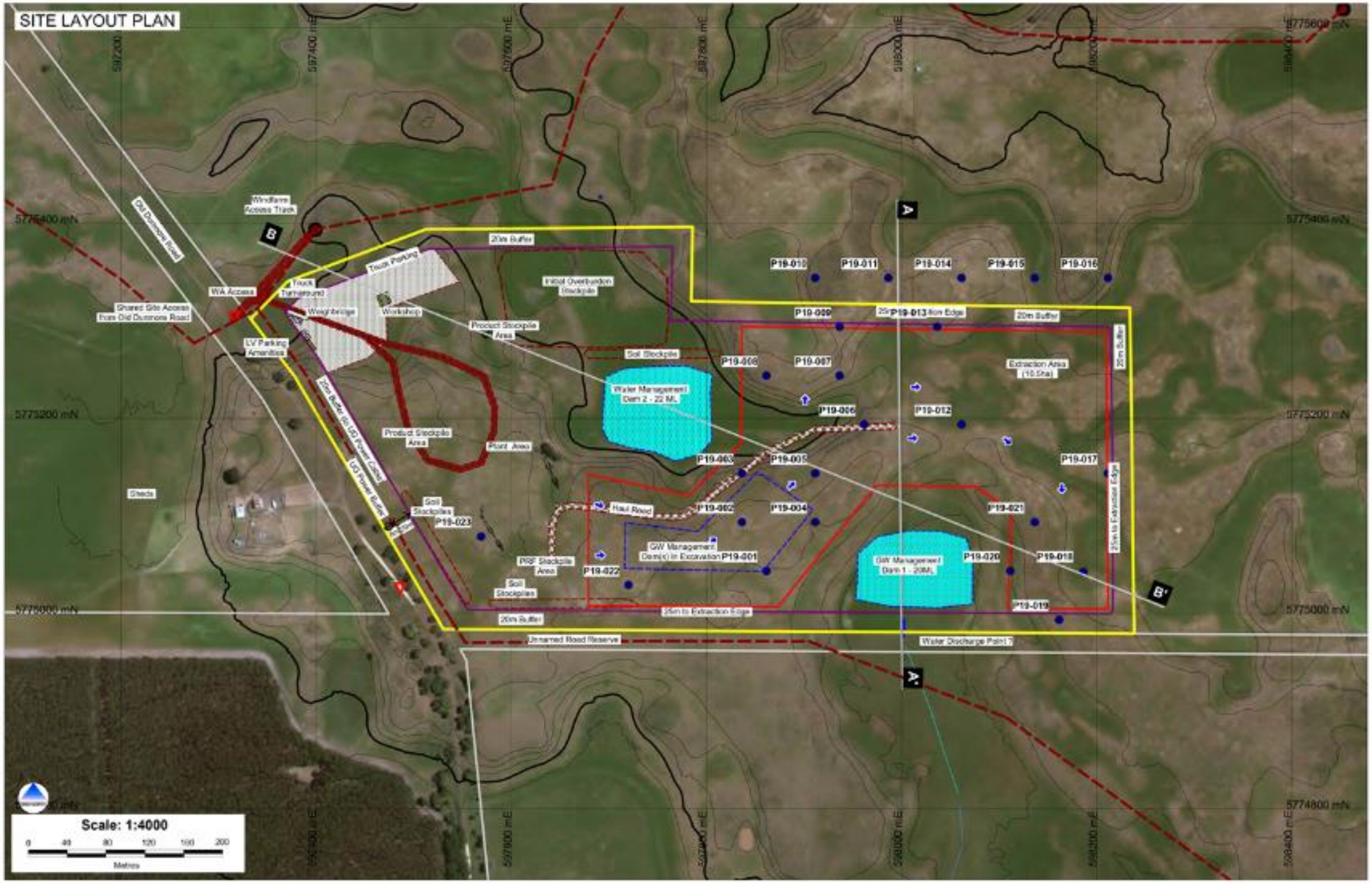

Figure 10-2: WWF quarry site layout

Appendix B. Wind Roses

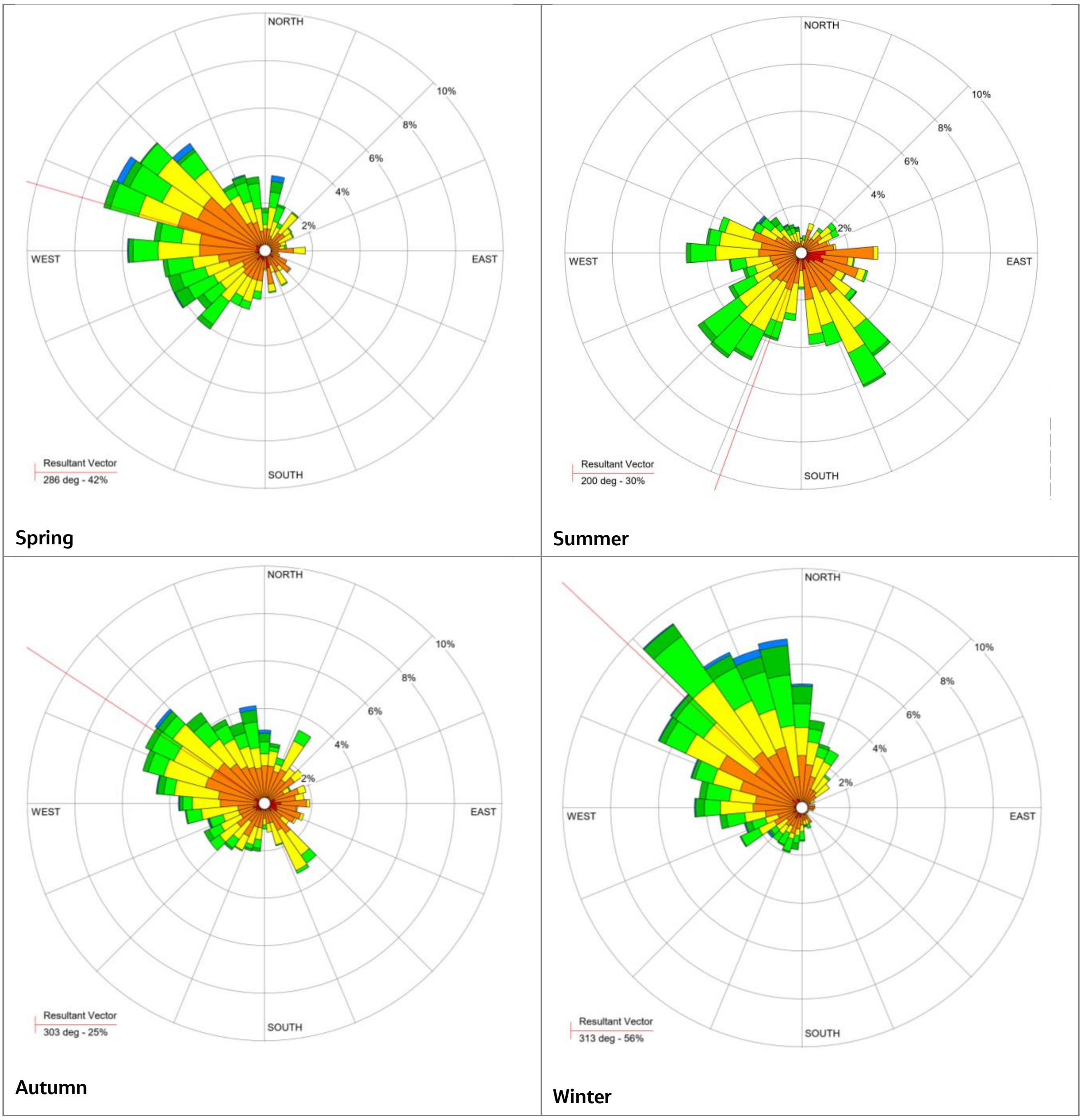

Figure 10-3: Modelled seasonal wind roses, year 2019, at proposed quarry site

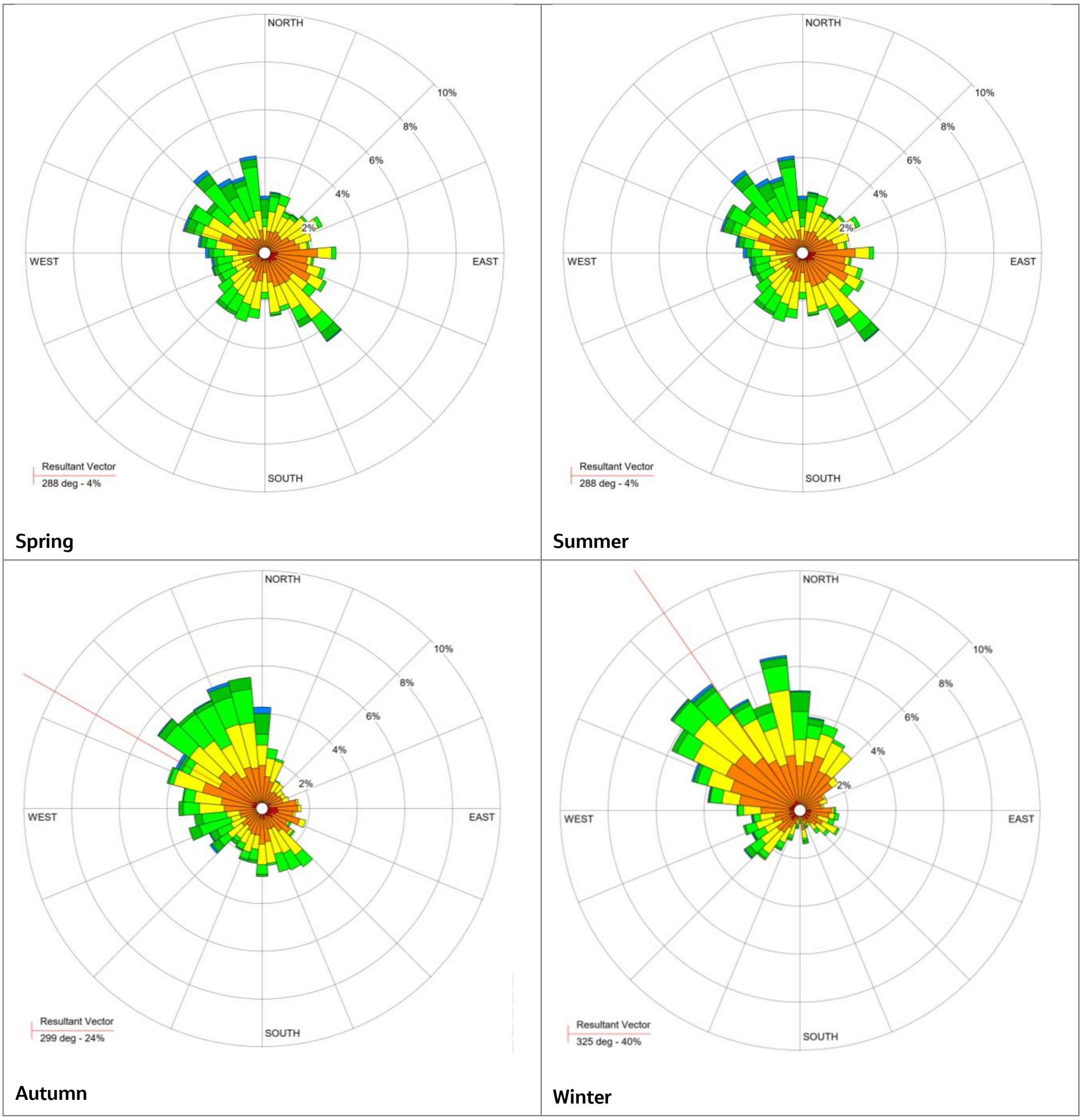

Figure 10-4: Modelled seasonal wind roses, year 2020, at proposed quarry site

Appendix C. Emission Factors and Equations

Table C-1: Emission factors and equations

Emission activity	TSP EFs	PM_{10} EFs	$PM_{2.5}$ EFs	Reference
Excavators loading overburden and rock to trucks and to mobile crusher (kg/tonne)	$EF\ (TSP) = 0.74\ \times 