Central Eyre Iron Project
Environmental Impact Statement

Appendix J

Air Quality Assessment

Central Eyre Iron Project

IRON ROAD LIMITED

Air Quality Impact Assessment – Infrastructure

Revision 0

Client Document Number: E-F-34-RPT-0040_0

31 March 2015

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Central Eyre Iron Project

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Abbreviations and Glossary of Terms

Aerodynamic diameter	Diameter of a spherical particle with density 1.0 g/cm^3 with the same aerodynamic resistance (therefore settling velocity) as a dust particle under study
AS/NZS	Australian Standard/New Zealand Standard
BoM	Bureau of Meteorology
CEIP	Central Eyre Iron Project
CEIP Infrastructure	Port, railway line, pipeline, transmission line, borefield and employee village associated with the proposed CEIP
CO	Carbon monoxide (molecular formula)
DEC	Department of Environment and Conservation (NSW, 2005)
Deposited dust	Total particulate matter deposited to the ground surface, usually reported in units of g/m^2/month. The relevant measurement is insoluble solids as defined by Australian Standard, AS/NZS 3580.10.1–2003. Note DEC (2005) cites an earlier (1991) version of the standard.
DGLC	Design Ground Level Concentration
DMITRE	Department for Manufacturing, Innovation, Trade, Resources and Energy Government of South Australia
Dust	In this report the generic term ‘dust’ is used for airborne or deposited dust particles of any size.
DWT	Dead weight tonnage, the carrying capacity of a vessel in tonnes
EETM	Emission Estimation Technique Manual
EPA	Environment Protection Authority (South Australia)
g/m^2/month	Grams per square metre per month
g/sec	Grams per second
JORC	Joint Ore Reserves Committee
km	Kilometres
km/h	Kilometres per hour
µg/m^3	Micrograms per cubic metre
µm	Micron (thousandth of a millimetre)
m	Metres
Mtpa	Mega (million) tonnes per annum
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NO_2	Nitrogen dioxide (molecular formula)
NO_x	Oxides of nitrogen (molecular formula)
NPI	National Pollutant Inventory
$PM_{2.5}$	Particulate Matter 2.5 – mass concentration of airborne particulate matter comprising a collection of particles with aerodynamic diameters less than 2.5 microns.

PM_{10}	Particulate Matter 10 – mass concentration of airborne particulate matter comprising a collection of particles with aerodynamic diameters less than 10 microns.
Proposed borefield	The CEIP borefield near Kielpa
Proposed infrastructure corridor	Incorporates the proposed railway line, rail access road, road crossings and realignments, water pipeline, borefield and transmission line between the mine site and the port site
Proposed long term employee village	The long term accommodation for Iron Road's mine site workforce at Wudinna
PSD	Particle Size Distribution
SO_2	Sulphur dioxide (molecular formula)
t/h	Tonnes per hour
TAN	Technical / Advice Note (Iron Road)
TEOM	Tapered Element Oscillating Microbalance
TSP	Total Suspended Particulates – total mass concentration of airborne particulate matter comprising a collection of particles with aerodynamic diameters up to approximately 30-50 microns.
WGD	Wheel Generated Dust (NPI term)
VKT	Vehicle Kilometres Travelled (NPI term)
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound

Executive Summary

This report presents the results of an air quality impact assessment carried out for Iron Road Limited's proposed Central Eyre Iron Project (CEIP) infrastructure ('the Project'); incorporating a proposed port, railway line, pipeline, transmission line, borefield and long term employee village.

The air quality impact assessment for the proposed port was based on a dust dispersion modelling study undertaken in accordance with the South Australian Environmental Protection Authority (EPA) Guidelines: *Air quality impact assessment using design ground level pollutant concentrations (DGLCs)*, EPA 386/06; and *Presentation of air pollution modelling outputs*, EPA 578/05.

The air quality assessment for the infrastructure corridor was undertaken using a qualitative approach, though it included the application of air dispersion modelling of the worst case locomotive operations, for representative receptor locations near a proposed railway line.

The assessment's main tasks included:

- identification of key air emissions sources from activities expected to be associated with the CEIP infrastructure operations;
- calculation of dust particle source terms for modelling;
- meteorological modelling using the 'TAPM' and 'CALMET' models; and
- dust particle dispersion modelling using 'CALPUFF'.

A number of air emissions scenarios were set out for modelling at the port site based on the main proposed modes of operation at the port and their associated activities.

The key air quality indicators identified for the project were associated with dust emissions including PM_{10}, $PM_{2.5}$, TSP and dust deposition (these terms are defined in the Glossary). In the assessment, model predicted ground-level concentrations for these indicators were compared with ambient air quality standards. The key ambient air quality standards adopted for the project were the National Environment Protection Measures (NEPMs) for PM_{10} and $PM_{2.5}$.

Air dispersion modelling of worst-case dust emissions from the proposed port operation showed that airborne particle concentrations (PM_{10} and $PM_{2.5}$) would comply with air quality standards at all sensitive receptors outside the port site boundary. This was achieved by the minor modification of operational activities for approximately 100 hours during the year using dust and meteorological forecasting tools.

The air dispersion modelling showed that no nuisance dust impacts are expected from dust deposition outside the port site boundaries, at any of the sensitive receptors.

The results of a qualitative assessment indicated that no air quality impacts would be expected to occur from combustion emissions at the port site or along the infrastructure corridor, during construction and later, during operations at the port.

1. Introduction

1.1 Background

The proposed Central Eyre Iron Project (CEIP) is South Australia's largest iron ore project and the second largest resources project in South Australian history behind Olympic Dam.

The CEIP is expected to produce 21.5 million tonnes per annum (Mtpa) of iron concentrate at full capacity, over an expected mine life of 25 years. CEIP includes development of an iron ore mine and process facility in the central Eyre Peninsula, a bulk export port facility at Cape Hardy on the east coast of the Eyre Peninsula, and an infrastructure corridor connecting the mine and port site. The infrastructure corridor would include a standard-gauge, heavy haul railway line, maintenance track and a water supply pipeline. Augmentation of the existing electrical transmission network would also be required to provide power to the proposed mine.

The CEIP consists of five key project components:

1) **Mine** – the mine site includes an open pit excavation, with on-site processing plant and waste rock handling. The processing plant includes metallurgical facilities, crushing, grinding and milling facilities, tailings handling and retention. Additional onsite infrastructure includes a small desalination plant for potable water supply, temporary and permanent camps for accommodation, workshops, warehouses, security, emergency services and rail infrastructure including a rail loop and train loading facility. Production of 21.5 Mtpa of iron concentrate is proposed with sufficient resource for a mine life of at least 25 years.
2) **Long term employee village** – long term accommodation for the mine site workforce is proposed to be located at Wudinna, approximately 26 km north-west of the mine site.
3) **Infrastructure corridor** – the infrastructure corridor connects the mine site with a port facility at Cape Hardy and is approximately 130 km in length[1]. Spanning the length of the infrastructure corridor is a standard gauge heavy railway line to transport iron concentrate from the mine to the port. Running parallel to the railway line in the northern section of the infrastructure corridor will be a water supply pipeline. An electricity transmission line will also be included along part of the corridor. The corridor will incorporate ancillary infrastructure such as a service road, laydown areas and pump stations to support the railway line, transmission line and water pipeline.
4) **Proposed borefield** – borefield located approximately 60 km from the proposed mine and 7.5 km west of Kielpa to supply saline groundwater for use in processing at the mine site.
5) **Port** – the port is proposed at a greenfield site, approximately 7 km south of Port Neill[2] in an area known as Cape Hardy. The site provides a natural deep water location with no dredging required. The port has been designed to have capacity to export 70 Mtpa, of which 21.5 Mtpa would be used by Iron Road. The port will support Panamax and Capesize vessels, with a 1.3 km jetty structure that incorporates a tug harbor, module off loading facility and wharf. Onshore, the port facility will incorporate material handling facilities, car parking and internal access roads, stormwater management and ancillary facilities including an administration building, emergency services building, control room(s), warehouse, maintenance workshop, ablutions facility and crib room, laboratory and fuel storage. Temporary construction workforce accommodation will also be located at the port site during construction of the port and infrastructure corridor. The proposed development is for infrastructure to support Iron Road's operations of 21.5 Mtpa. Any additional infrastructure or activities proposed by third party users of the port facility would be subject to a separate approvals process.

CEIP infrastructure includes all project components except for the proposed mine.

[1] Measured from the boundary of the mining lease to the boundary of the port site
[2] Measured from the approximate centre of Port Neill to the centre of the proposed port facility

1.2 Scope of Works

1.2.1 Overview

This assessment report considers air quality impacts associated with the construction and operation of the CEIP infrastructure. A separate air quality assessment report addresses air quality impacts from the proposed mine.

The scope of works of the air quality impact assessment for the proposed CEIP infrastructure is detailed in the following list of tasks:

- Detailed air quality impact assessment of the proposed port operations based on air dispersion modelling. The assessment used standard emissions estimation techniques for key dust sources such as train unloading, conveyors, an open stockpile, and ship-loading.
- Qualitative air quality impact assessment of non-dust particle emissions expected from other sources associated with the proposed port operation; e.g., emissions from diesel engine powered equipment.
- Qualitative air quality impact assessment of air emissions from the proposed infrastructure corridor, being a proposed railway line between the mine site and the port site. Although described as qualitative, this assessment made use of dispersion modelling to assist in providing support to the assessment.
- Qualitative assessment of the potential air emissions from CEIP infrastructure construction works.

1.2.2 Air quality impact assessment – port operations

This section describes the dust modelling study component of the air quality impact assessment for the port site. The main tasks of the assessment were:

1) Identification of key air (dust particle) emissions sources;
2) Identification of key environmental (ambient air quality) indicators;
3) Description of the existing environment;
4) Calculation of dust emissions estimates;
5) Meteorological modelling;
6) Dust dispersion modelling; and
7) Assessment of ambient air quality impacts by comparing model predictions with environmental indicators.

Key dust emissions sources associated with this Project were identified and air emissions estimates determined based on techniques set out in the National Pollutant Inventory (NPI) *Emission Estimation Technique Manual (EETM) for Mining* Version 3.1, January 2012. These are discussed in detail in Section 3.3.

Environmental effects and ambient air quality standards relevant for the port site are identified and set out in Section 3. Air quality standards for the infrastructure corridor are provided in Section 4.

In the absence of available local climatology and air quality data, the existing environment was described based on the nearest coastal Bureau of Meteorology observing station at Port Lincoln (North Shields) and particulate data provided by EPA South Australia.

The dust dispersion modelling study included meteorological modelling for the port site using the CSIRO Marine and Atmospheric Research model, TAPM; e.g., see Hurley (2008). The case study year selected for the assessment was 2009, considered to be representative of a wide range of weather conditions for South Australia.

Dust dispersion modelling was undertaken with ‘CALPUFF’ (Earth Tech 2000a; Earth Tech 2000b), which produced predictions of spatial distributions for the following environmental indicators:

- Ground level concentrations of PM_{10} and $PM_{2.5}$ for the assessment of human health impacts[3];
- Annual average TSP concentrations as an indicator for nuisance dust;
- Annual dust depositions as an indicator for nuisance dust as determined by modelled TSP fluxes to the ground surface.

1.2.3 Assessment of other (non-dust) emissions from port operations

A qualitative air quality impact assessment was undertaken investigating the potential air quality effects from other (non-dust) air emissions sources associated with the proposed port operations; e.g., gaseous emissions from ship exhausts, while berthed, and ancillary diesel equipment items.

Air pollutant emissions from the non-dust sources at the port site were not included as part of the quantitative (air dispersion modelling) component of the assessment. The gaseous and particle emissions from the relatively few stationary engines and vehicle engine exhausts on the proposed port site are expected to have an insignificant impact on local air quality. The emissions from combustion engines associated with the port site's vehicle fleet and other equipment is relatively small in comparison with, for example, the road vehicle fleets in cities where these emissions have a significant air quality impact on the urban environment.

1.2.4 Infrastructure corridor

An air quality impact assessment was undertaken for activities associated with the operation of the infrastructure corridor. This included a review of combustion emissions from locomotives and air dispersion modelling was undertaken for four receptor sites used to represent locations adjacent the railway line experiencing worst case air quality impacts.

Potential emissions from the infrastructure corridor and their predicted impacts are discussed in Section 4.

1.2.5 Construction CEIP infrastructure

Construction works at the port site, the long term employee village, the borefield, and the infrastructure corridor will cause dust emissions from, for example, the movements of heavy earth moving equipment. However these dust emissions are expected to be mitigated by the implementation of dust emissions controls such as the use of water carts. Details of the dust controls will be set out in the future as part of a construction environmental management plan.

The air pollutant emissions from other air emissions sources during construction; e.g., vehicle and machinery engine exhausts are expected to be insignificant with respect to potentially causing exceedances of ambient air quality standards. This is due to the relatively small fleet of vehicles and diesel fuel powered equipment associated with construction. Also, the existing (background) concentrations of the criteria pollutants, e.g. carbon monoxide, nitrogen dioxide etc., are expected to be very low. A qualitative assessment of the potential air emissions from construction works is set out in Section 5.

[3] Definitions for 'PM_{10}', $PM_{2.5}$' and other abbreviations are provided in 'Abbreviations and Glossary of Terms'.

2. Project Description

2.1 Port Facility

The proposed bulk export port site at Cape Hardy is located approximately 7 km south of Port Neill and 73 km north of Port Lincoln, on the Eyre Peninsula. The site area occupies approximately 1,100 hectares. The Cape Hardy location on the Eyre Peninsula is shown in Figure 2-1.

The proposed materials handling system at the port site comprises: a rail unloading facility; concentrate stockpile; and a ship loader on the jetty, all of which are connected by a series of conveyors and machinery to transport the iron concentrate. The proposed layout of the port site, showing key infrastructure items associated with dust emissions, is shown in Figure 2-2.

The rail unloading facility would be located at the north-western side of the site and the concentrate stockpile would be located to the south-west of the rail unloading facility. From the rail unloading facility, the conveyor system transfers the concentrate to the stockpile for storage. The stockpile is reclaimed and the concentrate transferred to the ship loader for loading onto ships.

A simplified schematic of the materials handling process is shown in Figure 2-3.

Figure 2-1: Eyre Peninsula showing port site (Cape Hardy) location

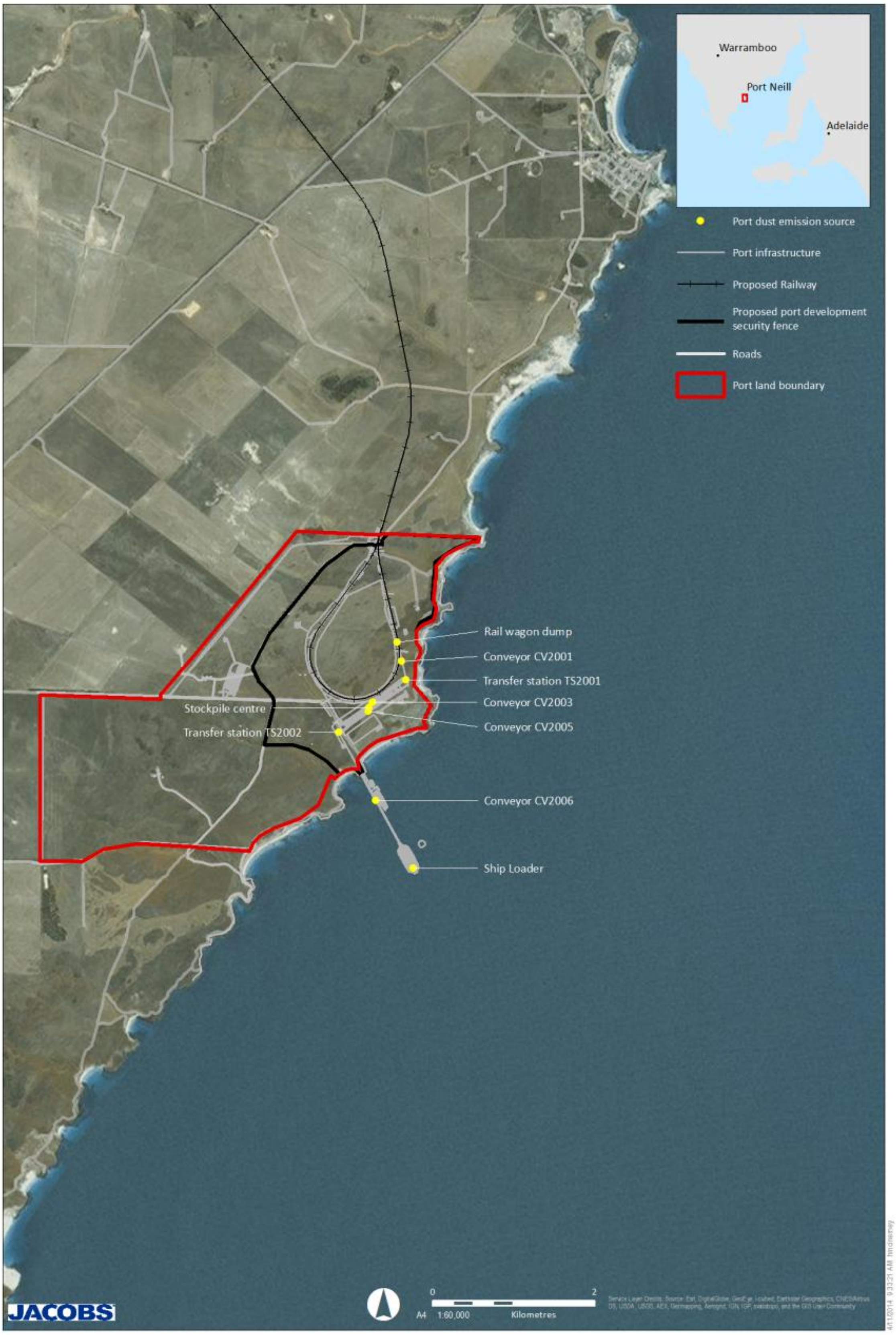

Figure 2-2: Port site layout, showing key infrastructure items associated with dust emissions

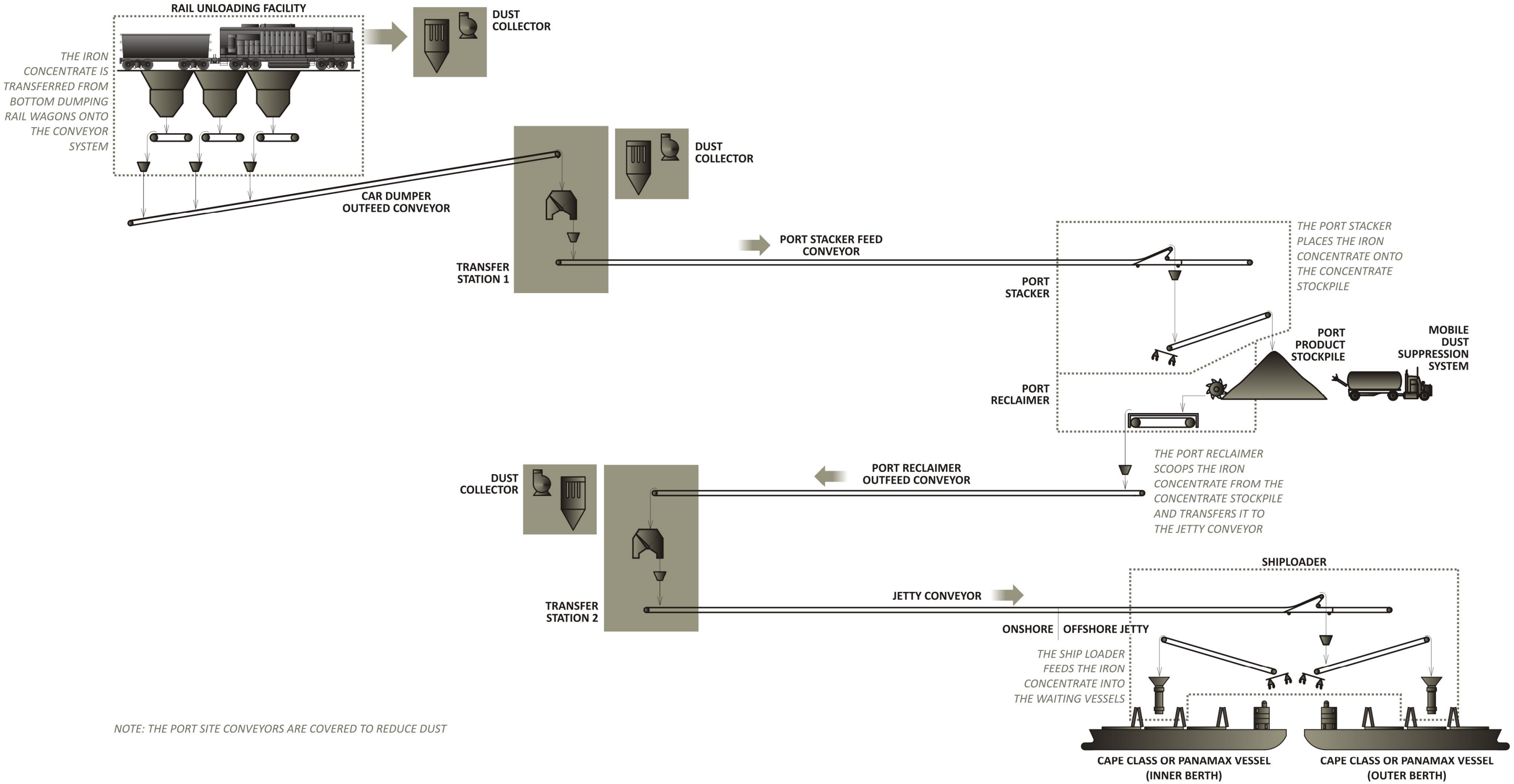

Figure 2-3: Simplified process flow diagram of port material handling operations

2.1.1 Rail unloading facility

A rail unloading facility is proposed to enable unloading of the concentrate from the rail wagons. The rail unloading facility will be an independent structure, approximately 20 m wide by 40 m long, with the majority of the structure located below the railway line level.

The unloading facility uses a triple cell bottom car dumper to transfer the material into three receiving hoppers below rail level. Underneath each hopper is a belt feeder, which will transfer iron concentrate from the hopper to the car dumper outfeed conveyor, CV2001. The car dumper will be enclosed to limit noise and dust generation.

There will be a dust collection system with air intakes located at the conveyor loading points. It will draw air through filters in order to collect escaping dust into a set of hoppers. This dust will then be returned to the material stream.

2.1.2 Stockpile conveyor system (from rail unloading facility to stockpile)

The car dumper outfeed conveyor (CV2001) will transfer material from the rail unloading facility to the Transfer Station TS2001, and is approximately 480 m long. From the transfer station TS2001, the concentrate is directed via the stacker feed conveyor (CV2003) onto the travelling boom stacker where it is added to the stockpile. The stacker feed conveyor is approximately 995 m long.

2.1.3 Concentrate stockpile

The port facility will have a single concentrate stockpile. Concentrate is delivered to the stockpile via the stacker feed conveyor (CV2003), tripper and boom stacker. Material is deposited in the form of a continuous prism approximately 44 m wide at the base. The approximate length of the stockpile is 960 m.

There will be a road on either side of the stockpile to allow access for water trucks with spray cannons for use on the stockpile. The water spray will contain chemicals to allow a veneer to be applied to the stockpile to reduce dust emissions.

2.1.4 Ship loading conveyor system (from stockpile to jetty)

The concentrate stockpile is reclaimed by a travelling bucket-wheel bridge reclaimer, which can operate from either end of the stockpile. The wheel reclaims from the base of the stockpile and travels from side to side to reclaim concentrate from across the full width of the stockpile.

A conveyor located on the reclaimer bridge loads concentrate to the port reclaim outfeed conveyor (CV2005) along the side of the stockpile to transfer station TS2002. The outfeed conveyor is approximately 900 m in length. From there, the concentrate is transferred to the jetty conveyor CV2006, which transfers concentrate to the ship loader. The jetty conveyor is approximately 1920 m long.

2.1.5 Transfer stations

There are two transfer stations at the port facility; TS2001 and TS2002. The transfer stations are designed to enclose the conveyor transfer chutes where concentrate is transferred from one conveyor to the next. Each transfer station is within a fully enclosed building with dust extraction. Access to the buildings for vehicles will be by roller doors which will be closed during normal operations. The buildings are approximately 26 m in height.

2.1.6 Ship loader

A ship loader will be located at the end of the jetty. The ship loader is designed to load bulk carriers from smaller Panamax vessels with a capacity of 60,000 Dead Weight Tonnage (DWT), to Capesize vessels with capacity 210,000 DWT.

The ship loader is able to travel, luff and slew to reach loading hatches on any of the vessels serviced by the port facility. The ship loader's travel limits will be approximately 240 m, with a reach of approximately 50 m.

2.2 Infrastructure Corridor

The infrastructure corridor connects the mine site with the port site. The infrastructure corridor is approximately 130 km in length and will vary in width between approximately 60 - 110 m wide

Spanning the length of the infrastructure corridor is a standard gauge heavy railway line to transport iron concentrate from the mine to the port. Twelve train movements per day (six loaded and six unloaded) are planned.

Running parallel to the railway line in the northern section of the infrastructure corridor will be a water supply pipeline. The water pipeline will pump water from the proposed borefield to the mine site.

A 275kV transmission line will join the infrastructure corridor at its intersection with the existing ElectraNet transmission line, approximately 8 km north-west of Rudall. This transmission line originates from the existing Yadnarie substation and will run west, parallel to the existing ElectraNet transmission line, before joining the infrastructure corridor and continuing to the mine site.

The corridor also incorporates ancillary infrastructure such as a 10 m wide service road, laydown areas and pump stations to support the railway line, transmission line and water pipeline.

2.2.1 Rail operation

The standard iron concentrate train will consist of two locomotives and 138 wagons. Each wagon has a volumetric capacity of 40 m^3 (78 tonnes at concentrate density of 2.1 t/m^3) and the total train product capacity will be 10,750 tonnes of concentrate. The total length of the train will be approximately 1.3 km.

For a train consisting of 138 wagons, the annual mine production rate dictates that six loaded trains must run from the mine site to the port site per 24 hour period. A maximum speed limit of 60 km/h will be enforced for loaded trains and 80 km/h for unloaded trains. The train will enter and exit the mine and port yards at approximately 10 km/h.

Each wagon (width 3.2 m and length 9 m) is to be fitted with a full cover to prevent dust emissions off the loaded concentrate.

3. Port Facility Air Quality Assessment

3.1 Ambient Air Quality Standards

The key ambient air quality indicators for the assessment for the port site are: for the protection of human health, Particulate Matter of equivalent aerodynamic size less than 10 µm (PM_{10}) and $PM_{2.5}$; and for the protection of amenity, Total Suspended Particulates (TSP) and dust deposition. This section sets out the ambient air quality standards (or criteria) used in this assessment, for these indicators.

3.1.1 Project ambient air quality criteria

In South Australia, air quality indicators and ambient air quality or 'design' criteria are specified in the Environment Protection Authority (EPA) guidance document, *EPA 386/06, Air quality impact assessment using design ground level pollutant concentrations (DGLCs), Updated January 2006* (EPA, 2006). While EPA (2006) does not list design criteria for particulate matter, there is a requirement to source appropriate alternatives. The *National Environment Protection (Ambient Air Quality) Measure* (NEPM) standards and guidelines for PM_{10} and $PM_{2.5}$ were adopted for the project (National Environment Protection Council, 2003).

The NSW Department of Environment and Conservation (DEC) standards and guidelines for TSP and deposited dust were adopted for the project for the protection of amenity from nuisance dust (DEC, 2005). The adoption of these standards for the Iron Road project was in accordance with discussions held between EPA, DMITRE, Iron Road and SKM throughout 2013.

The ambient air quality standards adopted for the Project are set out in Table 3-1 (NEPC, 2003); and Table 3-2 (DEC, 2005).

Table 3-1: Adopted project criteria for the protection of human health from airborne particles (NEPC, 2003)

Assessment Parameter	Averaging Period	Max GLC, including background	Goal (maximum allowable exceedances)
PM_{10}	24 hours	50 $\mu g/m^3$ (NEPM)	5 days a year
$PM_{2.5}$	24 hours	25 $\mu g/m^3$ (NEPM)	Not specified
$PM_{2.5}$	Annual	8 $\mu g/m^3$ (NEPM)	Not specified

Table 3-2: Adopted project criteria for nuisance dust (DEC, 2005)

Assessment Parameter	Averaging Period	Maximum including background level	Notes:
TSP	Annual	90 $\mu g/m^3$	Nil
Dust deposition	Annual	4 g/m^2/month [1]	Maximum total deposited dust level
	Annual	2 g/m^2/month [1]	Maximum increase in deposited dust level

Notes:

1. Dust is assessed as insoluble solids as defined by Australian Standard (AS); AS/NZS 3580.10.1:2003.

3.2 Existing Environment

This section provides a description of the existing Cape Hardy environment including the geographical setting and climatology.

3.2.1 Geographical setting

The proposed port site at Cape Hardy is centrally located on the east coast of the Eyre Peninsula (Latitude and Longitude; 34.18° S, 136.31° E), approximately 7 km south of Port Neill (34.12° S, 136.35° E). The nearest source of meteorological data is the Bureau of Meteorology's (BoM) Cleve Aerodrome weather station (No. 018014; 33.70° S, 136.49° E), located 47.7 km north-north-east, inland of Port Neill. The nearest coastal meteorological observing station is at Port Lincoln, 'North Shields' (BoM station number 018192; 34.72° S, 135.86° E), located approximately 80 km south-west of Port Neill.

A terrain map of the area surrounding the proposed port site is provided in Figure 3-1. The terrain elevations, from 0-150 m above sea level, are shown exaggerated in the vertical.

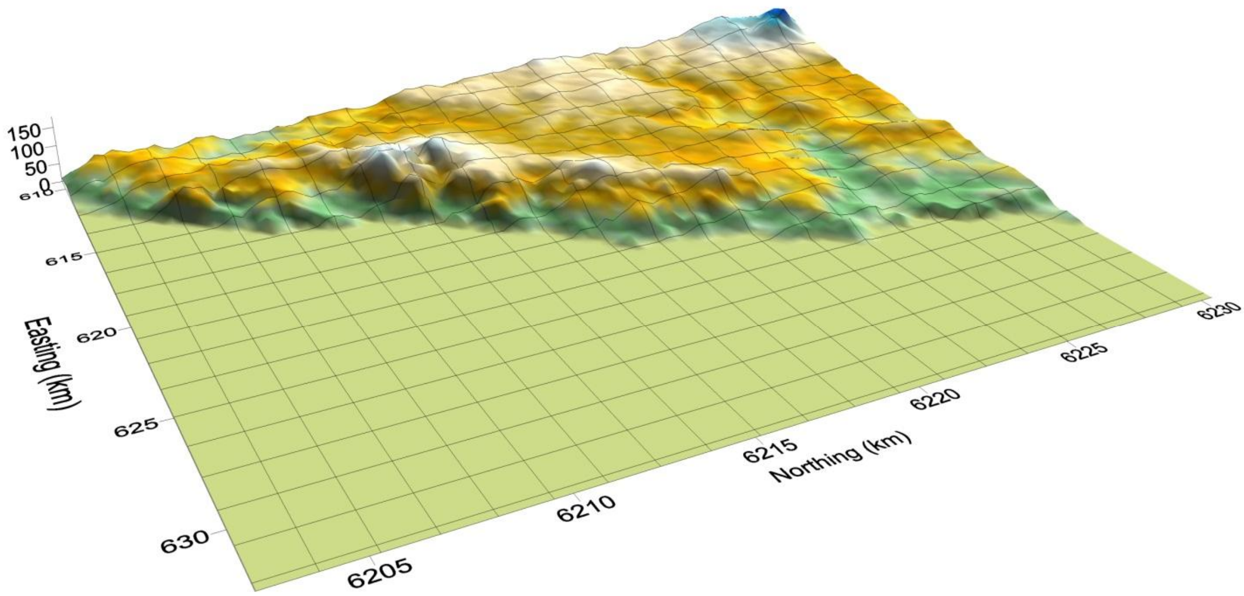

Figure 3-1: Port site terrain

3.2.2 Sensitive receptors and base map

The base map used for the air dispersion modelling study, for overlaying the CALPUFF modelling results, is shown in Figure 3-2. The base map design was in accordance with the guidance set out in EPA South Australia (2005) and EPA South Australia (2006). The co-ordinate system used is Map Grid of Australia 1994 (MGA94). The yellow markers shown represent the locations of the identified sensitive receptors in the vicinity of the proposed port site. The red line shows the boundary of the proposed port facility. Note that, at the time of writing, there was one dwelling outside and adjacent the port site boundary on the south-eastern side, located on the coastline (Receptor No.2). It is understood this land is owned by the local council.

The sensitive receptors have been identified at different stages of the project development and assessment process so are not sequential, however the same sensitive receptor numbers are used for the same sites in each CEIP environmental impact assessment report to allow cross-referencing, e.g. noise and air quality.

Figure 3-2 Port site base map and sensitive receptor locations

The distances between each of the identified receptors and the south-west end of the proposed concentrate stockpile (which represents the approximate centre of the emissions sources and is identified by the location of the transfer station TS2002 on Figure 2-2) are shown in Table 3-3.

Table 3-3 Sensitive receptor distances from the port site

Sensitive Receptor number (listed from south to north)	Description	Distance from south-west end of the proposed concentrate stockpile (km)
191	Dwelling	7.2
44	Dwelling	1.3
193	Dwelling	6.6
194	Dwelling	6.7
65	Dwelling	5.1
197	Dwelling	7.6
66	Dwelling	5.5
55	Dwelling	7.2
198	Dwelling	5.8
43	Dwelling	3.8
42	Dwelling	4.3

Sensitive Receptor number (listed from south to north)	Description	Distance from south-west end of the proposed concentrate stockpile (km)
75	Dwelling	5.8
76	Dwelling	6.2
40	Dwelling	6.1
229	Port Neill silos	6.3
205	Dwelling	7.0
203	Dwelling	7.1
53	Dwelling	7.0
54	Dwelling	7.1
51	Dwelling adjacent Sports field	7.4
Port Neill central	Port Neill centre	7.8
39	Dwelling	7.4
38	Dwelling	7.9
37	Dwelling	8.3
41	Dwelling	7.4
52	Dwelling	7.6

3.2.3 Climatological summaries

Although the Cape Hardy port site is located 73 km north of Port Lincoln, and in the absence of other quality datasets, the BoM Port Lincoln weather station (North Shields) was considered to provide the highest quality meteorological data most representative of conditions that would be experienced at the port site. There are similarities in the geographical settings between Cape Hardy and Port Lincoln; both are on the south-eastern coastline of Eyre Peninsula, and they have similar land use.

3.2.3.1 Meteorological Data 2009 - Comparisons between Cape Hardy and Port Lincoln

TAPM was used to generate 3-dimensional surface and upper-air temperatures, wind vectors, air pressures and other meteorological parameters as input into the dispersion model, CALPUFF. The meteorological data generated included 8,760 hourly average (one year) records for each meteorological parameters, covering a large study volume over the port site. Further details are provided in Section 3.4.2.

Comparisons between TAPM generated data for Cape Hardy (2009) and the BoM's observations at Port Lincoln (2009), for monthly average temperature and wind speed, are shown in Figure 3-3 and Figure 3-4. TAPM-generated meteorological data were extracted from three points for the port site: (1) Stockpile Centre; (2) Stockpile SW located 2 km west and 0.5 km south of the centre of the stockpile; and (3) Stockpile NW located 2 km west and 0.5 km north of the centre of the stockpile. The results from the three points were used to investigate any variability between the TAPM outputs.

Inspection of Figure 3-3 and Figure 3-4 shows that the TAPM output data and the Port Lincoln BoM data for 2009 are closely aligned for temperature. The TAPM estimates for wind speed at Cape Hardy are less than the wind speed observations at Port Lincoln, which may be due to Cape Hardy's more sheltered situation. As dust dispersion is worse for lower wind speeds, the adoption of lower wind speeds at Cape Hardy in the modelling is considered to be more conservative for the assessment.

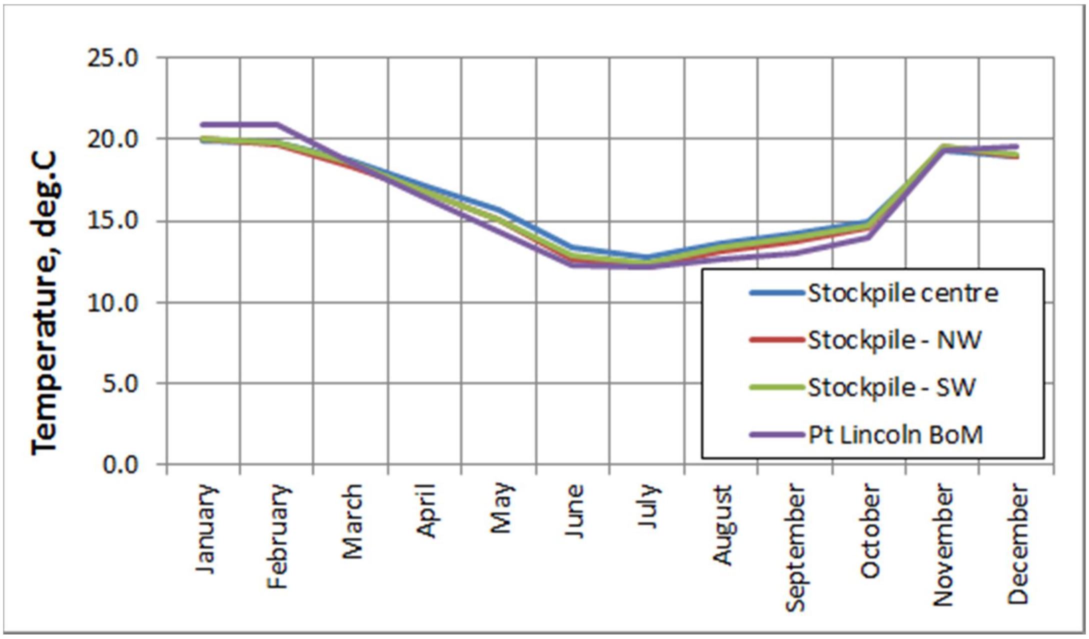

Figure 3-3: Monthly temperature: TAPM (Cape Hardy) and BoM (Port Lincoln)

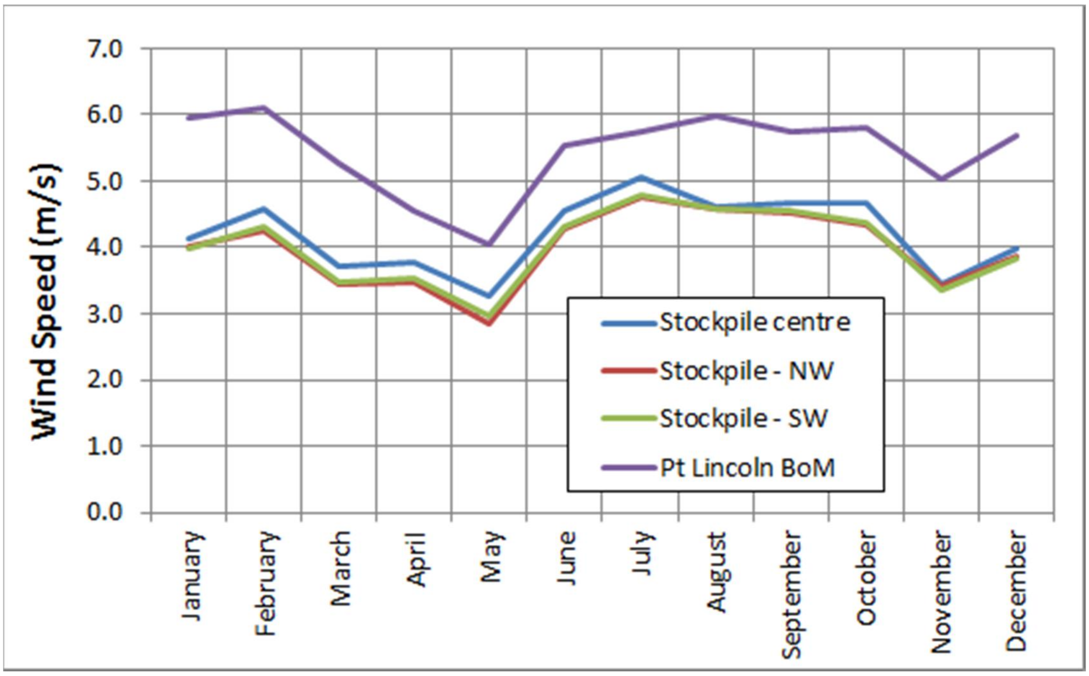

Figure 3-4: Monthly wind speed: TAPM (Cape Hardy) and BoM (Port Lincoln)

A wind rose created from the TAPM-generated hourly average wind data for near ground level at the port site and a corresponding wind rose generated from the BoM's wind observations at Port Lincoln (North Shields); are shown in Appendix A. Inspection of these wind roses shows the wind patterns compare well, especially as the locations are approximately 73 km apart. Westerly and south-easterly winds are dominant in both patterns seen in the wind roses, and again the higher wind speeds for Port Lincoln are clearly shown.

The comparisons between the wind roses, and the comparisons of the other modelled and measured parameters, provided strong evidence that the TAPM-generated data for Cape Hardy were of sufficient quality for the air dispersion modelling study for the site.

3.2.3.2 Long-term Climatological Summary – Port Lincoln

This section provides a more general review of the BoM's longer term climatological statistics determined from observations at Port Lincoln to gain an appreciation of the potential wider range of climate conditions that may be experienced at Cape Hardy.

Wind roses representing long-term (1992-2010) 9AM and 3PM wind observations at the Port Lincoln BoM weather station (018192) are provided in Appendix B, with the middle month of each season used to represent the season. Inspection of the wind roses shows that south-easterly winds are dominant in summer; easterly winds are dominant in spring and autumn; and north-westerly winds are dominant in winter.

Long-term BoM Port Lincoln observations of monthly mean maximum and minimum temperatures are provided in Figure 3-5. Relative humidity, rainfall and wind speed long term historical trends are provided in Figure 3-6 through to Figure 3-9.

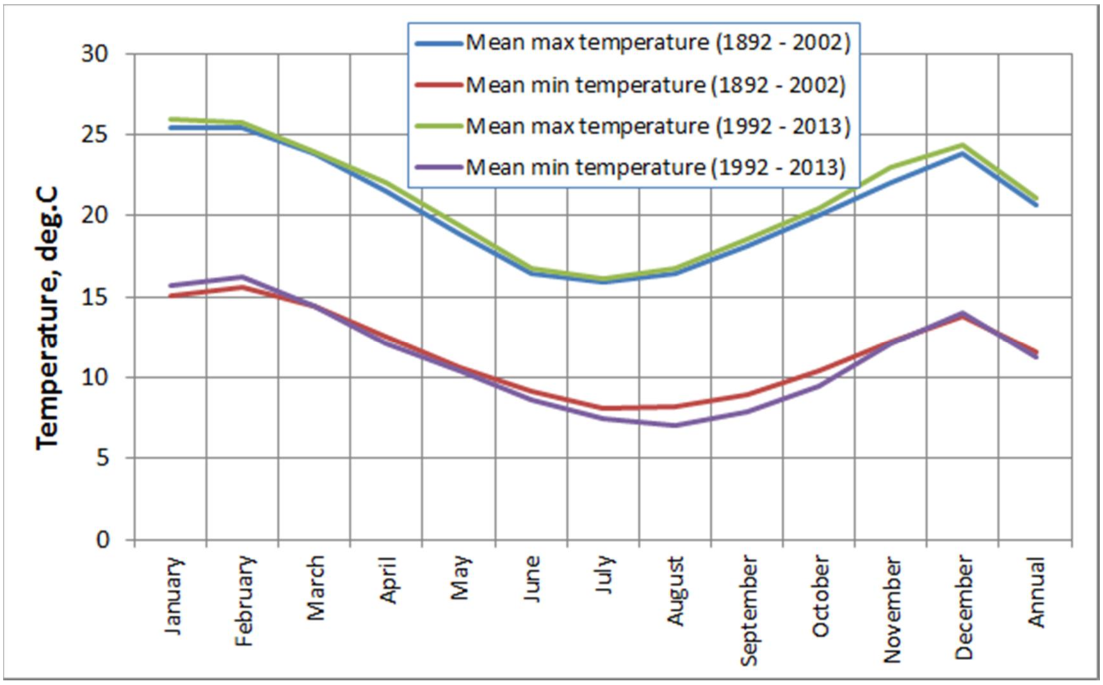

Figure 3-5: BoM Port Lincoln Temperature Observations (1982 – 2013)

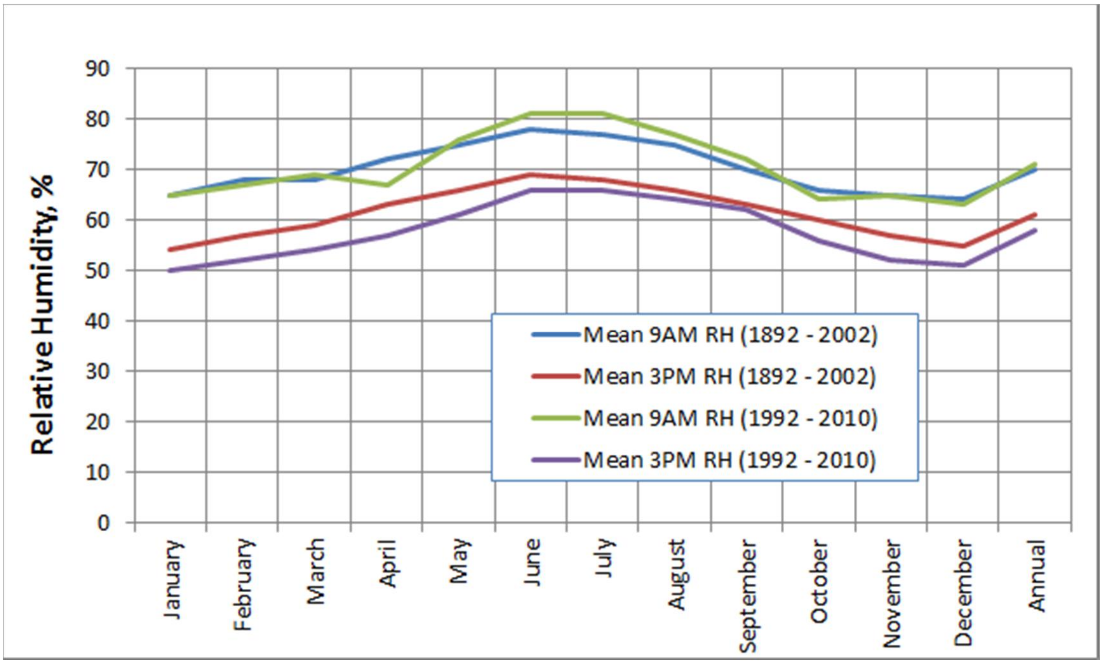

Figure 3-6: BoM Port Lincoln Relative Humidity Observations (1892 – 2010)