0.0016\ \times \frac{(U/_{2.2})^{1.3}}{(M/_{2})^{1.4}}$	$EF\ (PM_{10}) = 0.35\ \times 0.0016\ \times \frac{(U/_{2.2})^{1.3}}{(M/_{2})^{1.4}}$	5% of TSP	AG (2012), Appendix A, Section 1.1.2
Wheel generated dust (industrial sites), kg/VKT	$1.38 \times (s/12)^{0.7} \times (0.37*W)^{0.45}$	$0.42 \times (s/12)^{0.9} \times (0.37*W)^{0.45}$	5% of TSP	AG (2012), Table 2
Unloading overburden to dumps (kg/tonne)	0.012	0.0043	5% of TSP	AG (2012), Appendix A, Section 1.1.6
Drilling rock (kg/hole)	0.59	0.31	5% of TSP	AG (2012), Table 2
Blasting rock (kg/blast)	$0.00022 \times A^{1.5}$	$0.000114 \times A^{1.5}$	5% of TSP	AG (2012), Table 2
Loading crushers and loading stockpiles via conveyors	$EF\ (TSP) = 0.74\ \times 0.0016\ \times \frac{(U/_{2.2})^{1.3}}{(M/_{2})^{1.4}}$	$EF\ (PM_{10}) = 0.35\ \times 0.0016\ \times \frac{(U/_{2.2})^{1.3}}{(M/_{2})^{1.4}}$	5% of TSP	AG (2012), Appendix A, Section 1.1.2
Primary crushing (kg/tonne)	0.01	0.004	5% of TSP	AG (2012), Table 3
Secondary crushing (kg/tonne)	0.03	0.012	5% of TSP	AG (2012), Table 3
Screening (kg/tonne)	0.03	0.01	5% of TSP	AG (2012), Table 3
Wind erosion of active stockpiles and exposed areas (kg/ha/hr)	0.10	0.05	0.0075	USEPA (1985 and updates)