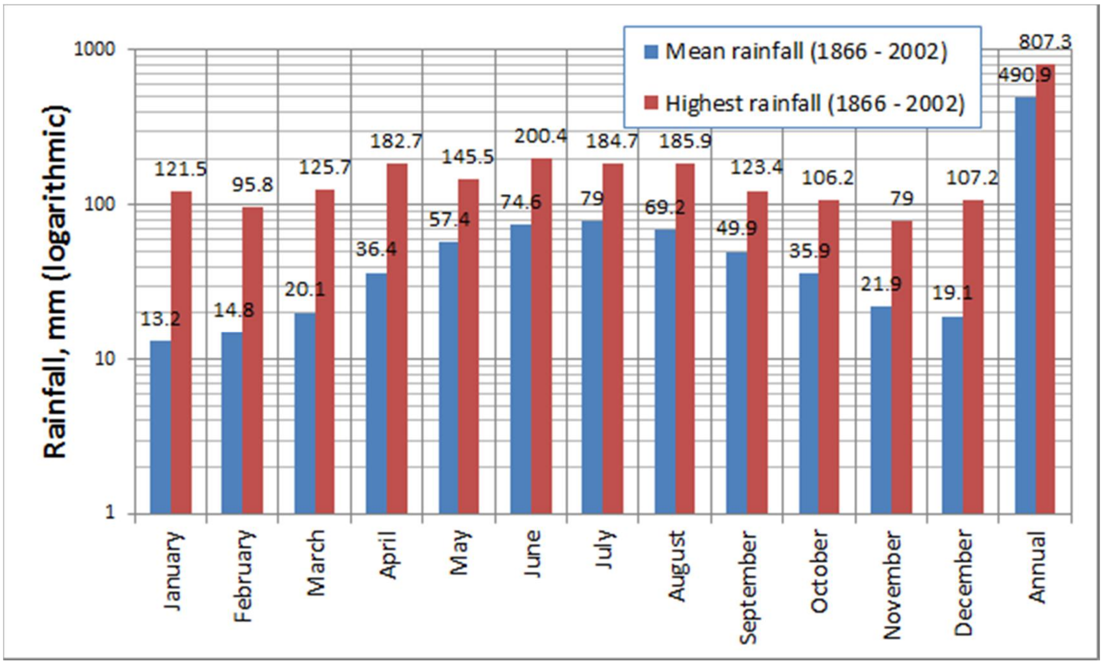

Figure 3-7: BoM Port Lincoln Rainfall Observations 1866–2002

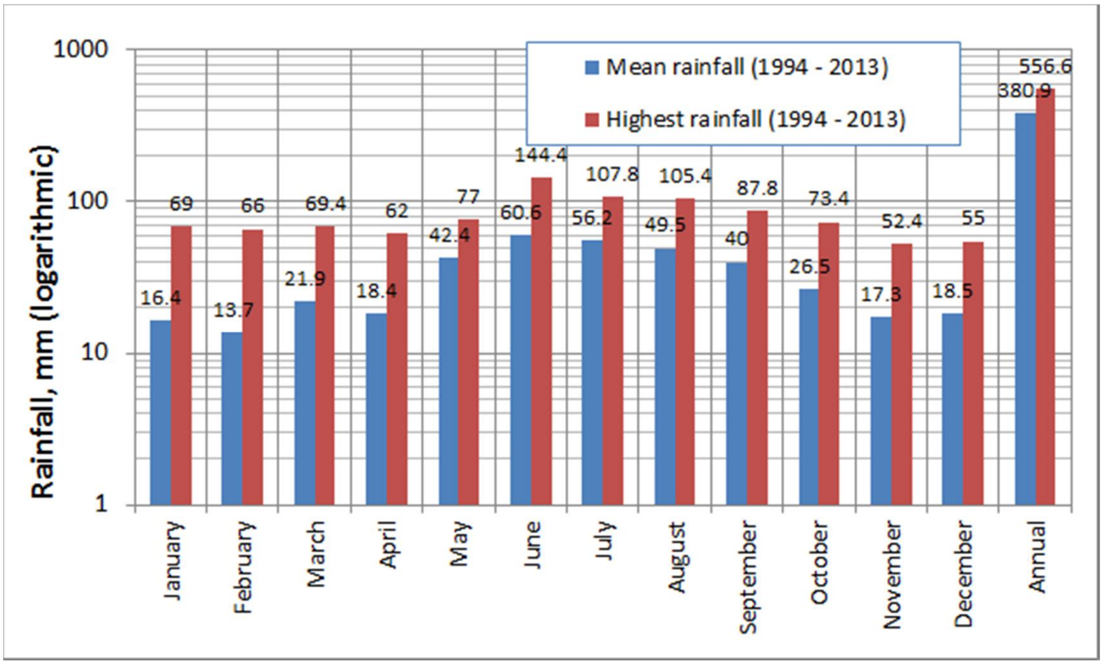

Figure 3-8: BoM Port Lincoln Long-Term Rainfall Observations 1994–2013

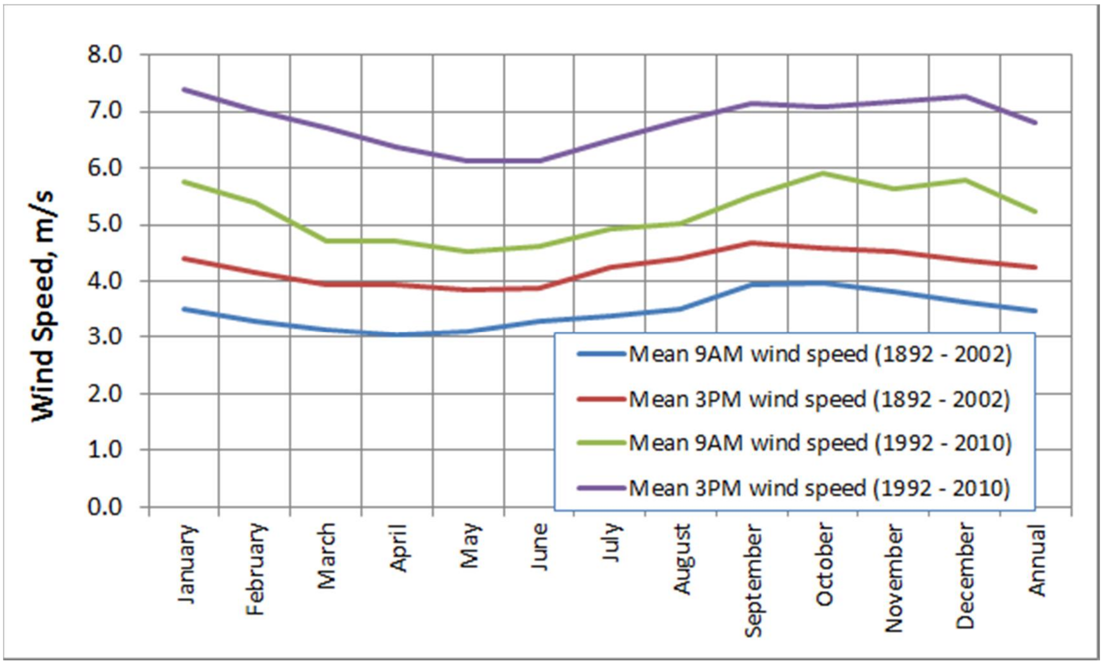

Figure 3-9: BoM Port Lincoln Wind Speed Observations (1892–2010)

A summary of selected BoM Port Lincoln climatological statistics is provided in Table 3-4.

Table 3-4 Summary of BoM Port Lincoln climatological statistics

Month	Mean Max Temp. (°C) 1992–2013	Mean Rainfall (mm) 1994–2013	Mean 9AM wind speed (m/s) 1992–2010	Mean 3PM Wind Speed (m/s) 1992–2010
Jan	26.0	16.4	5.8	7.4
Feb	25.8	13.7	5.4	7.0
Mar	24.0	21.9	4.7	6.7
Apr	22.1	18.4	4.7	6.4
May	19.4	42.4	4.5	6.1
Jun	16.8	60.6	4.6	6.1
Jul	16.1	56.2	4.9	6.5
Aug	16.8	49.5	5.0	6.8
Sep	18.6	40.0	5.5	7.1
Oct	20.5	26.5	5.9	7.1
Nov	23.0	17.3	5.6	7.2
Dec	24.4	18.5	5.8	7.3
Annual	21.1	380.9	5.2	6.8

3.2.4 Existing air quality

Cape Hardy is located on the eastern coast of Eyre Peninsula, in a rural environment expected to be characterised by clean air. The only existing air pollutant of significance is expected to be airborne particulate matter. Sources of particles would include wind-blown dust on regional and local scales, vehicle movements and wind-blown dust from unpaved roads and exposed areas, agricultural activities, and fires.

No air quality monitoring data were available for near Cape Hardy. As such, estimates for background particle levels for the study area were obtained from Tapered Element Oscillating Microbalance (TEOM) 24-hour average data provided by EPA South Australia. The data used to determine background estimates for Cape Hardy were: (1) PM_{10} data from Schultz Park, Whyalla; and (2) $PM_{2.5}$ data from Netley, Adelaide.

These datasets were used to calculate the 50th percentile (median) and 70th percentile particulate matter concentrations for the selected modelling year, 2009. The calculated 50th percentile concentrations for $PM_{2.5}$ were used for comparison with the $PM_{2.5}$ annual average concentration project criterion as set out in Section 3.1.1, and the 70th percentile particulate matter concentrations were used for comparison with the $PM_{2.5}$ and the PM_{10} 24-hour average project criterion. It is noted use of the 70th percentile of the 24 hour average concentrations is specified in the Victorian Government's State Environment Protection Policy (Air Quality Management) (2001).

The TSP background concentration was estimated by doubling the concentration of the 50th percentile PM_{10} dust concentration. The estimates for background PM_{10}, $PM_{2.5}$ and TSP concentrations for use in the dust modelling assessments are provided in Table 3-5.

Table 3-5 Background Dust Particle Concentrations

Parameter	Value
Background maximum 24-hour average PM_{10} concentration selected for input to modelling study	22 µg/m^3
Background maximum 24-hour average $PM_{2.5}$ concentration selected for input to modelling study	10 µg/m^3
Background annual average $PM_{2.5}$ concentration selected for input to modelling study	7 µg/m^3
Background annual average TSP concentration determined for modelling study (all seasons)	30 µg/m^3
Background monthly dust deposition determined for modelling study (all seasons)	2 g/m^2/month

3.3 Air Emissions Sources and Estimates

This section sets out the dust particle (TSP, PM_{10}, and $PM_{2.5}$) emissions estimates for modelling. Most of the emissions calculations were based on techniques set out in the NPI *Emission Estimation Technique Manual (EETM) for Mining* Version 3.1, January 2012. Emissions of other (gaseous) air pollutants are also discussed in this section.

3.3.1 Key air emissions sources

The air quality assessment for the port site is based on estimates of particle emission rates for the handling and transfer of concentrate at the port, including ship-loading.

The activities used for the air emissions estimates (see Table 3-6), are detailed in the following points:

- Unloading of the concentrate from the rail wagons at the rail unloading facility. The unloading facility consists of a triple cell bottom car dumper which transfers material from the rail cars to receiving hoppers below the rail level. The concentrate is transferred from the hopper to the car dumper outfeed conveyor, CV2001. The bottom rail car dumper is to be enclosed and fitted with a dust collection system at the dumper tip point and conveyor loading point.
- Handling, transferring and conveying. There are four conveyors and two transfer stations which are used to transport the concentrate to the stockpile and from the stockpile to the ship. The four conveyors are:
  - CV2001 – car dumper outfeed conveyor which transfers concentrate from the rail car dumper to Transfer Station, TS2001.
  - CV2003 – stacker feed conveyor, transfers concentrate from TS2001 to the stockpile travelling boom stacker.
  - CV2005 – port reclaim outfeed conveyor which is alongside of the stockpile and is used to transfer the concentrate to the transfer station TS2002
  - CV2006 – jetty conveyor which transfers concentrate from TS2002 to the ship loader
- Loading concentrate to the stockpile
- Wind erosion of the stockpile
- Stockpile reclaiming via bucket-wheel bridge reclaimer system
- Ship loading via telescopic chute

Each of the four conveyors will be covered to minimise dust emissions. The various transfer points, i.e. at the start of CV2001, between conveyors and stacking/reclaiming booms, and between CV2006 and the ship loading boom, will also be covered and water sprays will be applied to maintain the design moisture content, thereby also minimising dust emissions. The two transfer stations between the key conveyors are TS2001 and TS2002. Each of these transfer stations is designed to enclose the conveyor transfer chutes where the concentrate is transferred from one conveyor to the next. In addition to full enclosure, dust extraction systems are to be fitted for each transfer station building.

The conveying, handling and transfer system is to be designed such that train unloading can occur at the same time as ship loading, via the stockpile. Note that the ship loader nominal design rate is higher than that of the train unloading design rate. The three operating scenarios which may occur at the port facility are:

1) **Scenario No.1** – Train is unloaded (6550 t/h) and concentrate is transferred to the stockpile (train unloading only, no ship loading).
2) **Scenario No.2** – Stockpile is reclaimed (7300 t/h) and concentrate is transferred to the ship for loading (ship loading only, no train unloading)
3) **Scenario No.3** – Train is unloaded (6550 t/h) and concentrate is transferred to the stockpile simultaneously with the stockpile being reclaimed for loading of the ship (7300 t/h).

Dust control measures have been included in the design of equipment items and operational activities at the port to minimise dust emissions. Some of the dust mitigation measures could not be included in the modelling; e.g., baffles to reduce air velocity at conveyor transfer chutes, etc., due to a lack of supporting information in the literature. The design features and operational activities which specifically affect the modelling inputs are described below in Table 3-6.

Table 3-6: Key port activity information and assumptions for assessment

Dust Source	Notes
Two (2) transfer stations: TS2001 and TS2002	Each station is fully enclosed and fitted with a ventilation system and dust filter for extracting and recovering particulate dust.
Four (4) transfer points between conveyors	Transfer of material at the following locations: from the car dumper onto CV2001, from CV2003 to the stockpile stacker, from the stockpile reclaimer boom to CV2005 and from CV2006 to the ship loading boom. Each transfer point to be enclosed and fitted with water sprays to maintain design moisture level.
Open stockpile	Veneering agent to be applied to minimise fugitive dust emissions. Water sprays to be used to minimise fugitive dust emissions when loading and reclaiming the stockpile. There are no contributions to dust emissions from the stockpile when wind speeds are less than 5 m/s. A variable height stacker will be used to minimise the drop height and hence minimise dust emissions.
Wheel generated dust	All roads to be paved, hence wheel generated dust is not included in the modelling inputs.
Rail car bottom dumper	Dumper is a fully enclosed operation with dust extraction, filtering and dust recovery.
Ship loader	Ship loader is to have a telescopic chute for dust control.

Note that fugitive gas emissions such as VOCs from fuel storage and NO_x from vehicle use at the port site are expected to be minor and have not been included in the air dispersion modelling work. A qualitative assessment of these emissions is provided in Section 3.3.5.

For each operational activity at the port site under each operating scenario, dust particle emission rates were estimated and used as input to the modelling. The key design basis material movement data which was used as input to the emissions calculations is summarised in Table 3-7.

Table 3-7: Port emissions input data

Input Data	Value	Units
Unloading rate from train	6,550	t/h
Ship loading rate	7,300	t/h
Stockpile max angle of repose	47	deg.
Stockpile base width	44	m
Stockpile base length	960	m
Stockpile height	17.6	m

The conceptual layout design for the port site was used to map the air emissions source locations for modelling. The air emissions estimates associated with each of the activities listed in the points above were assigned to 'volume sources'. The centre points of the key equipment items, e.g. conveyors, transfer stations, etc. are shown in Figure 2-2.

The air emissions estimates for each component of the dispersion modelling study are detailed in the following sub-sections.

3.3.2 Particle emission factors

The NPI EETM for Mining (2012) emission factors selected for the dust particle emissions estimates and their levels of dust controls are set out in Table 3-8.

Table 3-8 NPI air emission factors and dust controls

Activity	TSP Emission Factor	PM_{10} Emission Factor	Control (and Factor)
Rail wagon dump [1]	0.012 kg/t	0.004 kg/t	Enclosure and air extraction (99%)
Handling and transferring [2]	0.005 kg/t	0.002 kg/t	Enclosure and use of fabric filters for transfer station buildings (99%) [3] Enclosure (70%) and water sprays (50%) to maintain moisture content of 8% (overall 85% control factor)
Loading stockpile	0.004 kg/t	0.0017 kg/t	Water sprays to maintain moisture content (50%) and variable height stacker (25%). Overall 62.5% control factor.
Wind erosion of stockpile	0.4 kg/ha/h	0.2 kg/ha/h	Chemical veneering of stockpile (90%) [4]
Stockpile reclaiming	0.005 kg/t	0.002 kg/t	Water sprays to maintain moisture content (50%)

Activity	TSP Emission Factor	PM_{10} Emission Factor	Control (and Factor)
Ship loader [5]	0.0004 kg/t	0.00017 kg/t	Telescopic chute (no water sprays) (50%) [6]

Notes:

1. The emission factor for the rail wagon dump has been based on ‘Trucks (dumping overburden)’, Appendix A Section 1.1.6 of the NPI EETM for Mining (2012).
2. Emission factor used for transferring the concentrate between conveyors was applied to the operation of each of the two transfer stations (TS0001 and TS0002) as well as 4 additional transfer points between conveyors.
3. The NPI EETM for Mining (2012) Table 4, provides an emission reduction factor of 99% for enclosure and use of fabric filters. This was adopted for TS0001 and TS0002.
4. The control factor used for veneering of the stockpile was adopted from the control factor used for the use of water sprays with chemicals for miscellaneous transfer and conveying operations (from Table 4 of the NPI Emission Estimation Technique Manual for Mining, Version 3.1, January 2012). The modelling work assumes that there is no contribution to dust emission from the stockpile when wind speeds are less than 5 m/s.
5. There is no specific emission factor provided in the NPI EETM for Mining (2012) for ship loading. As such, the emission factor for loading to trains has been adopted, per Appendix A, Section 1.1.15 of the EETM.
6. The emission control factor for the ship loading activity has been adopted from the ‘Loading Stockpiles’ emission control factor provided in Table 4 of the NPI EETM for Mining (2012). This provides control factors of 50% for water sprays and 75% for telescopic chute with water sprays. From these figures, a control factor of 50% was calculated for telescopic chute without water sprays.

For all emission sources, the emission factors used for $PM_{2.5}$ emissions were 35% of the PM_{10} emission factors, based on information received from the EPA[4].

3.3.3 Particle size distribution

The selection of particle size for air dispersion modelling of smaller particles such as those that fit within the PM_{10} and $PM_{2.5}$ size classes is not critical, as these small particles exhibit behaviour not dissimilar to that of a gas. The fall velocities of small particles are very slight, therefore the particles can be transported over very large distances. Sensitivity tests undertaken using CALPUFF for a two-day test at the port site confirmed that results for PM_{10} Ground Level Concentrations (GLCs) were not affected significantly by the selection of particle size. Therefore for this assessment the nominal particle size of 6.0 microns (µm) was selected to represent PM_{10} and 1.4 µm to represent $PM_{2.5}$.

The selection of the Particle Size Distribution (PSD) for particles approximately 10 µm and larger is important, as larger particles from dust emissions near ground level re-deposit to the surface over relatively short distances. These larger particles have a significant effect on the predicted dust deposition and therefore on the (depleted) TSP GLCs.

CALPUFF has the capability to model a lognormal particle size distribution of particles using the PSD geometric mean and geometric standard deviation as input (Earth Tech, 2000b). A review of literature was conducted to determine reasonable estimates for the PSD geometric mean and geometric standard deviation for TSP dispersion modelling. Ayers et al. (1999) provided a result for an Australian aerosol mass distribution comprising soil-derived elements (silicon, iron and aluminium), which indicated that 10 µm would be a reasonable estimate for the geometric mass mean diameter of a dust aerosol PSD. A review of measured lognormal dust size distributions including dust aerosols provided by Zender (2010), indicated that 2.0 µm would be a reasonable estimate for the geometric standard deviation of a dust aerosol. In summary the two parameters selected for the TSP modelling were: geometric mean of lognormal PSD, 10.0 µm; and geometric standard deviation for the lognormal PSD, 2.0 µm. The particle size parameters used in the modelling are shown in Table 3-9.

[4] EPA communication by email to DMITRE, IRD and SKM, 9 October 2013.

Table 3-9: Particle size input data

Particle group	Geometric mass mean diameter (µm)	Geometric standard deviation (µm)
PM_{10}	6.0	0
$PM_{2.5}$	1.4	0
TSP	10.0	2.0

3.3.4 Summaries of emissions estimates

The particle emissions estimates were based on design maximum hourly tonnages of material moved (see Section 3.3.1). Emissions estimates were calculated for each of the three operating scenarios. A summary of total emissions corresponding to each of these scenarios is provided in Table 3-10.

Table 3-10 Summary of dust particle emission scenarios

Scenario	Description	TSP Emission Rate (g/s)	PM_{10} Emission Rate (g/s)	$PM_{2.5}$ Emission Rate (g/s)
Scenario No.1	Unloading of train, transfer of concentrate to stockpile and loading of stockpile (includes wind erosion of stockpile)	5.8	2.4	0.8
Scenario No.2	Reclaiming stockpile (bucket-wheel reclaimer), transfer concentrate to ship and ship loading (includes wind erosion of stockpile)	8.7	3.5	1.2
Scenario No.3	Unloading of train, transfer of concentrate to stockpile, reclaiming of concentrate from the stockpile and ship loading (includes wind erosion of stockpile)	14.5	5.9	2.1

Scenario No.3, which is: unloading concentrate from trains at a rate of 6550 t/h; transfer of concentrate to stockpile; simultaneously reclaiming concentrate from the stockpile; and ship loading at a rate of 7300 t/h, represents the worst case emissions scenario due to the highest total estimated emissions. Scenario No.2 estimates resulted in the second highest total emissions.

Air emissions parameters and results for Scenario No.3 are set out in Table 3-11.

It should be noted that in a 24 hour period, there will be times when Scenario No.3 will not occur, and instead, Scenario No.1 or No.2 will be representative of actual operations. Based on design material handling rates, it is estimated that train unloading operations will occur for approximately 50% of a 24 hour period, i.e. 6 loaded trains each taking approximately 2 hours to unload at the port site, although the timing of the unloading events may change in any given day. As such, the modelling of the Scenario No.3 operating scenario was adjusted to include variable emissions for the train unloading, stockpile loading and materials handling activities between the train unloading facility and the stockpile. Under the variable emissions input information within the model, there are no emissions for these activities for two consecutive hours, and then the emissions are ‘switched on’ for the next two hour period. The cycle is repeated 6 times within the 24 hour period to reflect 6 trains being unloaded each 24 hour period. Modelling was carried out for both the ‘two hours on, then two hours off cycle’ as well as the ‘two hours off, then two hours on cycle’ to ensure that the maximum emissions scenario was captured and presented.

As outlined in Section 3.3.5, it is expected that ship loading will occur for 2,959 hours in a year, i.e. approximately 34% of the time. This means that for 66% of the time, operational activities will be as described for Scenario No.1 (or there will be no materials movement activities at all, i.e. no train unloading). The model predictions for this operating scenario are not presented within this report because, unlike the train unloading activities, the average ship loading time is expected to be approximately 33 hours, i.e. greater than the 24 hour averaging period for dust emissions. This means there will be some days were ship loading will be occurring continuously over the 24 hours. Continuous ship loading activities are included in Scenario No.3 and the predicted modelling results for this 'worst case' operating scenario are therefore expected to be conservative.

A summary of the calculated particle emission rates determined for each of the materials handling activities at the port site are shown in Table 3-11.

Table 3-11 Summary of dust particle emissions estimates

Activity	TSP Emission Rate (g/sec)	PM_{10} Emission Rate (g/sec)	$PM_{2.5}$ Emission Rate (g/sec)
Rail wagon dump	0.22	0.08	0.03
Stockpile loading	2.73	1.16	0.41
Stockpile reclaiming	5.07	2.03	0.71
Transfer stations and points	5.96	2.39	0.83
Wind erosion of stockpile	0.07	0.03	0.01
Ship loader	0.41	0.17	0.06

A summary of the calculated particle emission rates for each of the source areas is provided in Table 3-12.

Table 3-12 Summary of dust particle emissions from source areas

Source Area	Description	TSP Emission Rate (g/sec)	PM_{10} Emission Rate (g/sec)	$PM_{2.5}$ Emission Rate (g/sec)
Car dumper and CV2001	Total of emissions from unloading of trains and transfer to CV2001	1.6	0.6	0.2
Stockpile area	Total emissions from stockpile area (includes TS2001, TS2002, stockpile wind erosion, loading and reclaiming, and 2 transfer points)	10.9	4.5	1.6
Transfer to ship	Includes 1 transfer point and ship loading	1.9	0.8	0.3

3.3.5 Other (non-Particulate) Air Emissions

In addition to particulate matter there are expected to be other air emissions associated with the port operations, primarily these are the result of the combustion of diesel in engines and ancillary equipment at the port site. The combustion of diesel will result in a mixture of gaseous and particulate emissions including: carbon monoxide (CO), nitrogen dioxide (NO_2), Volatile Organic Compounds (VOCs), sulfur dioxide (SO_2), and PM_{10} and $PM_{2.5}$.

The largest consumer of diesel at the port site is expected to be the ships berthed at the port during loading operations. Ancillary equipment items which consume diesel will include, for example: light utility vehicles, trucks, compressors, and power generators. Emissions from these sources are discussed in the following sections.

3.3.5.1 Shipping emissions

It is expected that the port facility could handle between 125 and 180 vessels per year, depending upon the mixture of vessel sizes. At the upper end of this range, the port will be handling 3–4 vessels per week. With an arrival and departure movement for each ship that visits the port facility, this equates to a large vessel movement at the facility on most days.

As a result of the berthing and loading of ships at the port site wharf, various gaseous emissions will be emitted from ship exhausts while the ships are in port. For the purposes of this assessment, it has been assumed that each ship will have an auxiliary engine which will continue to operate while the ship is berthed. In addition, it has been assumed that each ship will have a boiler for the purposes of heating the fuel and for the supply of hot water, which will also continue to operate. The main emissions from these operations are expected to be NO_x and SO_2. Other pollutants including VOCs, CO and particulate matter (PM_{10} and $PM_{2.5}$), are also expected to be present in the ship's stack exhaust.

To provide an initial estimate of the emission rates for these gases, the *National Pollutant Inventory Emission Estimation Technique Manual for Maritime Operations Version 2.1* (July 2012) was used. The input data used for the emission rate calculations is shown in Table 3-13 below.

Table 3-13: Input data for shipping operation emission calculations

Input Information	Value	Units
Number of shipment (calls) per year	156	ships/year
Loading time – annual	2959	hours/year
Non-loading time – annual	2233	hours
Time in berth – annual	5191	hours/year
	216	days/year
Average ship time in berth	33	hours/ship
Average ship auxiliary engine power	600 [1]	kW
Average ship auxiliary boiler fuel consumption	0.0125 [2]	t/h

Notes:
1. The auxiliary power value is a default value as provided in the NPI EETM for Maritime Operations (2012).
2. The auxiliary boiler fuel consumption is a default value as provided in the NPI EETM for Maritime Operations (2012).
3. The shipping movement design data above was sourced from the document "Basis of Design – Port Materials Handling and Infrastructure", E-F-65-RPT-0004.

The emissions factors and resulting emission mass rates calculated for each of the pollutants identified are presented in Table 3-14.

Table 3-14: Emission factors and calculated emission rates

Pollutant	EFi (aux engine) kg/kWhr	EFi (aux boiler) kg/tonne	IRD Port - Emission Rate (g/sec)	White Bay Terminal – Emission Rate (g/sec)
NO_x	0.0147	12.3	1.48	32.2

Pollutant	EFi (aux engine) kg/kWhr	EFi (aux boiler) kg/tonne	IRD Port - Emission Rate (g/sec)	White Bay Terminal – Emission Rate (g/sec)
CO	0.0011	4.6	0.12	
Total VOCs	0.00038	0.36	0.04	
$PM_{2.5}$	0.0011	1.04	0.11	
PM_{10}	0.00114	1.3	0.12	2.2
SO_2	0.0111	54	1.21	21.6

The last column in Table 3-14 sets out the emission rates calculated from a shipping air quality assessment project carried out in Sydney (reference White Bay Passenger Terminal, Air Quality Assessment, SKM, September, 2010). This project assessed potential effects on air quality from the emissions of NO_2, PM_{10} and SO_2 from passenger ships while at berth at a proposed Cruise Passenger Terminal within the Glebe Island and White Bay Port Precinct on the Balmain Peninsula in Sydney NSW. The calculated emissions for the worst-case scenario were 32.2, 2.2 and 21.6 g/sec for NO_2, PM_{10} and SO_2, respectively. The model results predicted that the project was unlikely to cause exceedances of NSW impact assessment criteria for NO_2, PM_{10} and SO_2, at the nearest sensitive receptors.

The calculated emission rates listed above (Table 3-14) for the IRD port, are significantly lower than those of the Sydney shipping project. In addition, in the absence of local industrial or vehicle sources, the existing ambient concentrations of the pollutants which would contribute to the cumulative concentrations are expected to be low for the rural, and relatively remote area of Cape Hardy, in comparison with emissions within built up areas e.g. from cars and industrial facilities.

Road vehicle emissions have a significant air quality impact when very large vehicle fleets are involved; e.g., all of Adelaide's road vehicle traffic. In the township of Whyalla on the Eyre Peninsula, located approximately 175 km north-east of Cape Hardy, the SA EPA's air monitoring data tables for 2005 show the annual average of the NO_2 concentration for Whyalla was 0.003 ppm, with an annual peak of 0.025 ppm. This is lower than the metropolitan Adelaide NO_2 concentrations recorded of 0.004 to 0.009 for the annual average and 0.031 – 0.051 ppm for the peak 1-hour average values. The NEPM standard for NO_2 is 0.12 ppm for 1-hour averages. The background NO_2 concentration for the Cape Hardy region is expected to be less than that of Whyalla as the number of vehicles will be substantially lower and there are no significant industries nearby.

In summary, the assessment of the proposed ship stack emissions is that they will not have a significant effect on ambient air quality; as such these emissions were not included in the dispersion modelling.

3.3.5.2 Ancillary Diesel Equipment

Diesel engine powered equipment expected to be used at the port site includes: light utility vehicles, sweeper/vacuum, fuel, water and stockpile veneering trucks, generators and pump sets; and light mobile machinery such as cranes, bobcats and backhoes. The total estimated diesel consumption for the port site from ancillary equipment is 743 L/day (SKM Iron Road, 2012).

The total diesel fuel use expected for the port site is significantly less than the fuel that would be consumed in a small urban area. For example, 1000 light vehicles consuming an average of 50 litres of diesel fuel per week equates to 7,143 litres of diesel used per day – significantly higher than fuel consumption expected for the ancillary equipment at the port site. Monitoring data for cities such as Adelaide shows that emissions of gaseous air pollutants from very large road vehicle fleets, such as carbon monoxide and oxides of nitrogen, do not normally cause exceedances of national ambient air quality criteria.

Also, PM_{10} and $PM_{2.5}$ emissions from the combustion of diesel are expected to be low in comparison with dust emissions from the site (Section 3.3.2). For example, if all the diesel usage was by light utility vehicles, the estimated PM_{10} and $PM_{2.5}$ emission rates would be 0.021 and 0.020 g/sec for PM_{10} and $PM_{2.5}$, respectively. These are equivalent to small fractions of the total estimated total dust emission rates for the port site; e.g., only 0.4% of PM_{10} and 1.0% of $PM_{2.5}$ for Scenario No.3.

In summary, air emissions from the combustion of diesel fuel at the port site were not included in the assessment for the main reason: air emissions estimates from the combustion of diesel fuel at the port site were very small in comparison with dust emission estimates.

3.4 Modelling Methodology

This section sets out the methodology and parameters used for the meteorological and air dispersion modelling methodology.

3.4.1 Selection of study year

The modelling assessment used hourly average meteorological data for a selected study year to assess the project dust emissions under a very wide range of conditions; a total of 8760 hours were tested. Following a review of annual weather conditions for Australia (BoM, 2014), the year 2009 was considered to be a typical meteorological year for South Australia and selected for the assessment. The selection of this study year for the assessment was confirmed with the EPA[5]. A brief summary of weather conditions for 2009 is provided in the following paragraph.

A weak and very short La Niña event occurred across the north of Australia during the period August 2008 to April 2009. January to February 2009 was very dry across much of southern Australia, including Victoria and South Australia. Two extreme heat waves occurred during the same period, contributing to the Black Saturday bushfires. Moving into 2009, there were weak effects from an El Niño event: while most of Australia was dry from May to October 2009, eastern Victoria and most of NSW had below average rainfall. Western Victoria and southern South Australia had average to above average rainfall. By November, a wet period occurred over the eastern half of the country. For the 5 months from November 2009 to March 2010, South Australia had areas of rainfall in the top 10% (BoM, 2014).

3.4.2 Meteorological modelling

Meteorology will vary across the port site horizontally and vertically, particularly wind patterns. On a relatively small scale, the port site winds will be affected by local topography. At larger scales, winds are affected by synoptic scale winds, which are modified by atmospheric phenomena such as convective processes in the daytime and drainage flows that can develop overnight. It is important that the complex mechanisms that affect air movements are incorporated into dispersion modelling studies for accurate predictions of air pollutant concentrations.

A limitation of Gaussian plume dispersion models is that they assume that the meteorological conditions are the same, spatially, over the entire modelling domain for any given hour. Meteorological and dispersion conditions are expected to be more accurately represented using wind-field and so called “puff” models, which has been done for the Cape Hardy case. This assessment used the CALPUFF dispersion model. The CALPUFF model, through the CALMET meteorological processor, simulates complex meteorological patterns that exist in a particular region.

In the absence of long-term, quality meteorological data for the locality, surface and upper-air meteorological data for 2009 were generated for this study by the CSIRO’s prognostic model known as TAPM (‘The Air Pollution Model’). TAPM is a prognostic model which has the ability to generate meteorological data for any location in Australia, commonly from 1997 onwards, based on synoptic information obtained from the six-hourly Limited

[5] EPA/DMITRE/IRD/SKM meeting, 10th May, 2013.

Area Prediction System (LAPS). TAPM is further discussed in the model's user manual and various model verification studies; *e.g.*, see Hurley (2008) and Hurley *et al.* (2009).

TAPM was used to generate 3-dimensional surface and upper-air temperatures, wind vectors, air pressures and other meteorological parameters. The meteorological data generated included 8,760 hourly average (one year) records for each meteorological parameters, covering a large study volume over the port site.

The TAPM default vegetation for the port site (Cape Hardy) geography was found to be inaccurate, for example, some low elevation areas were identified by TAPM as water. To improve TAPM's estimates of the surface roughness for Cape Hardy the vegetation type along the coast line was modified to land use type 'pasture, very sparse', for the higher resolution grids (Grids 4 and 5). The default land use types were used for the lower resolution grids (grids 1, 2 and 3).

While there is some influence of real observations to TAPM inputs through the LAPS data, it is recognised that this approach is a simulation of actual conditions. In recognition of using a prognostic model to generate upper air data, the 3-dimensional meteorological data from TAPM were used as CALMET's initial guess wind-field. This approach places less emphasis on the prognostic data for the development of the final wind field as the prognostic data are not treated as observations.

For improved accuracy of the meteorological file, CALMET was processed using a finer grid spacing (i.e. 250 m) and increased number of grid points. The geophysical terrain and land use input data for CALMET was also generated using the same fine resolution. A summary of the data and parameters used as part of the meteorological component of this study is shown below in Table 3-15.

Table 3-15 Summary of meteorological modelling parameters

Met Modelling Parameter	Setting
TAPM met modelling parameters:	
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grids point	25 (west-east) x 30 (north-south) x 25 (vertical)
Year of analysis	Jan 2009 to Dec 2009
Centre of analysis	Port facility - centre of stockpile: S. 34 ^{o} 11'; E. 136 ^{o} 19'
Meteorological data assimilation	None (a better prescriptive modelling approach)
CALMET modelling parameters:	
Meteorological grid domain	<u>Horizontal</u>: 80 x 80 grid points at 250 m resolution (20 km x 20 km), for a total of 6400 horizontal grid points. <u>Vertical</u>: 10 x levels from the surface to 1,200 m height
Surface meteorological stations	3-dimensional met. output from TAPM used as initial guess wind-field for CALMET
Upper air meteorological data	3-dimensional met. output from TAPM used as initial guess wind-field for CALMET
Simulation length	8760 hours (Jan 2009 to Dec 2009)

3.4.3 Dust dispersion modelling methodology

The CALPUFF (Version 6.42) model was used to predict Ground Level Concentrations (GLCs) using the air emissions estimates as inputs. CALPUFF is a Lagrangian dispersion model that simulates the dispersion of pollutants within a turbulent atmosphere by representing emissions as a series of puffs, emitted sequentially. Provided the rate at which the puffs are emitted is sufficiently rapid, the puffs overlap and the serial release is representative of a continuous release.

The CALPUFF model differs from traditional (simpler) Gaussian plume models in that it models spatially varying wind and turbulence fields that are important in complex terrain, long-range transport and near calm conditions. It is the preferred model of the United States Environmental Protection Agency (USEPA) for the long-range transport of pollutants and for complex terrain (TRC, 2007).

The modelling has been performed using the meteorological information provided by the CALMET model and the source emission estimates. The model has been used in this study to predict the pollutant concentrations at a set of ground-level receptors covering a region of 20 km by 20 km. Gridded receptors with spacing of 250 m were used for the entire model domain representing a total of 6400 receptors in the horizontal plane. Dispersion coefficients used turbulence computed from micrometeorology and the partial plume path method was used for terrain adjustment.

The worst case emissions scenario, i.e. Scenario No.3, was modelled based on the activities detailed in Section 3.3.1. Results are provided for $PM_{2.5}$, PM_{10} and TSP concentrations, and dust depositions. The modelled results were provided as contour plots showing the spatial distribution of dispersed indicators. The results have been compared with relevant air quality criteria (Section 3), where appropriate.

3.5 Modelling Results

This section presents the results of the TAPM meteorology modelling work and the results of the air dispersion modelling work for dust emissions at the port site using CALPUFF.

3.5.1 TAPM modelled meteorology

TAPM model results for near-ground level winds at the port site were shown as wind roses (see Appendix A and Appendix C), these were based on all hourly average winds for 2009 (8,760 records). Frequency distributions of the TAPM model results for wind speeds at the port site, (2009), are provided in Appendix D. Inspection of the TAPM-generated seasonal wind patterns and comparisons with the corresponding BoM Port Lincoln data indicated the modelled port site 2009 results are in general agreement with patterns exhibited for Port Lincoln.

Quality checks were undertaken on the TAPM outputs by inspection of the frequency distribution of stability class; stability class by hour of day; mixing layer height versus hour of day; wind occurrence matrix showing dominant southerly winds; and the wind speed frequency distribution.

3.5.2 CALPUFF Modelling Results

This section sets out CALPUFF modelling results for the following indicators and criteria:

- Maximum 24-hour average PM_{10} concentration (project criterion, 50 µg/m^3);
- Maximum 24-hour average $PM_{2.5}$ concentration (project criterion, 25 µg/m^3);
- Maximum annual average $PM_{2.5}$ concentration (project criterion, 8 µg/m^3);
- Maximum annual average TSP concentration (project criterion, 90 µg/m^3); and
- Maximum annual average dust deposition (project criterion, 4 g/m^2/month; and maximum addition to background, 2 g/m^2/month).

3.5.2.1 Maximum 24-hour Average PM_{10} Concentrations

The CALPUFF predicted maximum (Rank 1) 24-hour average PM10 GLCs (µg/m3) for Scenario No.3, are provided in Figure 3-10. A background PM10 concentration of 22 µg/m3 is included in these results. The 50 µg/m3 contour (shown as the purple contour) is equal to the project ambient air quality criterion and extends beyond the port site boundary.

The results shown include the effects of ceasing stockpile reclaiming through to ship loading at selected times to prevent model-predicted exceedances of ambient air quality standards occurring at any of the sensitive receptors. To achieve this result, in the model the simulated stockpile reclaiming was deactivated for a total of 102 hours (1% of the year only). In practice, the suspension of some activities at the port would be triggered by an operational air monitoring system signalling that a project criterion was exceeded. Further information regarding this approach to dust management is provided in Section 3.5.3.

The modelling results for the modified operation indicate that for Scenario No. 3, PM_{10} concentrations would be below the 50 µg/m^3 level at all sensitive receptors outside the port site boundaries.

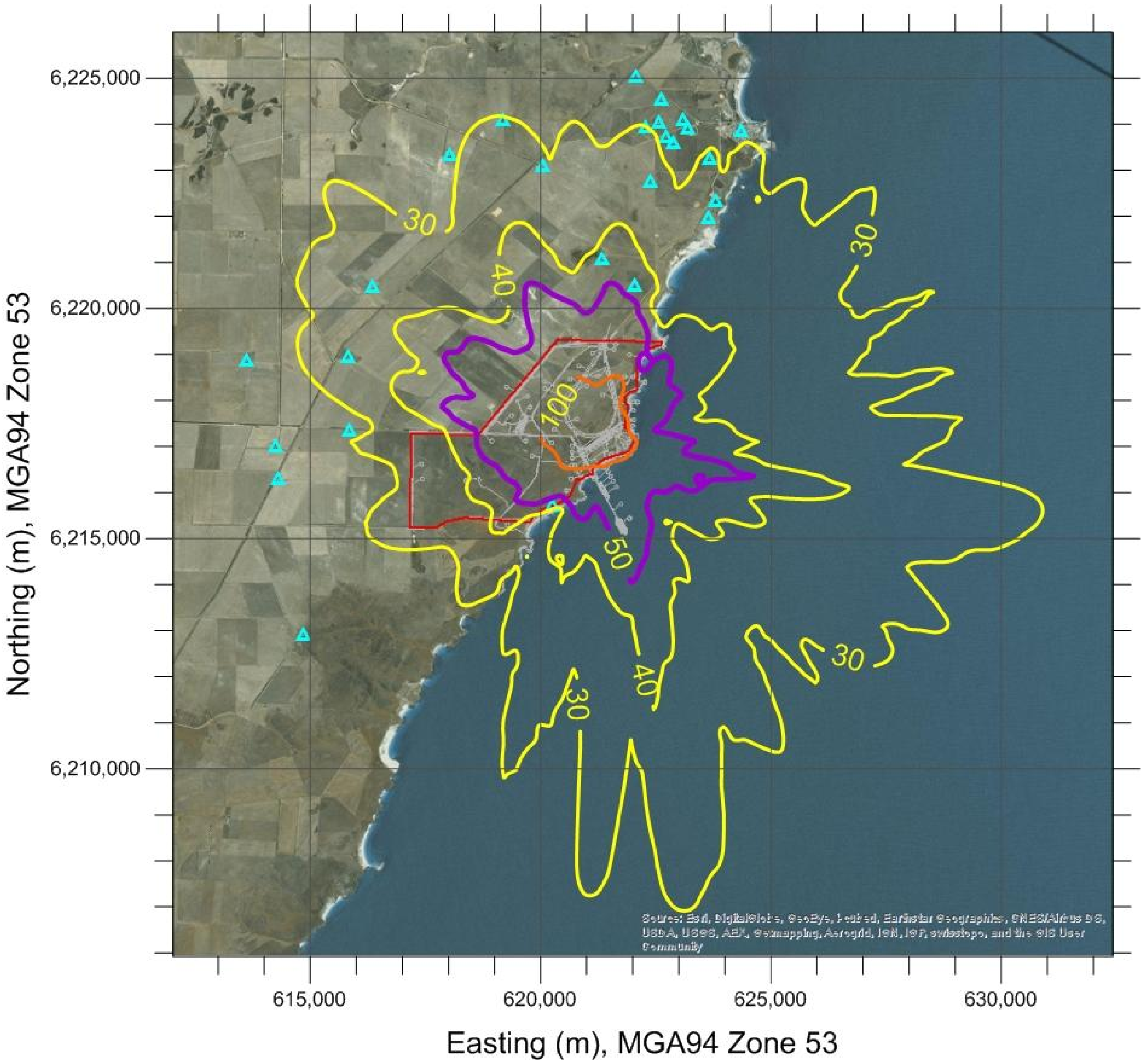

Figure 3-10: Predicted Maximum 24-hour Average PM_{10} Concentration (µg/m³), modified operations

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

The results for predicted maximum (Rank 1) 24-hour average PM2.5 concentrations (µg/m3), for Scenario No.3, are provided in Figure 3-11. The relevant standard for the 24-hour average PM2.5, 25 µg/m3, is shown by the purple contour. The results include the background PM2.5 concentration of 10 µg/m3.

As for the PM_{10} modelling, minor modification of the normal operations, representing practical dust management activities, was also adopted for the modelling of $PM_{2.5}$ emissions. The modelling input included suspension of the stockpile reclaiming through to ship loading activities for approximately 100 hours for the year. The results of the modelling for the modified operation show that $PM_{2.5}$ concentrations are predicted to be less than the 25 µg/m^3 criterion at all sensitive receptors.

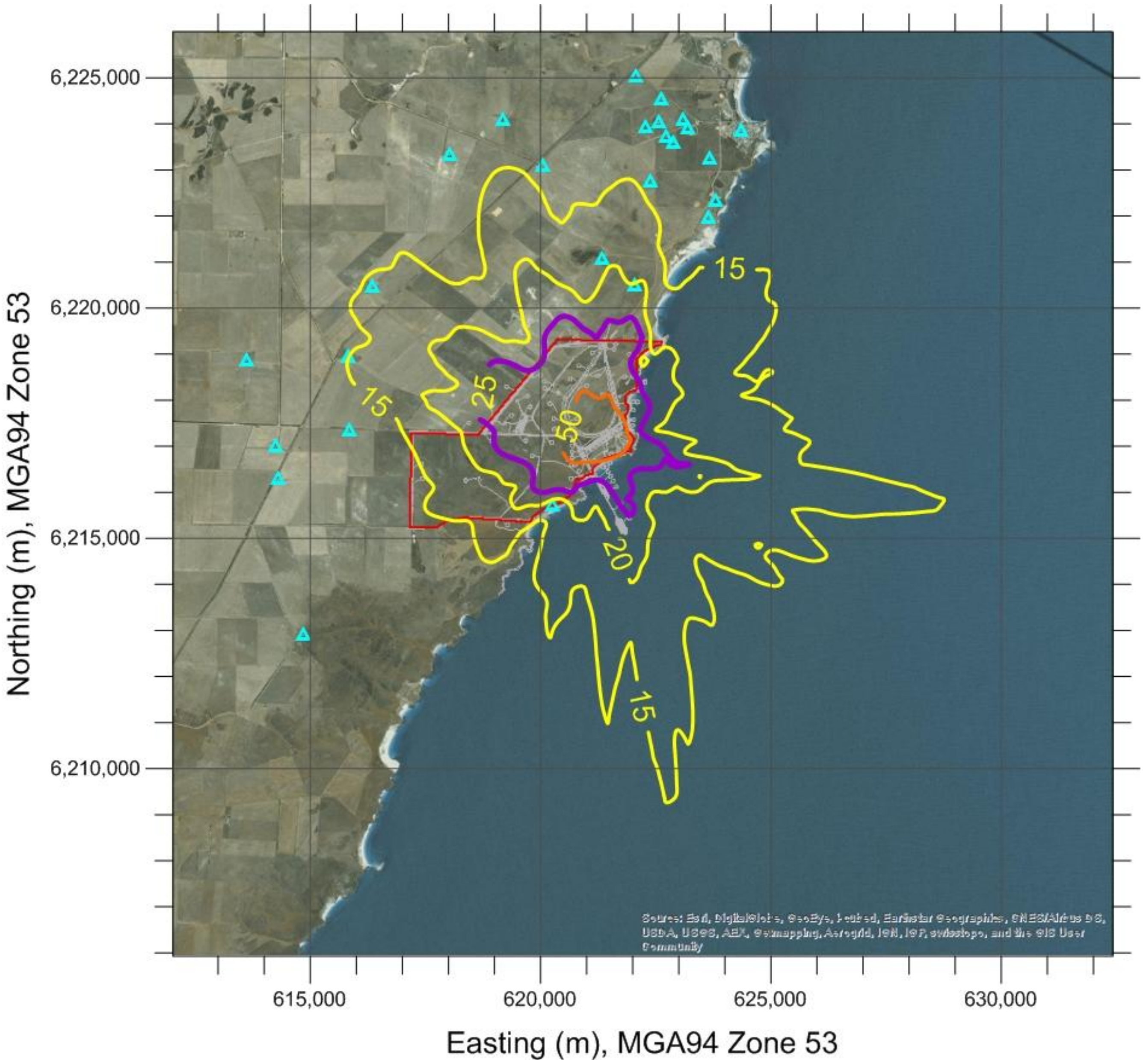

Figure 3-11: Predicted Maximum 24-hour Average $PM_{2.5}$ Concentration (µg/m^3), modified operations

3.5.2.3 Annual average $PM_{2.5}$ concentrations

The $PM_{2.5}$ annual concentration model predictions for the port site are shown in Figure 3-12 for Scenario No.3. The model output includes a $PM_{2.5}$ background concentration of 7 µg/m³. The project criterion is 8 µg/m³, as shown by the purple contour.