Abbreviations:

s = silt content in % (by weight)

M = moisture content in % (by weight)

A = area blasted in m^2

W = vehicle gross mass in tonnes

VKT = vehicle kilometres travelled

S = mean vehicle speed in km/h

U = mean wind speed in m/s

Appendix D. AERMOD Input File

```
** AERMOD Input Produced by:
** AERMOD View Ver. 9.8.3
** Lakes Environmental Software Inc.
** Date: 01/06/2021
** File: Willatook
**
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**
**
****************************************
** AERMOD Control Pathway
****************************************
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   TITLETWO PM10 2018 Run 1
   MODELOPT DFAULT CONC
   AVERTIME 1 24 PERIOD
   POLLUTID PM_10
   RUNORNOT RUN
   ERRORFIL Willatook_1.err
CO FINISHED
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****************************************
** AERMOD Source Pathway
****************************************
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SO STARTING
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** Source ID - Type - X Coord. - Y Coord. **
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   LOCATION S002    VOLUME    597716.401 5775322.251    91.140
   LOCATION S003    VOLUME    597918.912 5775253.740    96.630
   LOCATION S004    VOLUME    598022.230 5775252.250    95.330
   LOCATION S005    VOLUME    598124.800 5775251.499    93.560
   LOCATION S006    VOLUME    597847.045 5775051.599    95.550
   LOCATION S007    VOLUME    597523.985 5775066.954    97.230
   LOCATION S008    VOLUME    597653.509 5775009.303    96.850
   LOCATION S009    VOLUME    597743.722 5775266.467    92.090
   LOCATION S010    VOLUME    597532.598 5775208.076    96.080
   LOCATION S011    VOLUME    597747.000 5775051.000    97.900
   LOCATION S012    VOLUME    597553.190 5775314.010    91.090
   LOCATION S013    VOLUME    597604.845 5775120.106    96.840
   LOCATION S014    VOLUME    597583.132 5775079.681    96.280
   LOCATION S015    VOLUME    597641.704 5775077.215    95.65
   LOCATION S016    VOLUME    597715.375 5775103.664    96.46
   LOCATION S017    VOLUME    597806.508 5775121.524    94.90
   LOCATION S018    VOLUME    597887.500 5775177.311    94.53
   LOCATION S019    VOLUME    597983.869 5775189.039    95.20
   LOCATION S020    VOLUME    598082.662 5775187.962    92.07
   LOCATION S021    VOLUME    598161.226 5775145.917    94.61
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   LOCATION S024    VOLUME    597649.019  5775192.352     94.58
   LOCATION S025    VOLUME    597642.586  5775251.081     93.63
   LOCATION S026    VOLUME    597357.782  5775317.315     90.42
   LOCATION S027    VOLUME    597444.111  5775286.923     92.87
   LOCATION S028    VOLUME    597531.821  5775261.476     93.35
   LOCATION S029    VOLUME    597582.760  5775197.389     96.17
   LOCATION S030    VOLUME    597524.159  5775155.009     97.92
   LOCATION S031    VOLUME    597483.687  5775231.658     96.16
** Source Parameters **
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   SRCPARAM S003     1.0     2.000      9.302     0.500
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   SRCPARAM S030     1.0     2.000     15.000     0.500
   SRCPARAM S031     1.0     2.000     15.000     0.500
   HOUREMIS EMISS1_PM10.VRE S001-S031

   CONCUNIT 1000000 g/s µg/m³
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   SRCGROUP HAUL     S021 S022 S023 S024 S025 S026
   SRCGROUP HAUL     S027 S028 S029 S030 S031
   SRCGROUP ALL
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  DISCCART   602966.22   5769562.37   67.91   67.91
  DISCCART   600933.84   5769675.21   63.13   63.13
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  DISCCART   597946.40   5769696.47   65.26   65.26
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   PLOTFILE 1 HAUL 1ST 01H1G001.PLT
   PLOTFILE 24 ALL 1ST 24H1GALL.PLT
   PLOTFILE 24 HAUL 1ST 24H1G001.PLT
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** DTMRGN   Australia
** UNITS    m
** ZONE     -54
** ZONEINX  0
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