These results show that concentrations would comply with the $PM_{2.5}$ criterion at all sensitive receptors outside the port boundary.

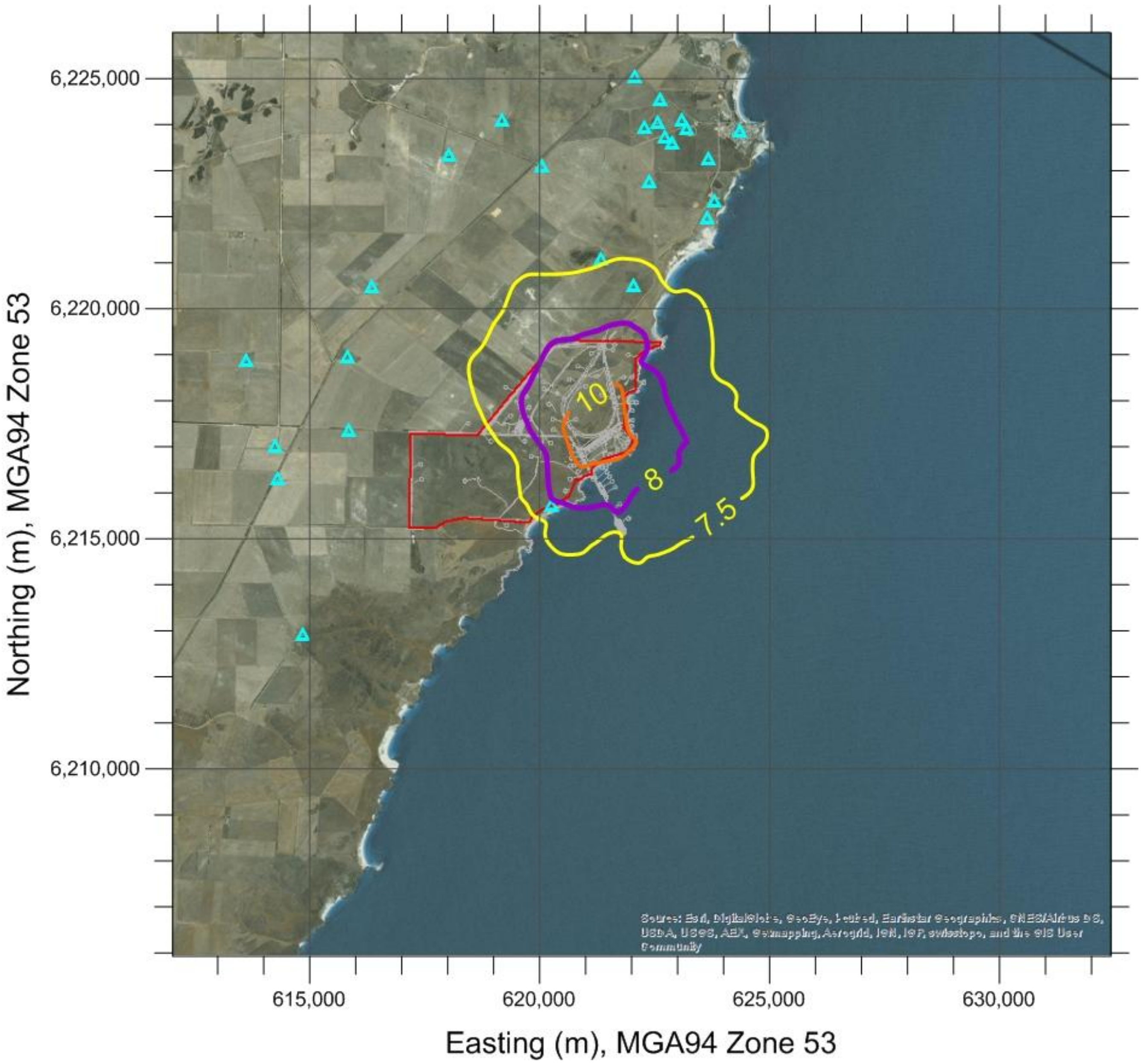

Figure 3-12: Predicted annual average $PM_{2.5}$ concentration (µg/m³)

3.5.2.4 Annual TSP concentrations

The modelled TSP results are an intermediary step to producing the dust deposition results. The predicted annual average TSP GLCs (µg/m^3) for Scenario No.3, are provided in Figure 3-13. These results include a background TSP level of 30 µg/m^3. These results show that the TSP GLCs due to the port operation are likely to be less than with the relevant air quality standard selected for the project (90 µg/m^3, shown by the purple contour), at all sensitive receptors and at all locations outside of the port boundary.

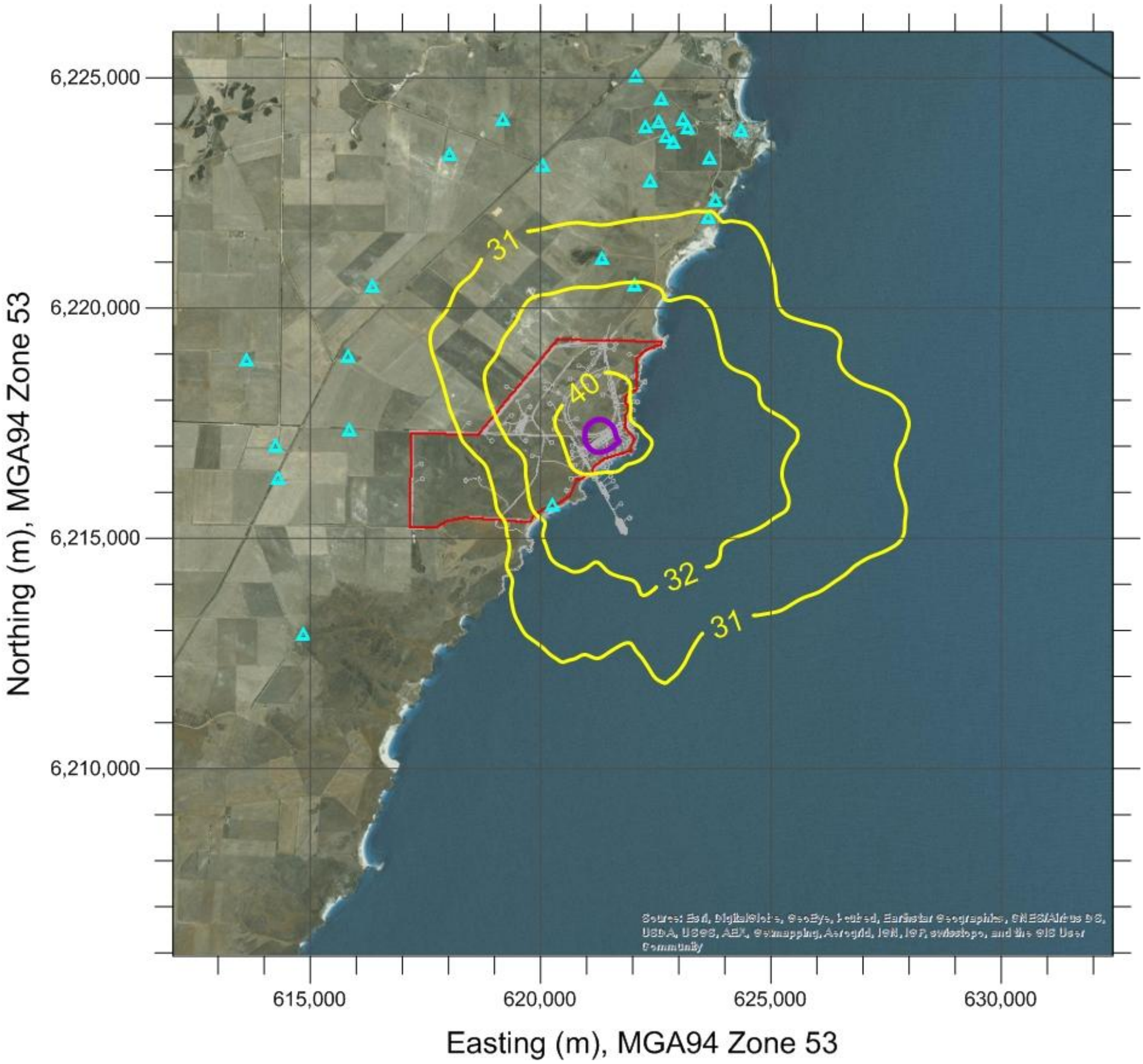

Figure 3-13 Predicted annual average TSP concentration (µg/m^3), Scenario No.3

3.5.2.5 Annual dust depositions

The predicted annual average dust depositions (g/m^2/month) for Scenario No.3 are provided in Figure 3-14. The results include a background dust deposition level of 2.0 g/m^2/month. The project criterion of 4.0 g/m^2/month (maximum total dust deposition), is shown by the purple contour. This shows nuisance dust from the port operations is expected to be minimal outside the main port site operational area, i.e. away from the stockpile area. These results show that deposition levels would comply with the project criteria for dust deposition at all sensitive receptors.

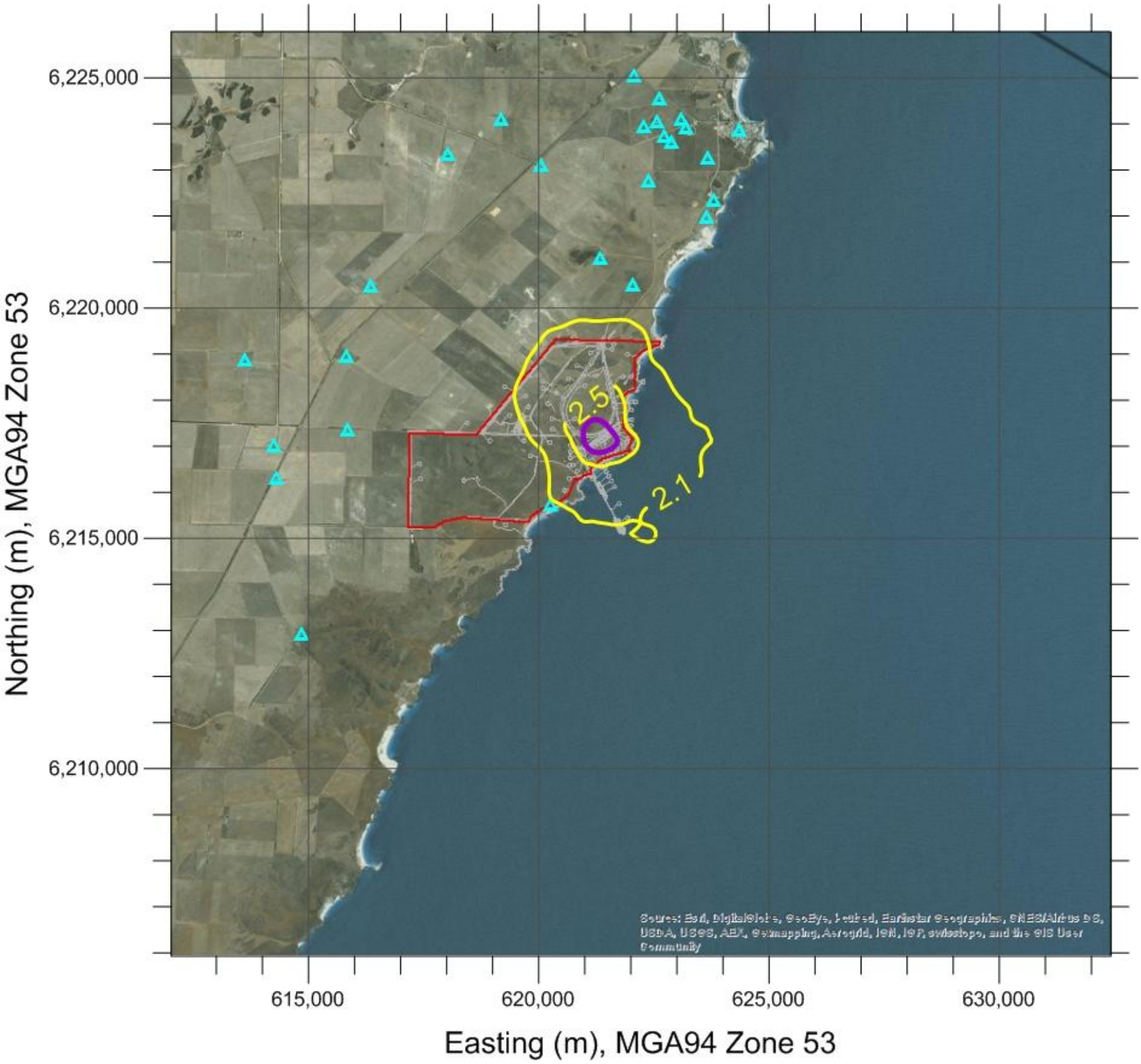

Figure 3-14 Predicted annual average dust deposition (g/m^2/month), Scenario No.3

3.5.2.6 Assessment at Sensitive Receptors

A summary of the CALPUFF results for predicted GLCs and dust deposition at each of the sensitive receptors identified for the port site is provided in Table 3-16. The results correspond to the maximum, i.e. Rank 1, predicted concentrations, and include relevant background concentrations and dust deposition. The results for PM_{10} and $PM_{2.5}$ incorporate the modified operations for 100 hours in the year as discussed above.

Table 3-16: Predicted Maximum (Rank 1) GLCs at Sensitive Receptors

Sensitive Receptor numbers	PM_{10} 24 hr avg. (ug/m^3)	$PM_{2.5}$ 24 hr avg. (ug/m^3)	$PM_{2.5}$ annual avg. (ug/m^3)	TSP annual avg. (ug/m^3)	TSP deposition (g/m^2/month)
191	24.8	11.2	7.0	30.1	2.0
44	40.5	17.7	7.8	33.2	2.1
193	26.6	11.8	7.1	30.1	2.0
194	27.9	12.2	7.1	30.2	2.0
65	28.6	13.3	7.1	30.3	2.0
197	27.3	12.5	7.1	30.2	2.0
66	33.4	15.0	7.2	30.4	2.0
55	30.1	13.4	7.2	30.5	2.0
198	34.1	15.3	7.2	30.6	2.0
43	46.1	20.4	7.7	32.1	2.1
42	43.7	18.8	7.5	31.4	2.0
75	32.1	13.9	7.3	31.0	2.0
76	31.5	13.7	7.3	30.9	2.0
40	32.4	14.3	7.3	30.7	2.0
229	31.3	14.1	7.2	30.6	2.0
205	30.7	13.4	7.2	30.7	2.0
203	29.2	13.2	7.2	30.5	2.0
53	28.6	12.8	7.2	30.6	2.0
54	29.2	13.0	7.2	30.5	2.0
51	27.5	12.1	7.2	30.6	2.0
Port Neill central	28.8	12.7	7.2	30.5	2.0
39	29.4	13.1	7.2	30.5	2.0
38	28.5	12.7	7.2	30.4	2.0
37	27.2	12.2	7.1	30.3	2.0
41	30.2	13.7	7.2	30.4	2.0
52	27.3	12.2	7.2	30.5	2.0
Project air quality standard (maximum)	50	25	8	90	4

3.5.3 Port site monitoring and mitigation

An operational dust management program will be implemented at the port site to assist with air quality management for the Cape Hardy locality. This will include analysis of weather forecasts and real-time, continuous dust monitoring at selected locations to be set out in a dust management plan at a later date. This dust management approach will enable modification or suspension of operational activities at the port site in response to the following triggers:

- Predicted increased dust risk from meteorological forecast information e.g. specific wind speeds in specific directions
- Warnings or exceedance alarms from real time dust monitoring at selected sites around the port facility
- Visual observations(s) of significant dust generation.

The approach of adjusting operations based on forecasting and/or real-time dust monitoring has been included in the modelling work for PM_{10} and $PM_{2.5}$ emissions (on a 24 hour average basis) to demonstrate the impact of operational changes on predicted dust ground level concentrations at sensitive receptors.

4. Infrastructure Corridor Air Quality Assessment

This section provides the assessment of air emissions associated with the proposed infrastructure corridor.

It is expected that six loaded trains will transport iron concentrate from the mine site to the port site each 24 hour period. Each train will consist of two diesel engine powered locomotives and 138 wagons, approximately 1.3 km in length. Each loaded train will have a capacity to carry approximately 10,750 tonnes of product. The empty trains travelling from the port site back to the mine site will have one locomotive. The maximum loaded train speed is 60 km/h and the maximum empty train speed is 80 km/h. The maximum speed on entry and exit to the port and mine sites will be 10 km/h.

The rail cars will be covered to prevent dust emissions during the transport of the concentrate product from the mine site to the port site.

There will be a 10 m wide unsealed access road adjacent the rail alignment for light vehicle use with a design speed of 60 km/h. A daily track patrol comprising a light vehicle will travel the length of the rail alignment.

4.1 Ambient Air Quality Standards

The ambient air quality standards applicable to dust emissions within the infrastructure corridor are the same as those adopted for the port site, i.e. the NEPM standards and guidelines for PM_{10} and $PM_{2.5}$ and the NSW DEC standards and guidelines for TSP and deposited dust. The ambient air quality standards for dust are set out in Table 3-1 (NEPC, 2003); and Table 3-2 (DEC, 2005).

For gaseous emissions from the locomotives, air quality indicators and ambient air quality or 'design' criteria for South Australia are specified in the Environment Protection Authority (EPA) guidance document, *EPA 386/06, Air quality impact assessment using design ground level pollutant concentrations (DGLCs), Updated January 2006* (EPA, 2006). The relevant standards are set out in Table 4-1 below.

Table 4-1: Adopted project criteria for gas emissions (EPA, 2006)

Assessment Parameter	Averaging Period	Maximum including background level	Notes:
Nitrogen dioxide	1 hour	0.158 mg/m^3	Outside Adelaide metro area, based on toxicity
Sulphur dioxide	1 hour	0.45 mg/m^3	Based on toxicity
Carbon monoxide	1 hour	29 mg/m^3	Based on toxicity

4.2 Existing Environment

4.2.1 Geographical Setting

The infrastructure corridor connects the mine site with the port site. From the port site on the Spencer Gulf coast, the alignment initially travels to the north east, before curving north and continuing away from the coast. The railway line then travels in a north-west direction towards the north of Hambidge Conservation Park. It travels in a westerly direction parallel to the northern boundary of the Hambidge Conservation Park before turning to the north and travelling to the mine site. Apart from the southern-most section of the corridor at the port site, the proposed infrastructure corridor will be located at significant distances away from large water bodies, i.e. Spencer Gulf and the Great Australian Bight. As such, it is expected that it will be influenced predominantly by inland meteorological conditions.

4.2.2 Climatological Summary

Coastal

The section of the infrastructure corridor located at the port site will be influenced by coastal meteorology. This is described in detail in Section 3.2.3 of this assessment where Port Lincoln BoM is adopted as the most representative site with detailed long term meteorological information. In summary, the maximum daily temperatures for Port Lincoln typically range from 16.2 to 26.0 deg.C and the average annual rainfall is 381 mm. Wind speeds range from 4.5 to 5.9 m/s in the morning (9 am) and 6.1 to 7.4 m/s in the afternoon (3 pm).

Inspection of the wind roses shows that south-easterly winds are dominant in summer; easterly winds are dominant in spring and autumn; and north-westerly winds are dominant in winter.

Inland

The majority of the proposed infrastructure corridor will be located inland. A detailed description of the meteorology relevant to the mine site is provided in the report *CEIP Air Quality Impact Assessment – Mine Site* (Jacobs 2014). As the corridor spans a large distance, a BoM site located along the mid-section of the corridor was sought. Cleve Aerodrome (BoM station number 018116) was selected as the nearest inland site to the mid-section of the infrastructure corridor. For this station, the maximum daily temperature historically ranges between 15.3 and 28.3 deg.C and the average annual rainfall is 401 mm. Wind speeds range from 3.0 to 4.1 m/s in the morning (9 am) and 3.8 to 4.8 m/s in the afternoon (3 pm).

The wind roses, provided in Appendix E, show that south-easterly winds are dominant in summer and spring; and north-westerly winds are dominant in winter. There is no obvious dominant wind direction for autumn, with wind directions being largely variable.

4.3 Air Emission Sources and Estimates

The key emissions associated with the infrastructure corridor are expected to be:

- Wheel generated dust from light vehicles travelling along unsealed track (track access road)
- Dust from wind erosion of product in rail cars
- Combustion emissions, primarily NO_x, VOCs, SO_2, CO and particulates from the locomotives

4.3.1 Dust emissions

Wheel Generated Dust

The wheel generated dust from the daily inspection work is expected to be minor as there will typically be only one vehicle travelling along the track at any time.

Wind erosion of product from rail cars

An extensive review of dust from coal trains was carried out for Queensland Rail Limited in 2008 (Connell-Hatch, 2008). From this review, the sources of dust from the rail cars include:

- Wind erosion from the top exposed surface of the product in the rail cars
- Leakage from the sides and base of the rail cars
- Spillage of the loaded product from the rail cars onto the railway track
- Residual dust within empty rail cars on the return trip to the mine site
- Residual dust on the external walls of the rail cars, locomotives and associated equipment

For the CEIP, the rail wagons will be covered to prevent the wind erosion of dust from the exposed surface of the rail cars. As such, any emissions from the rail cars are expected to be very minor and a result of potential leakage from the rails cars, residual dust from the empty rail cars and residual dust on the external walls of the trains. Emissions from these sources are not expected to exceed the ambient air quality criteria.

Dust mitigation measures to be implemented for the corridor are expected to include: using lowered train speeds through any towns or residential areas, ensuring regular maintenance of the rail cars to reduce leakage, and ensuring the covers are well fitting to avoid dust emissions. In summary there will be a high level of dust emissions control along the length of the infrastructure corridor.

Dust emissions generated during rail car unloading activities at the port site are addressed within Section 3.3 and Section 3.5.

4.3.2 Locomotive combustion emissions

The main emissions from the combustion of diesel fuel by the locomotives are expected to be NOx, VOCs, CO, particulates and SO_2. USEPA (2009) sets out emission factors for locomotives by tiers, which have been used to estimate pollutant emission rates for locomotives travelling between the port and the mine site. The uncontrolled emission factors for Line-Haul locomotives are provided in Table 4-2 below. As the extent of locomotive emission controls to be used for the project are currently not known, the most conservative approach has been used by adopting the ‘uncontrolled’ emission factors.

For SO_2, the emission factor is calculated using the diesel fuel density and sulphur content of the fuel. The current Australian diesel fuel specification of 10 ppm maximum sulphur content has been adopted for this assessment.

A summary of the locomotive emission factors used for the air emissions estimates is provided in Table 4-2.

Table 4-2: Emission factors for Uncontrolled Line-Haul Diesel Locomotives

Pollutant	Emission factor (g/L)
NO_x	71.4
CO	7.03
Hydrocarbons	2.64
PM_{10}	1.76
$PM_{2.5}$	1.71 [1]
SO_2	0.017 [2]
Total VOCs	2.78 [3]

Notes:
1. The $PM_{2.5}$ is calculated at 97% of PM_{10} emission factor (USEPA, 2009).
2. The SO_2 emission factor calculation assumes that the fraction of fuel sulphur converted to SO_2 is 97.8% (USEPA, 2009).
3. The total VOCs are calculated as 1.053 times the hydrocarbon emission factor (USEPA, 2009).

A summary of the input data used for calculated mass emissions rates is provided in Table 4-3.

Table 4-3: Input data summary for locomotive emission estimates

Input Variable	Value	Source
Locomotive fuel use, L/km	6 - 7	SKM Iron Road (2012)
Number of locomotives for loaded train	2	Iron Road
Number of locomotives for empty train	1	Iron Road
Diesel sulphur content, max, ppm	10	DoE (Australian Government, Department of the Environment, web-site)
Diesel density, max, kg/m^3	850	DoE (Australian Government, Department of the Environment, web-site)

The calculated emission rates for each of the pollutants are provided in Table 4-4.

Table 4-4: Estimated emission rates from locomotives

Pollutant	Emission Rate – Empty Train (g/sec)	Emission Rate – Loaded Train (g/sec)
NO_2	11.1	22.2
CO	1.1	2.2
PM_{10}	0.27	0.55
$PM_{2.5}$	0.27	0.53
SO_2	0.003	0.005
Total VOCs	0.43	0.86

The emission rates for NO_2 shown in Table 4-4 are based on the assumption that 100% of the NOx from the locomotive emissions is NO_2. In reality, a 100% conversion of NO to NO_2 does not occur in the atmosphere as the conversion is dependent on, among other factors, the concentration of ozone in the atmosphere. As there is expected to be relatively low levels of ozone present in the Cape Hardy and inland localities, in comparison with metropolitan regions, the xtent of conversion of NO to NO_2 would be relatively low. The US EPA's Ozone Limiting Method, as described in Section 4.4, was adopted for estimation of the conversion of NO to NO_2 in the atmosphere.

4.4 Modelling Methodology

The emission rates for the pollutants listed in Table 4-4 were calculated using locomotive fuel consumption rates (refer to Table 4-3). The locomotive emissions would occur along the entire length of the railway. To quantify the typical air quality effects from the emissions at any location near the railway line, a single modelling scenario was carried out for a short, but representative section of railway track. The calculated emission rates (Table 4-4) were adjusted to reflect expected emissions from both a loaded train and an empty train passing through a 1 km long section of track near a siding; i.e., taking approximately 60 and 45 seconds, respectively, to travel the 1 km distance and averaged across a 1 hour period. 20 volume sources, evenly spaced along the 1 km track, were used to represent the emissions in the model input.

The location of the track segment was selected from inspection of the wind data for the meteorological regions modelled for both the mine site and the port site. The mine site was observed to have the higher percentage of low to medium wind speeds considered to represent a 'worst case' scenario in terms of particulate ground level concentrations occurring near the railway line.

The modelled 1 km length of track was positioned in a north-west to south-east direction; i.e., heading into the dominant wind direction. Four nominal sensitive receptor locations were selected for the assessment: receptors A and B were located approximately 300 m on either side of the track; and receptors C and D were located approximately 140 m either side of the track. The closest actual sensitive receptors along the length of the railway line are approximately 140 m from the proposed track.

Of the gaseous air pollutants, i.e. CO, NO_2, and SO_2, and particulates (PM_{10} and $PM_{2.5}$), NO_2 has the highest potential to exceed ground level concentration criteria based on ratios of emission concentrations to ground level concentration criteria for each pollutant. As such, NO_2 was the focus of this assessment. Note that an applicable criteria for the general VOC group is not available as VOCs can include a large number of compounds. A breakdown of the composition of the VOCs within the combustion gas from the locomotive would be required such that each contaminant could be individually assessed. From NPI EETM for Combustion Engines (2008), benzene is a key hydrocarbon emission for large diesel engines. The emission factor provided was used to estimate the emission rate for benzene from large combustion engines using diesel and this was compared with the ground level concentration criteria for benzene. From this analysis, it is not expected that VOCs would present a higher risk than NO_2 for locomotive combustion engines, and as such, NO_2 is still considered to be the appropriate focus for the study.

It was assumed that in a 1 hour period, one empty (single locomotive only) and one loaded train (two locomotives) would pass through the 1km railway section, the loaded train at a speed of 60 km/hr and the unloaded train at 80 km/hr. Due to the remoteness of the majority of the railway line, it is expected that the extent of conversion of NO to NO_2 would be limited by, among other factors, the presence of ozone in the atmosphere. As such, the Ozone Limiting Method was used to predict the ground level concentrations of NO_2 at the sensitive receptors. This method assumes that all the available ozone in the atmosphere will react with NO until either all of the ozone or all of the NO is used up.

The ambient ozone and NO_2 concentrations for the infrastructure corridor were taken from the SA EPA's campaign monitoring data set for Whyalla for 2006 (EPA Whyalla 2006). Note that there is limited data available for the Eyre Peninsula, and this data set was found to be the most complete and appropriate for use for the infrastructure corridor. The 90th percentile hourly average concentrations from the annual data were adopted. These were 0.019 ppm (39 ug/m^3) for NO_2, and 0.036 ppm (77 ug/m^3) for ozone.

4.5 Modelling Results

A summary of the CALPUFF modelling results for NO_2 GLCs due to locomotive emissions travelling along a 1 km section of rail-line on a representative part of the infrastructure corridor is provided in Table 4-5.

Table 4-5: Comparison of predicted maximum ground level concentrations, including background, with project criteria

Indicative Receptor ID	Maximum 1h average NO_2, GLC (ug/m^3)	Distance from track (m)
Receptor A	108	300 (N-E of track)
Receptor B	122	300 (S-W of track)
Receptor C	126	140 (S-W of track)
Receptor D	123	140 (N-E of track)

Notes:
1. All predicted concentrations shown included background concentration 39 µg/m^3.
2. The US EPA's Ozone Limiting Method has been applied to the modelling output.
3. The corresponding EPA 2006 standard for NO_2 outside of the Adelaide metropolitan area is 158 ug/m^3 (maximum 1-hour average).

The CALPUFF results indicate that concentrations of NO_2 and all other gaseous pollutants from the locomotive emissions are unlikely to exceed relevant air quality standards along the infrastructure corridor, at distances of and greater than 140 m from the railway line. As the closest sensitive receptor for the infrastructure corridor is located 140 m from the track, no exceedances of the NO_2 criteria are expected at the sensitive receptors.

Note that the NO_2 ground level concentrations predicted by the model are considered to be conservative. This is because the approach assumes that the NO to NO_2 conversion occurs instantaneously. Whereas, in practice, the reaction will occur over a number of hours in the atmosphere, and by this time, the plume is likely to be well dispersed. In addition, the existing ambient concentrations for NO_2 and ozone used for the calculations were relatively high, with the 90th percentile concentrations selected from the township of Whyalla. The concentrations in the remote areas of Eyre Peninsula along the proposed infrastructure corridor alignment are expected to be lower than these values.

5. Construction Qualitative Air Quality Impact Assessment

5.1 Introduction

The earthworks material movements associated with construction of the port infrastructure are expected to be substantially less than those for the future port infrastructure and iron concentrate ship-loading operations. Also the dust emissions from construction earthworks are expected to be more easily controlled using conventional dust mitigation measures such as water carts and water sprays. It follows that the dust emissions from the construction earthworks will be substantially less than the port operations. For these reasons an assessment of smaller scale construction phase by air dispersion modelling was not warranted. A similar argument applies for construction of the infrastructure corridor and the accommodation village at Wudinna.

The focus of this section is on identifying the likely and potential sources of dust emissions from construction activities. This will allow appropriate dust mitigation measures and environmental management procedures to be set out to ensure a minimum of dust complaints from neighbours and to ensure that, as far as practicable, construction activities do not cause exceedances of project air quality criteria. It is assumed that the project criteria applied for assessment of the CEIP operations would also apply to construction.

5.2 Construction Dust Emissions

This section provides a short description of the construction activities in the context of their potential to cause dust emissions that may impact on amenity and human health.

Construction of the proposed port development will occur over approximately three years. There will be a dedicated construction camp located within the proposed port site, comprising approximately 650 rooms for the duration of construction. Construction activities for the proposed port facility, for the infrastructure corridor, and the accommodation village at Wudinna are expected to include, but not be limited to, the following works:

- Vegetation clearing and grading
- Establishment of ancillary sites such as material stockpiles, site offices, truck turnarounds and water extraction points
- Deliveries and stockpiling of gravel and other construction materials
- Hauling of equipment items
- Excavation for installation of new rail equipment
- Excavation for in-ground services works
- Hauling and transferring excavated material
- Blasting
- Concrete batching
- Establishing foundations
- Lifting operations, e.g. use of cranes
- General construction works associated with the construction of various buildings and storage facilities
- New road construction and road improvement/upgrade works
- Landscaping
- Earthworks and construction activities associated with the installation of new (and upgrade of any existing) services including power, sewerage, and stormwater
- Painting, preparation and coating of new structural items

A range of construction plant and equipment would be required for the above activities. Typically these would include:

- Excavators
- Cranes
- Graders
- Vibratory rollers
- Water carts
- Concrete batching trucks
- Haul trucks and other heavy transport vehicles
- Various small plant

Dust emissions will be the most significant air emissions from construction of the port site and the infrastructure corridor, with respect to the potential to cause air quality impacts. Construction activities resulting in dust emissions at the port site will include:

- Causing wheel-generated dust from unsealed roads:
  - Light vehicles
  - Fuel and lubrication deliveries, typically by A Double road trains
  - Delivery trucks, typically by semi-trailers and A Double road trains
- Wind erosion from areas cleared of vegetation such as unsealed roads and stockpiles
- Earthworks by, for example: scrapers, articulated dump trucks, excavators, and bulldozers

The degree of dust nuisance would depend on the proximity of sensitive receptors, intensity of earthworks in specific areas, the duration of construction time, the nature of the soil/excavated material, and weather conditions; e.g., current experience on the Eyre Peninsula shows that a wind speed near ground level of approximately 5 m/s can lead to significant dust lift-off from exposed areas[6].

5.3 Construction Dust Mitigation Measures

Two key environmental goals for the CEIP's construction activities are: (1) Zero nuisance dust complaints from neighbours; and (2) Zero detected exceedances of project ambient air quality criteria. This section sets out the environmental management procedures recommended for construction, including dust mitigation measures, with a view to achieving these goals.

Dust control measures will include:

- All materials transported to and from the construction site will be covered
- Temporary stockpiles of soil or other material are to be covered or sprayed with water or suitable chemical wetting agents on a regular basis, particularly during dry or windy conditions
- Vegetation will be retained on site where possible to minimise erosion
- All stockpiles will be located as far from residences and any other sensitive receptors as far as practicable
- Temporary haul roads will be constructed of compacted gravel, or similar

[6] Continuous-TSP measurements on Central Eyre Peninsula on two days in April 2014 showed that a 5-minute average wind speed of 5–6 m/s, (measured at a height of approximately 1.5 m above ground level), was strongly associated with a substantial increase in airborne dust particle concentrations.

- Water/chemical wetting agents will be used to suppress dust on temporary roadways and other exposed areas
- Dust-generating activities will be minimised during windy conditions, particularly when dust is visible in the air
- Best practice engine emissions controls will be installed on vehicles and diesel engine powered equipment where practicable (partly for protection of Work, Health and Safety); and vehicles and machinery will be maintained and operated to minimise emissions of gaseous and particulate pollutants.

The dust management activities will be detailed in Construction Environmental Management Plans at a later date; to assist with on-site environmental management, and may also include analysis of weather forecasts and the use of real-time dust monitoring equipment.

6. Conclusion

This report provides the results of an air quality impact assessment undertaken for Iron Road's proposed CEIP infrastructure incorporating a proposed port, railway line, pipeline, transmission line, borefield and employee village. The study was undertaken by the identification of key air pollutant sources from activities expected to be associated with the proposed CEIP; calculation of dust particle source terms for modelling; TAPM and CALMET meteorological modelling; and dust particle dispersion modelling using CALPUFF.

The main part of this assessment was a dust dispersion modelling study of the proposed port operations. Three air emissions scenarios were set out based on material movement activities at the port site. The scenario with the highest particulate mass emission rate was Scenario No.3 involving the unloading of concentrate from the trains and loading of the stockpile, simultaneously with reclaiming from the stockpile, transfer to the jetty, and loading of concentrate to ships. The modelling assessment focussed on the following air quality indicators:

- Maximum 24 hour average PM_{10} and $PM_{2.5}$ particle concentrations
- Annual average airborne particle (TSP) and $PM_{2.5}$ concentrations
- Annual average dust depositions

A summary of the results of the air dispersion modelling for the port site operations is provided in the following points:

- **PM_{10}:** Model predictions were undertaken using estimates for 24-hour average background concentration of 22 µg/m^3 for PM_{10}. The modelling work demonstrated that the project criterion for PM_{10} (maximum 24-hour average concentration 50 µg/m^3) can be achieved with minor changes to operational activities based on dust monitoring and forecasting tools used to assess potential impacts for the nearest sensitive receptor.
- **$PM_{2.5}$:** Similarly, the 24-hour average project criterion for $PM_{2.5}$ (25 µg/m^3) was predicted to be achievable at all sensitive receptors with the adoption of minor changes to operational activities during specific meteorological conditions. Modelling for maximum 24-hour average $PM_{2.5}$ concentrations included a background of 10 µg/m^3. For annual average $PM_{2.5}$, using a background concentration of 7 µg/m^3, there were no predicted exceedances of the project criterion of 8 µg/m^3 (for all receptors).
- **Dust deposition.** Typical model results for dust deposition within the port boundary were 2–3 g/m^2/month; results of 4 g/m^2/month and higher were predicted directly over the site's stockpile area. The model results for dust deposition indicated that there would be no nuisance dust impacts outside the port boundaries, including no dust impacts at sensitive receptors.

An operational dust management program will be implemented at the port site to assist with air quality management for the Cape Hardy locality. This will include analysis of weather forecasts and real-time, continuous dust monitoring at selected locations to be set out in a dust management plan at a later date.

The results of a qualitative assessment indicated that no air quality impacts would be expected to occur from locomotive combustion emissions at the port site or along the infrastructure corridor.

Any potential dust impacts created during construction are expected to be less than those during normal operation due to the lower material movement rates and the use of adaptable dust control measures which can be tailored to the specific construction activity. As such, construction dust emissions will be effectively managed by the use of accepted dust control mitigation practices and may also include meteorological forecasting combined with real-time dust monitoring.

7. References

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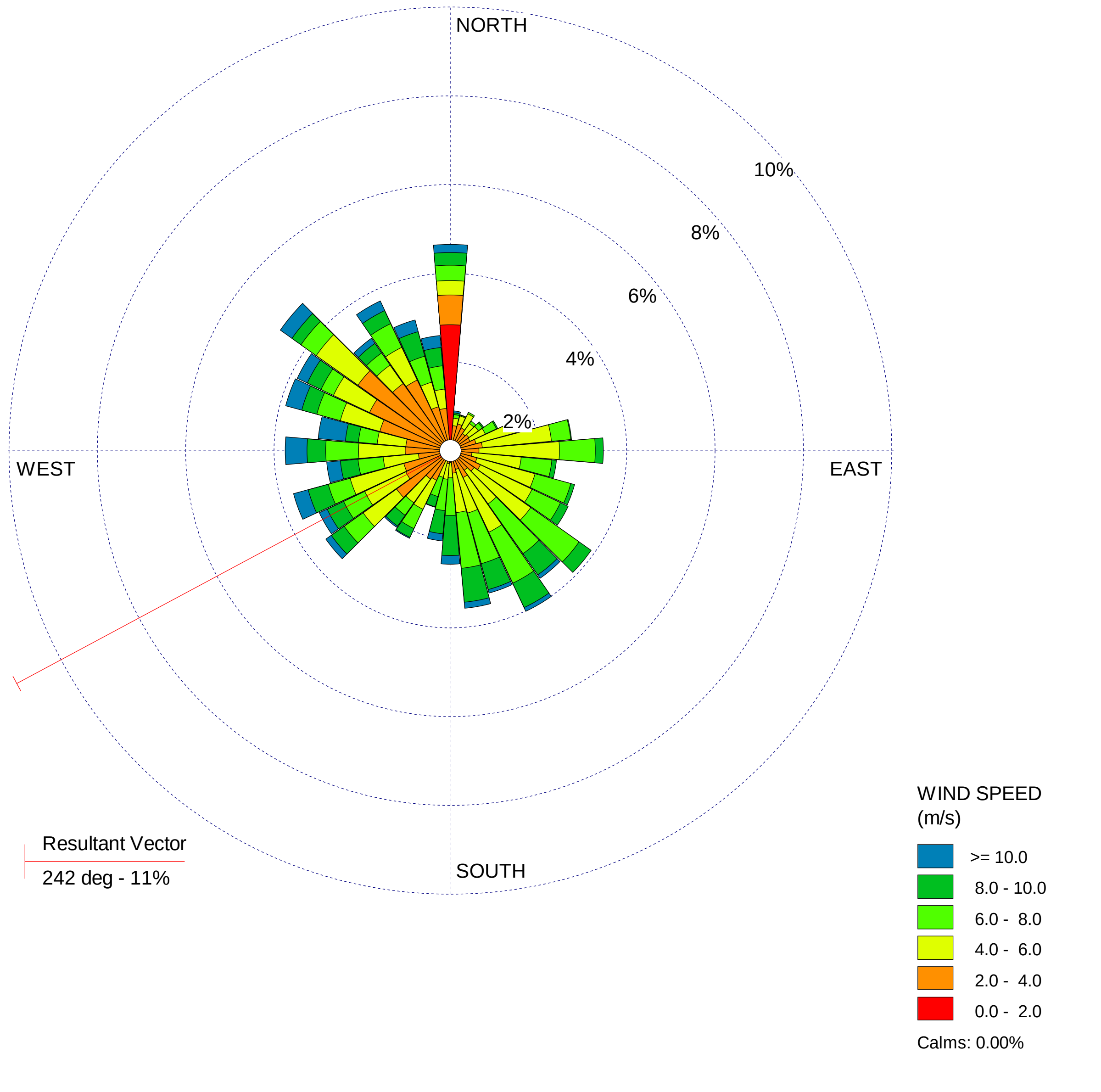
Appendix A. Wind roses 2009: Port Lincoln (BoM observations) and Cape Hardy (TAPM model)

WIND ROSE PLOT:

BoM Observations Port Lincoln (North Shields) 2009
1/1/2009 1:00 - 31/12/2009 24:00 (all hours)

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:

DATA PERIOD:

Start Date: 1/01/2009 - 00:00
End Date: 31/12/2010 - 00:00

TOTAL COUNT:

8750 hrs.

AVG. WIND SPEED:

5.25 m/s

DATE:

1/08/2014

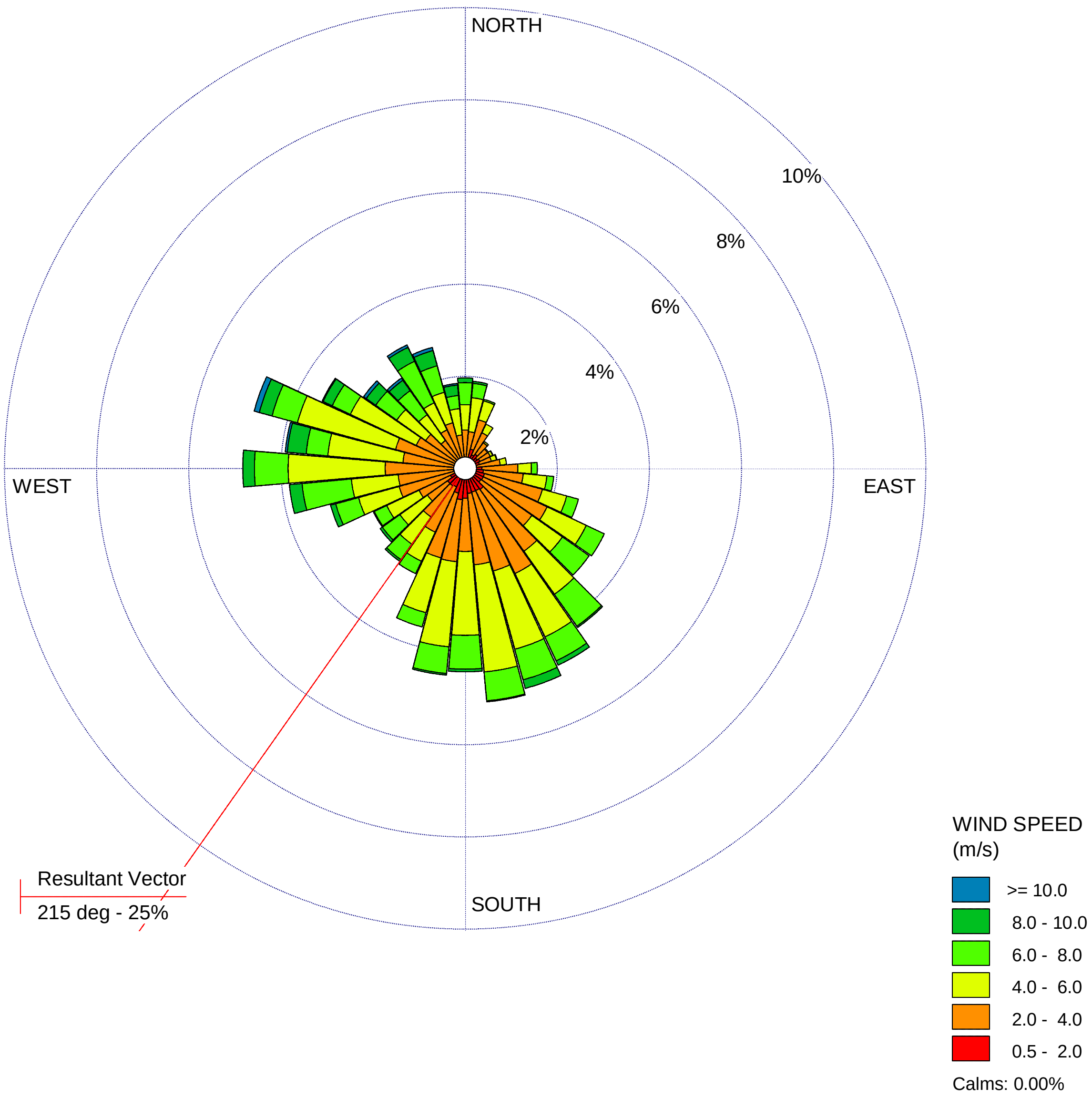
PROJECT NO.:

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:

TAPM results Cape Hardy 2009
1/1/2009 1:00 - 31/12/2009 24:00 (all hours)

DISPLAY:
Wind Speed
Direction (blowing from)



Start Date: 01/01/2009 - 00:00 **End Date: 31/12/2009 - 23:00**		
CALM WINDS: **0.00%**	TOTAL COUNT: **8760 hrs.**	
AVG. WIND SPEED: **4.20 m/s**	DATE: **17/06/2014**	

Appendix B. Wind roses Port Lincoln (BoM observations 1992-2010)

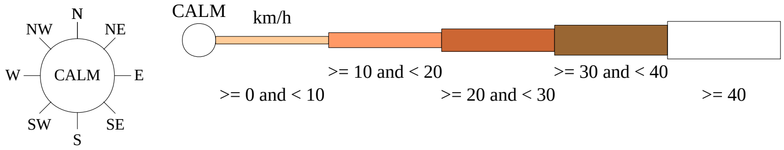
Rose of Wind direction versus Wind speed in km/h (02 Apr 1992 to 30 Sep 2010)

Custom times selected, refer to attached note for details

NORTH SHIELDS (PORT LINCOLN AWS)

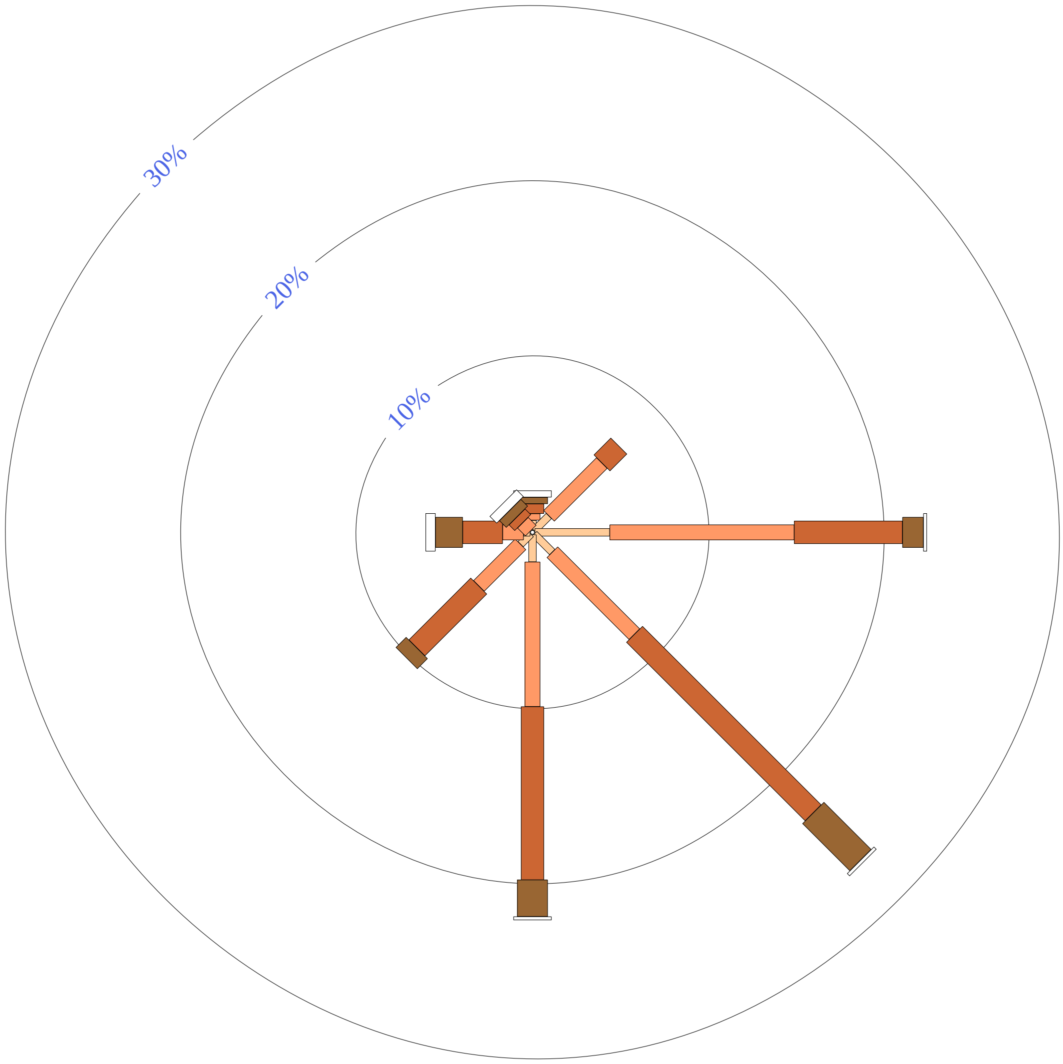
Site No: 018192 • Opened Apr 1992 • Still Open • Latitude: -34.5993° • Longitude: 135.8784° • Elevation 8.m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



9 am Jan
542 Total Observations

Calm 1%



Australian Government
Bureau of Meteorology

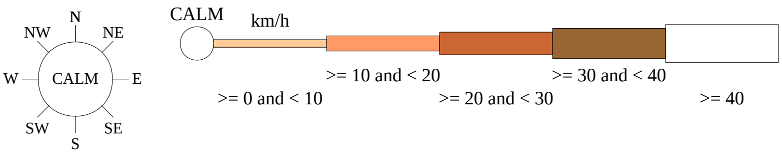
Rose of Wind direction versus Wind speed in km/h (02 Apr 1992 to 30 Sep 2010)

Custom times selected, refer to attached note for details

NORTH SHIELDS (PORT LINCOLN AWS)

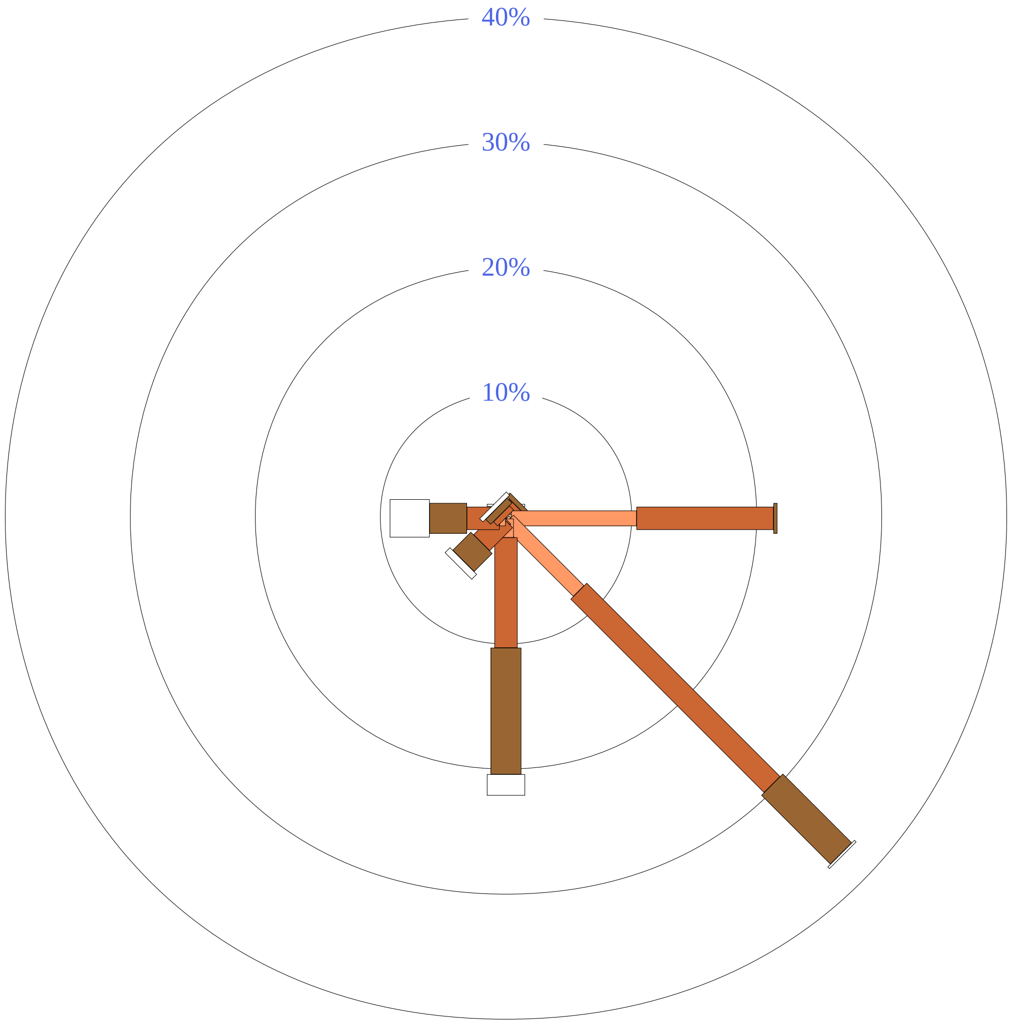
Site No: 018192 • Opened Apr 1992 • Still Open • Latitude: -34.5993° • Longitude: 135.8784° • Elevation 8.m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm Jan
540 Total Observations

Calm *



Australian Government
Bureau of Meteorology

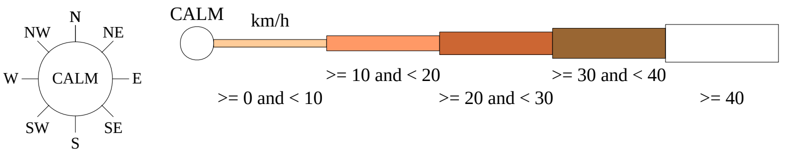
Rose of Wind direction versus Wind speed in km/h (02 Apr 1992 to 30 Sep 2010)

Custom times selected, refer to attached note for details

NORTH SHIELDS (PORT LINCOLN AWS)

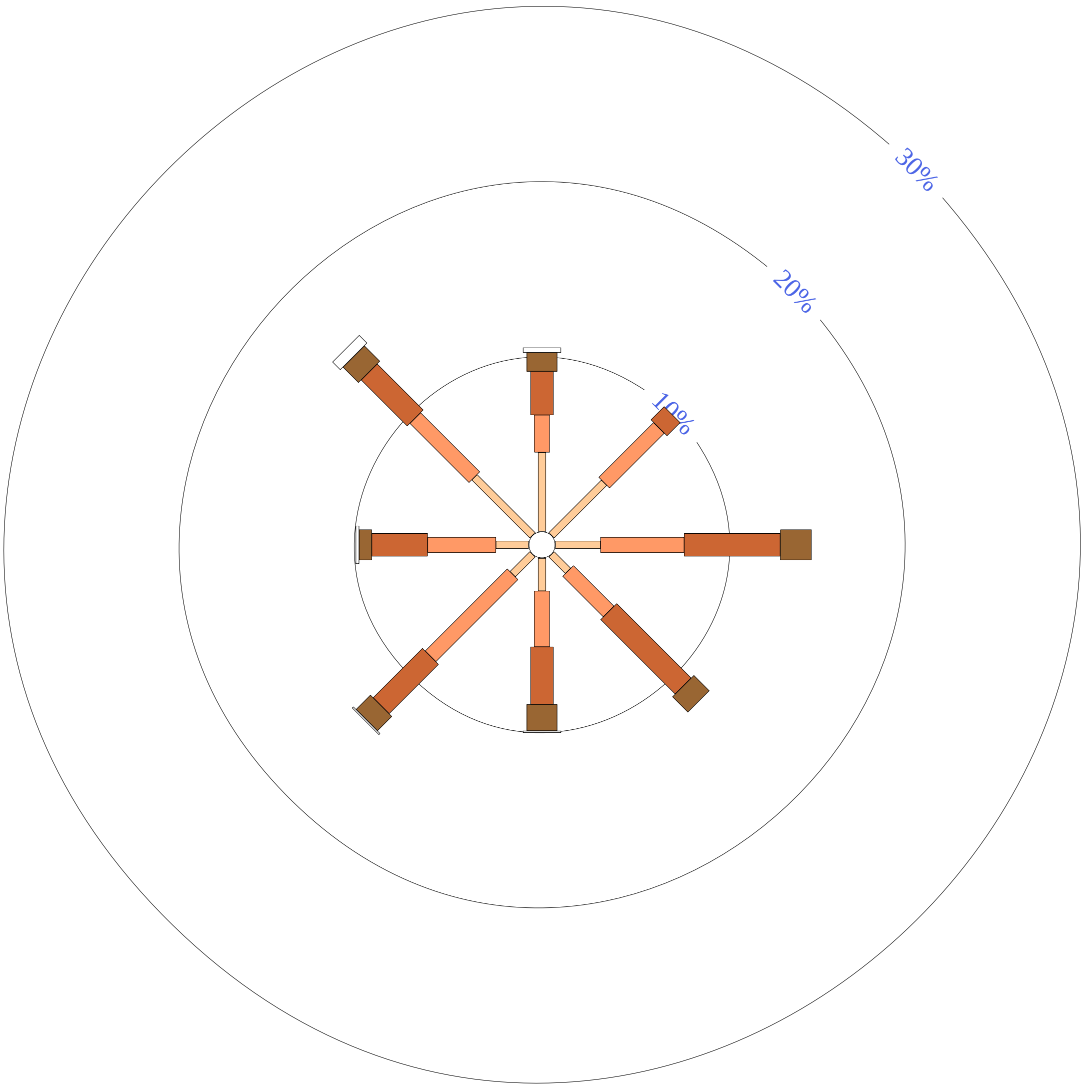
Site No: 018192 • Opened Apr 1992 • Still Open • Latitude: -34.5993° • Longitude: 135.8784° • Elevation 8.m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



9 am Apr
557 Total Observations

Calm 4%



Australian Government
Bureau of Meteorology

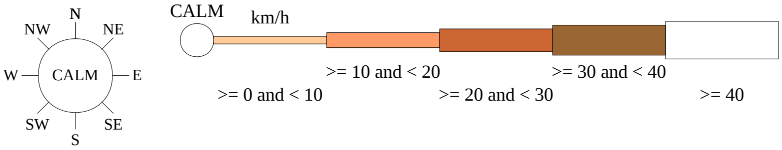
Rose of Wind direction versus Wind speed in km/h (02 Apr 1992 to 30 Sep 2010)

Custom times selected, refer to attached note for details

NORTH SHIELDS (PORT LINCOLN AWS)

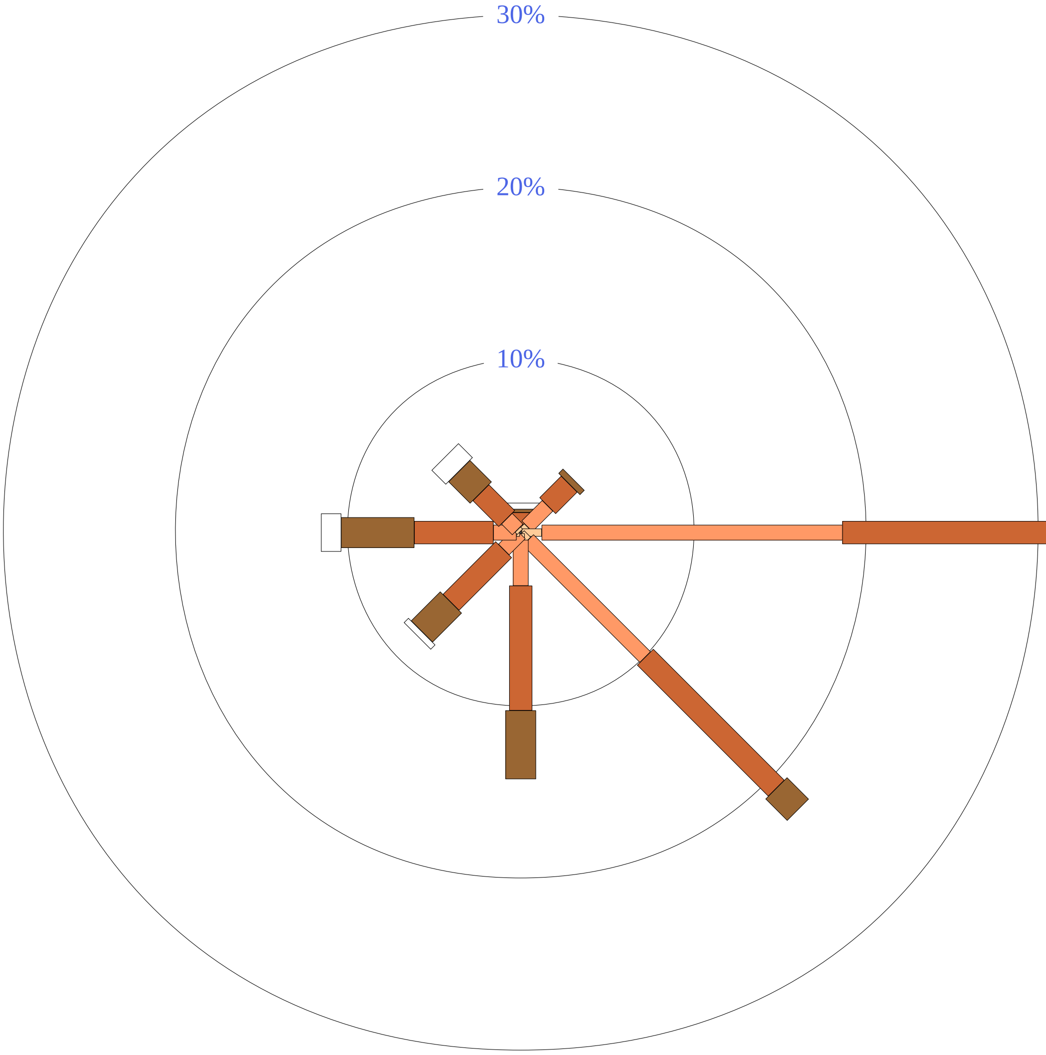
Site No: 018192 • Opened Apr 1992 • Still Open • Latitude: -34.5993° • Longitude: 135.8784° • Elevation 8.m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm Apr
567 Total Observations

Calm *



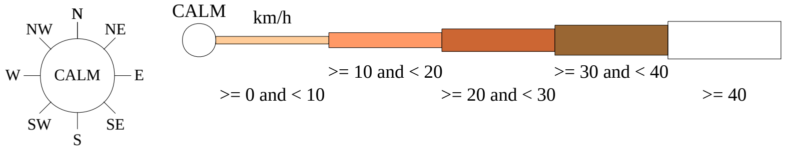
Rose of Wind direction versus Wind speed in km/h (02 Apr 1992 to 30 Sep 2010)

Custom times selected, refer to attached note for details

NORTH SHIELDS (PORT LINCOLN AWS)

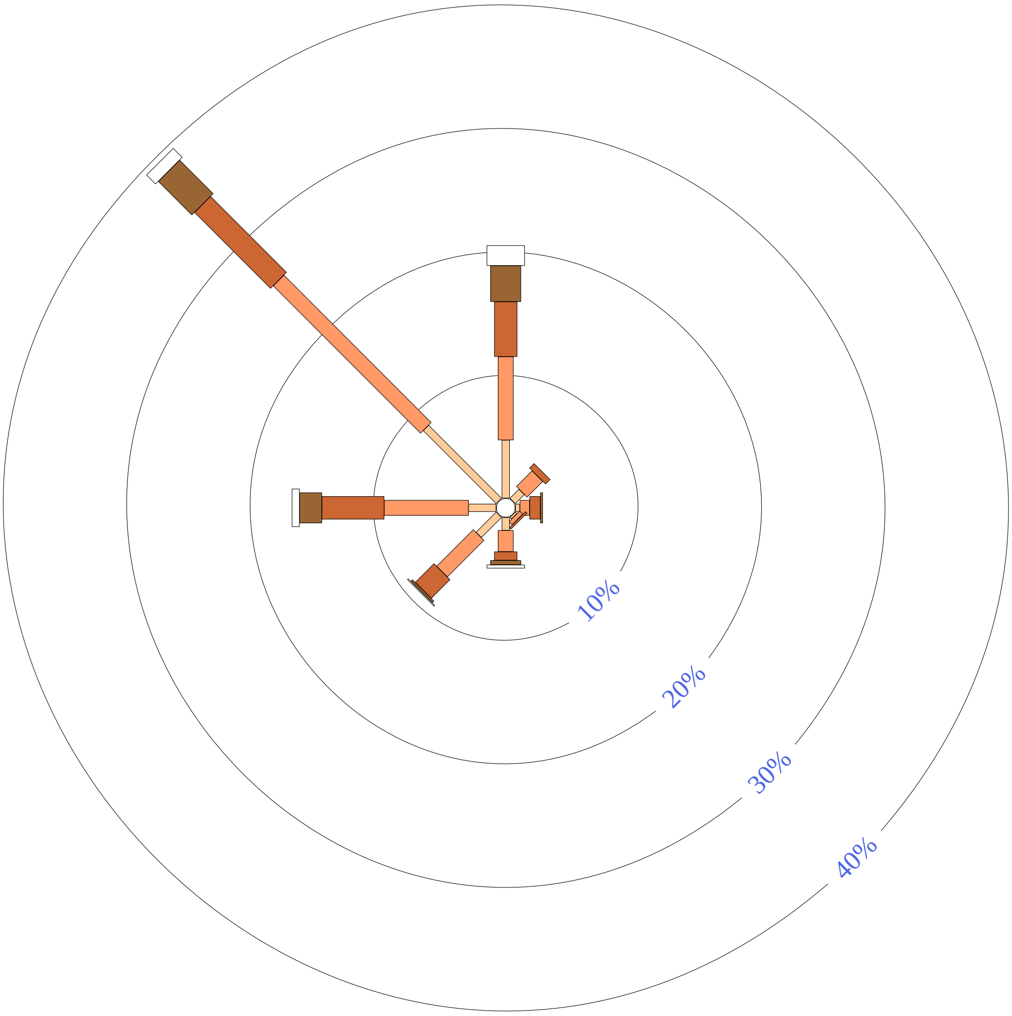
Site No: 018192 • Opened Apr 1992 • Still Open • Latitude: -34.5993° • Longitude: 135.8784° • Elevation 8.m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



9 am Jul
577 Total Observations

Calm 4%



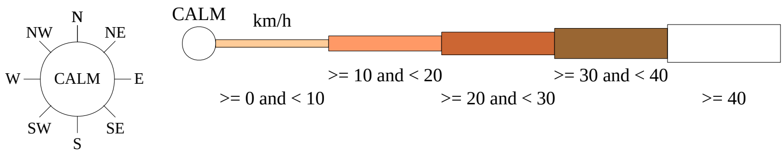
Rose of Wind direction versus Wind speed in km/h (02 Apr 1992 to 30 Sep 2010)

Custom times selected, refer to attached note for details

NORTH SHIELDS (PORT LINCOLN AWS)

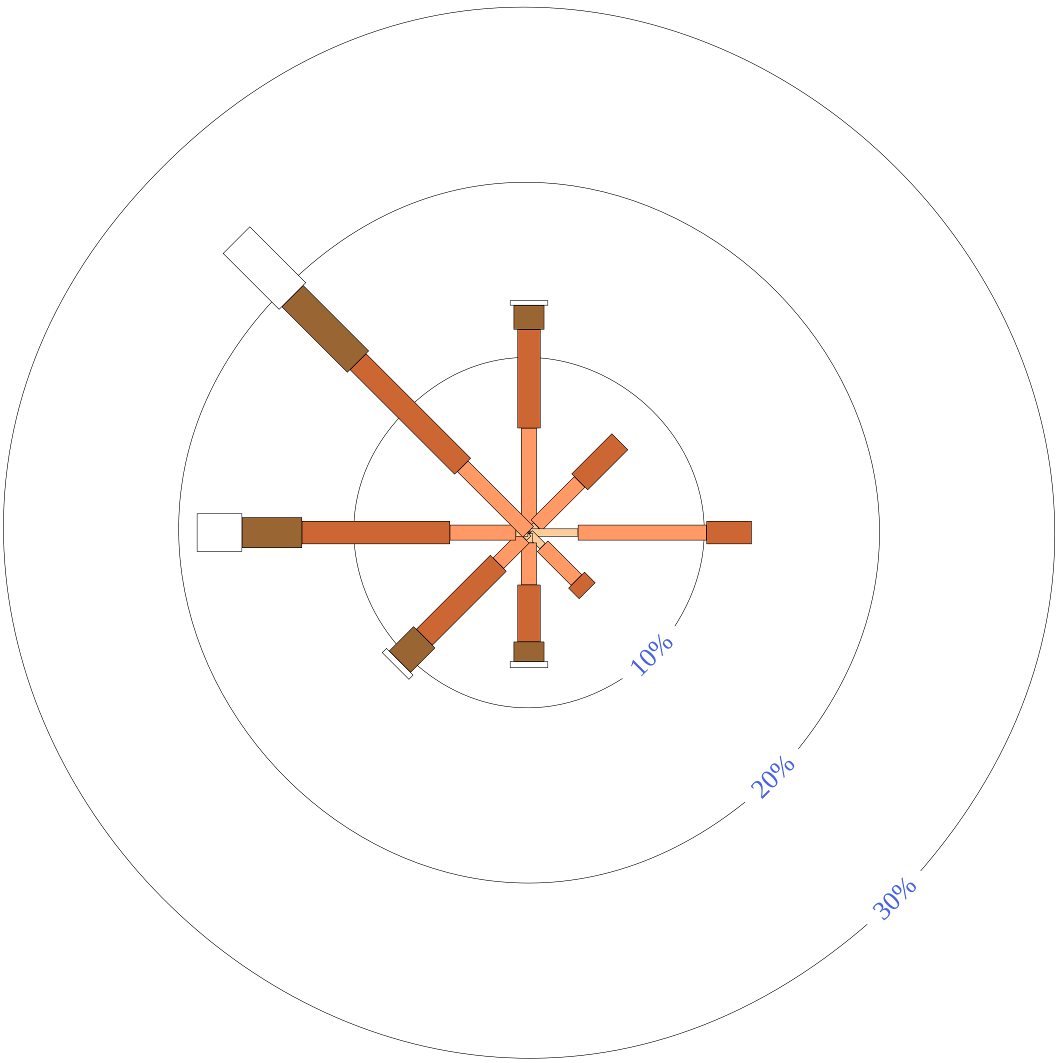
Site No: 018192 • Opened Apr 1992 • Still Open • Latitude: -34.5993° • Longitude: 135.8784° • Elevation 8.m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm Jul
577 Total Observations

Calm *



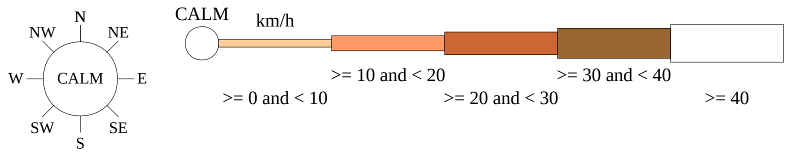
Rose of Wind direction versus Wind speed in km/h (02 Apr 1992 to 30 Sep 2010)

Custom times selected, refer to attached note for details

NORTH SHIELDS (PORT LINCOLN AWS)

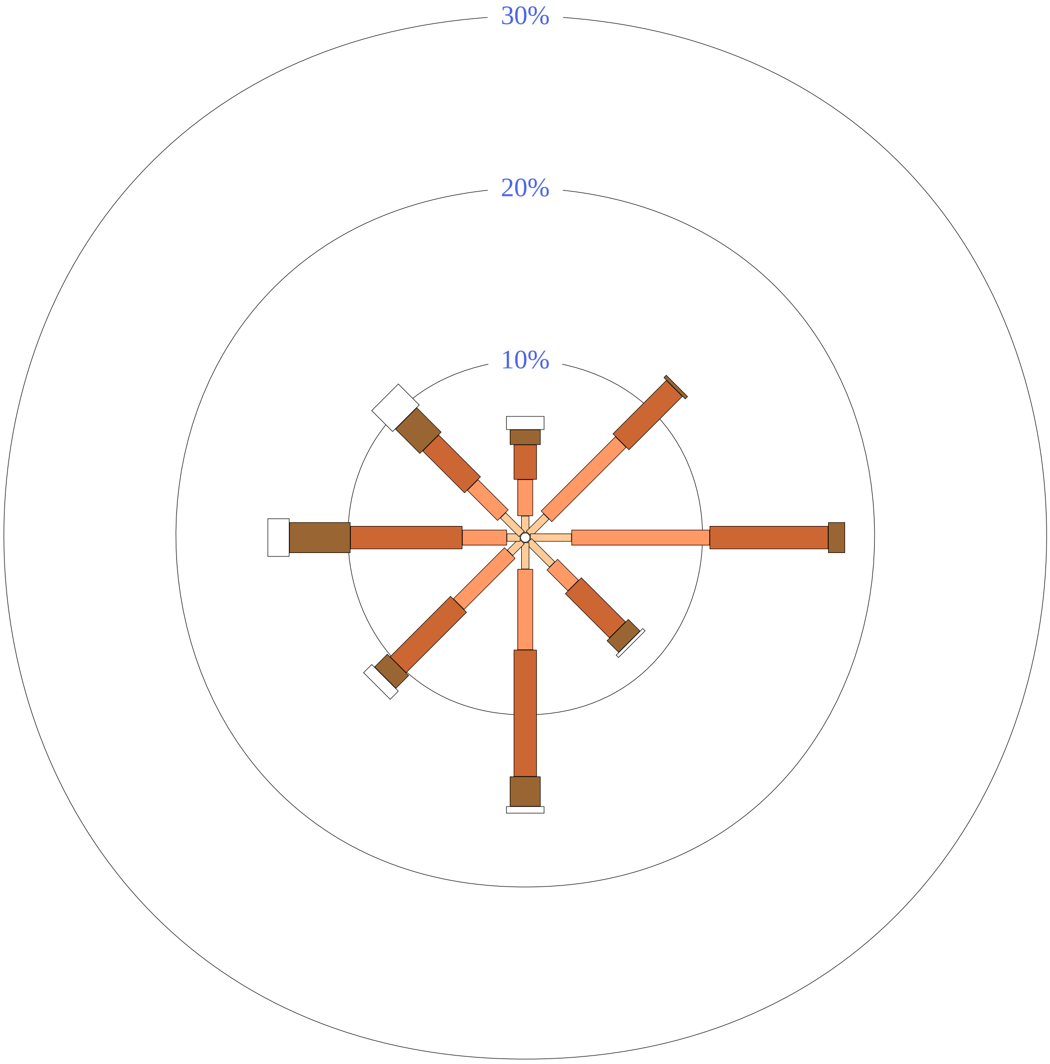
Site No: 018192 • Opened Apr 1992 • Still Open • Latitude: -34.5993° • Longitude: 135.8784° • Elevation 8.m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



9 am Oct
524 Total Observations

Calm 1%



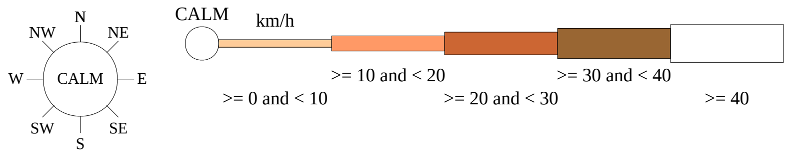
Rose of Wind direction versus Wind speed in km/h (02 Apr 1992 to 30 Sep 2010)

Custom times selected, refer to attached note for details

NORTH SHIELDS (PORT LINCOLN AWS)

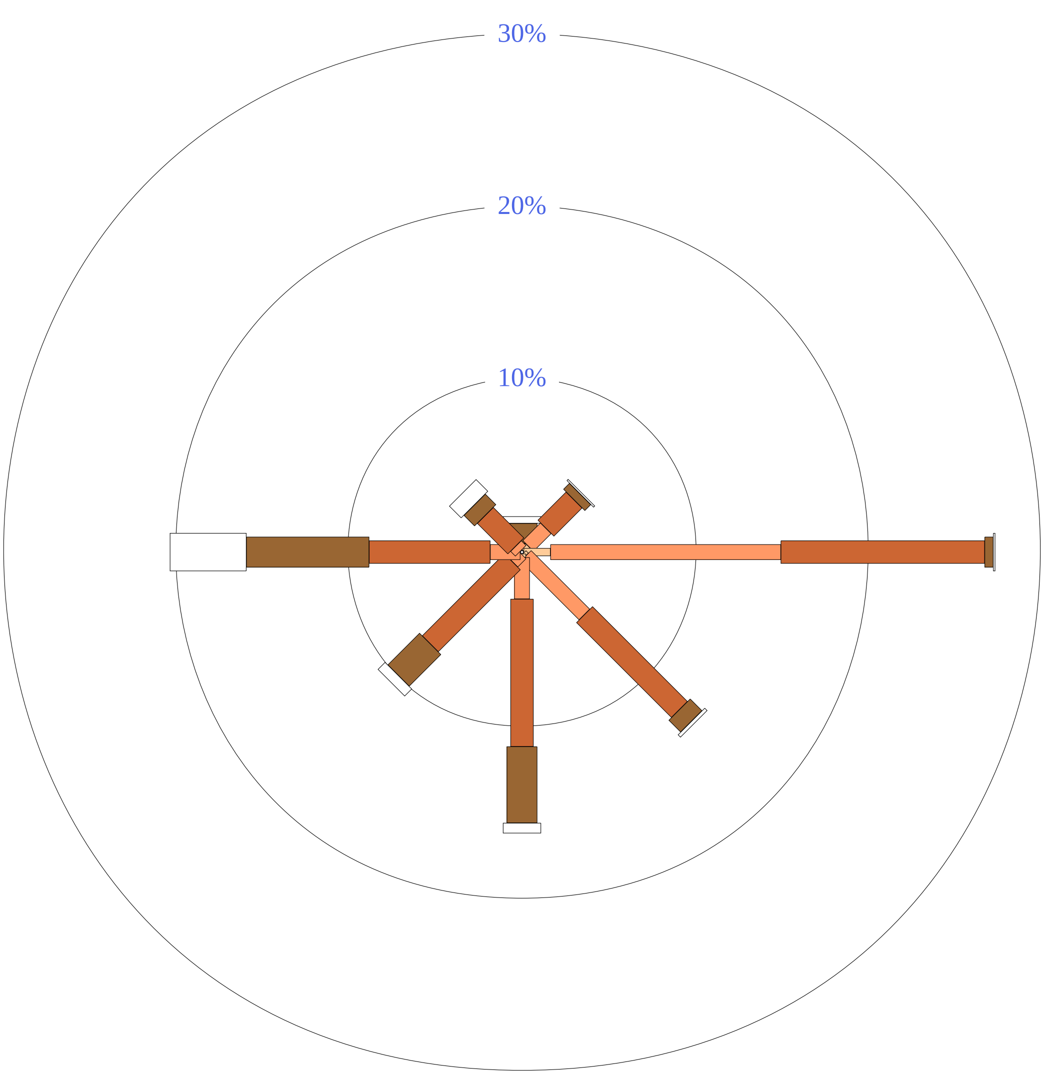
Site No: 018192 • Opened Apr 1992 • Still Open • Latitude: -34.5993° • Longitude: 135.8784° • Elevation 8.m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm Oct
520 Total Observations

Calm *



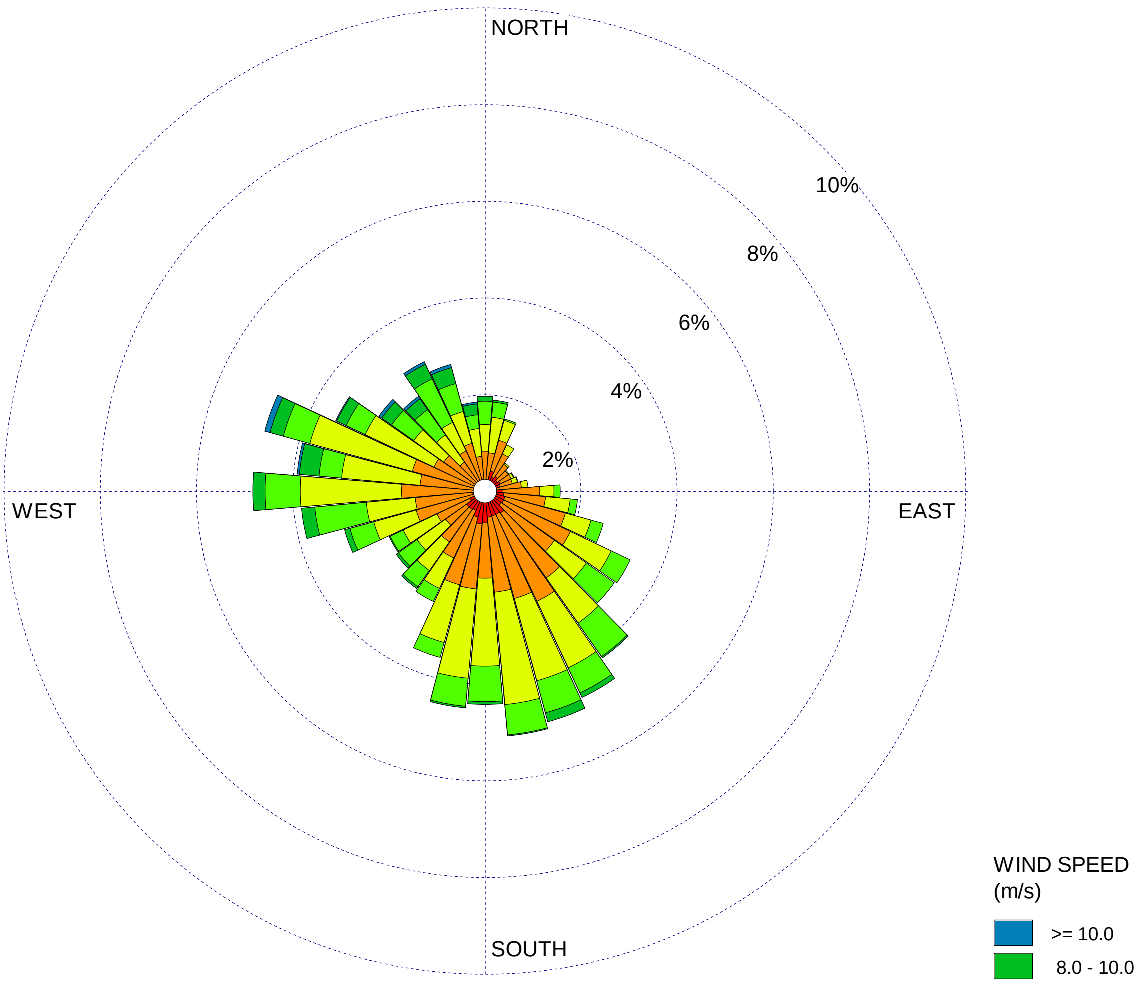
Appendix C. Cape Hardy seasonal wind roses 2009 (TAPM model)

WIND ROSE PLOT:

IRD Port Site
Cape Hardy

DISPLAY:

Wind Speed
Direction (blowing from)



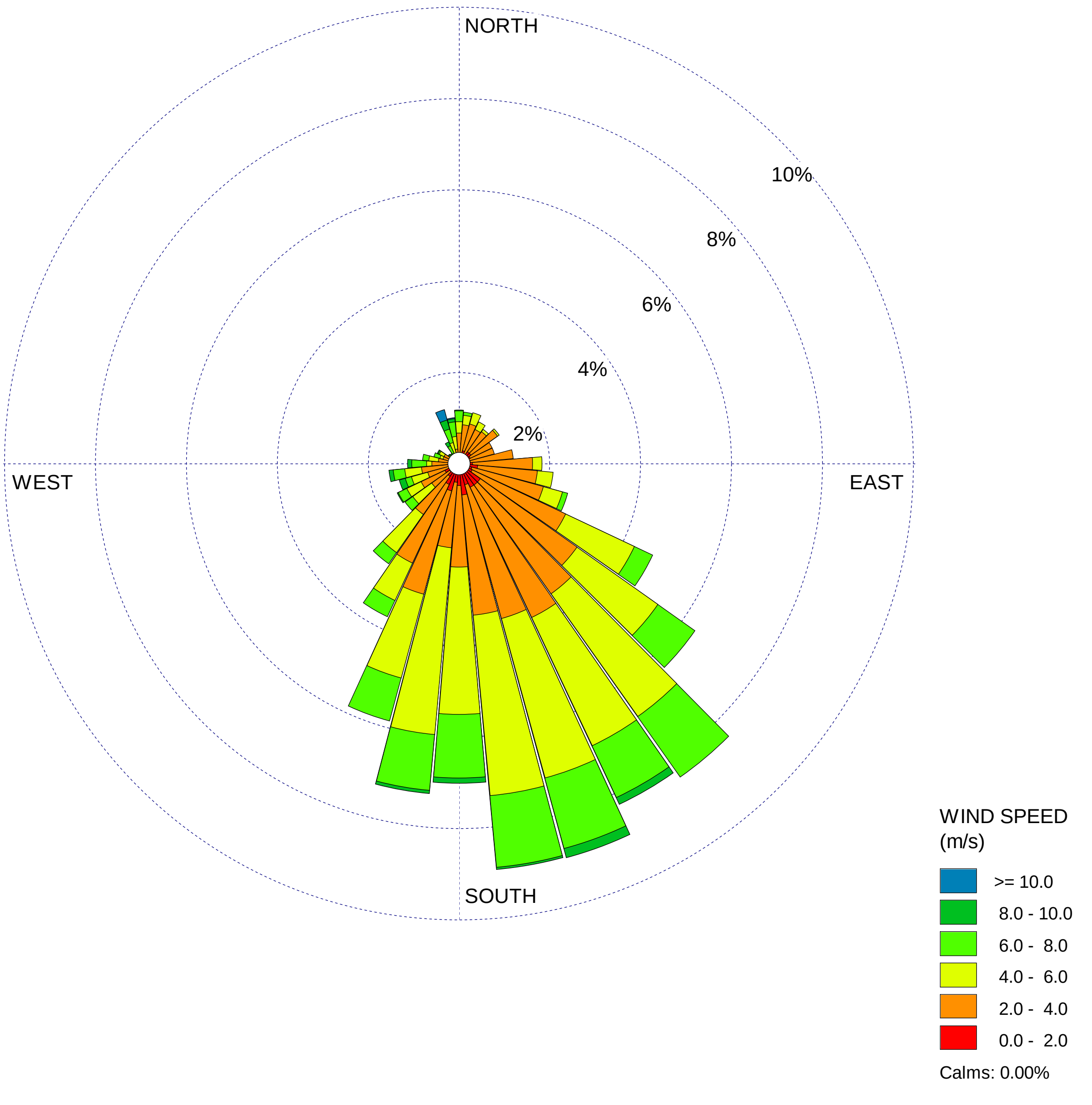
COMMENTS: 2009	DATA PERIOD: **Start Date: 1/1/2009 - 00:00** **End Date: 12/31/2009 - 23:00**	COMPANY NAME: **Sinclair Knight Merz**	
		MODELER: **Matt Pickett**	
		TOTAL COUNT: **8760 hrs.**	
	AVG. WIND SPEED: **4.20 m/s**	DATE: **8/7/2013**	PROJECT NO.: **VE23730**

WIND ROSE PLOT:

IRD Cape Hardy 2009: TAPM Model Results
Summer (all hours)

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:

2009

DATA PERIOD:

Start Date: 1/1/2009 - 00:00
End Date: 12/31/2009 - 23:00

COMPANY NAME:

Sinclair Knight Merz

MODELER:

Michelle Hall

TOTAL COUNT:

4320 hrs.

AVG. WIND SPEED:

4.12 m/s

DATE:

8/7/2013

PROJECT NO.:

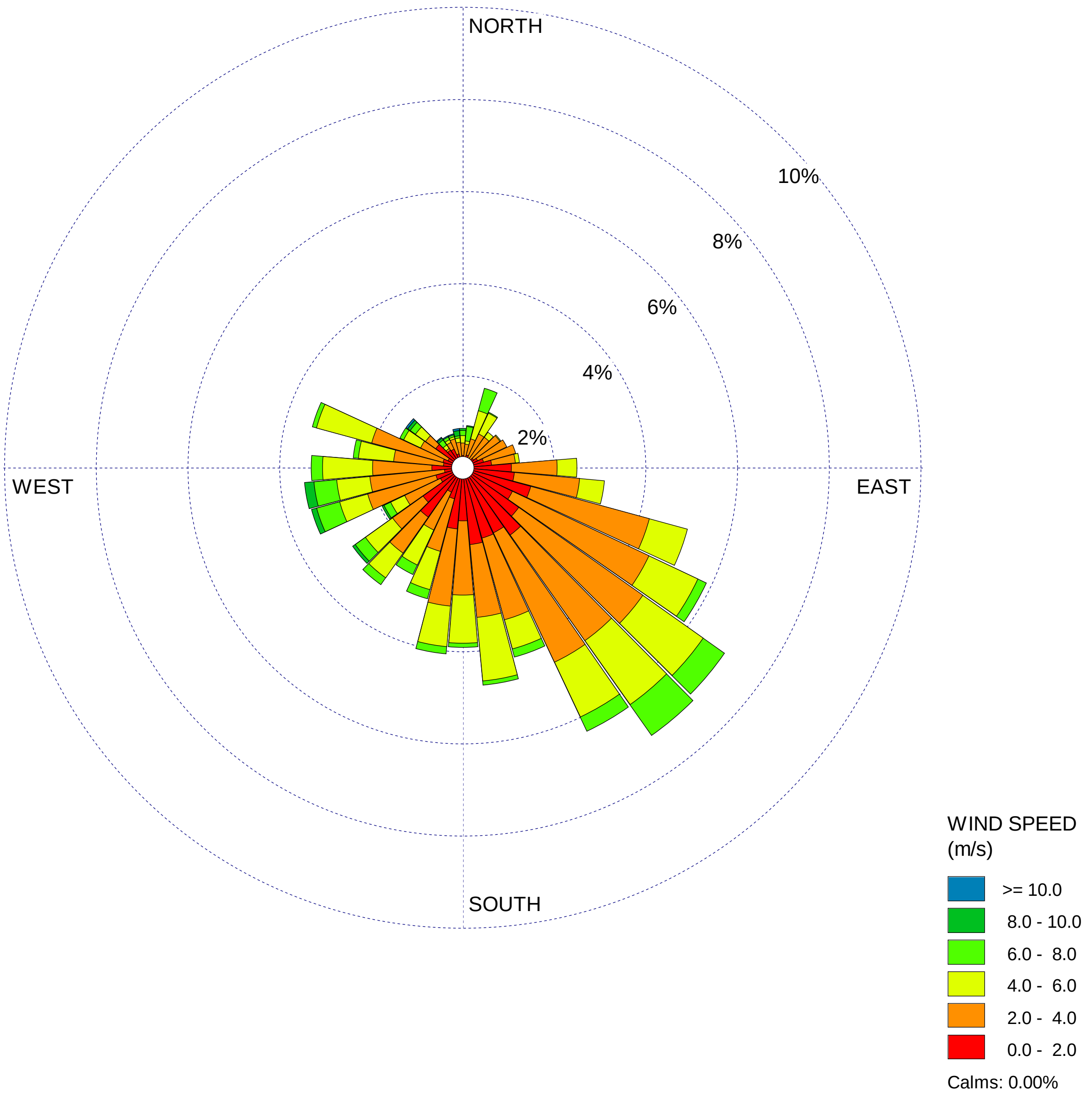
VE23730

WIND ROSE PLOT:

IRD Cape Hardy 2009: TAPM Model Results
Autumn (all hours)

DISPLAY:

Wind Speed
Direction (blowing from)



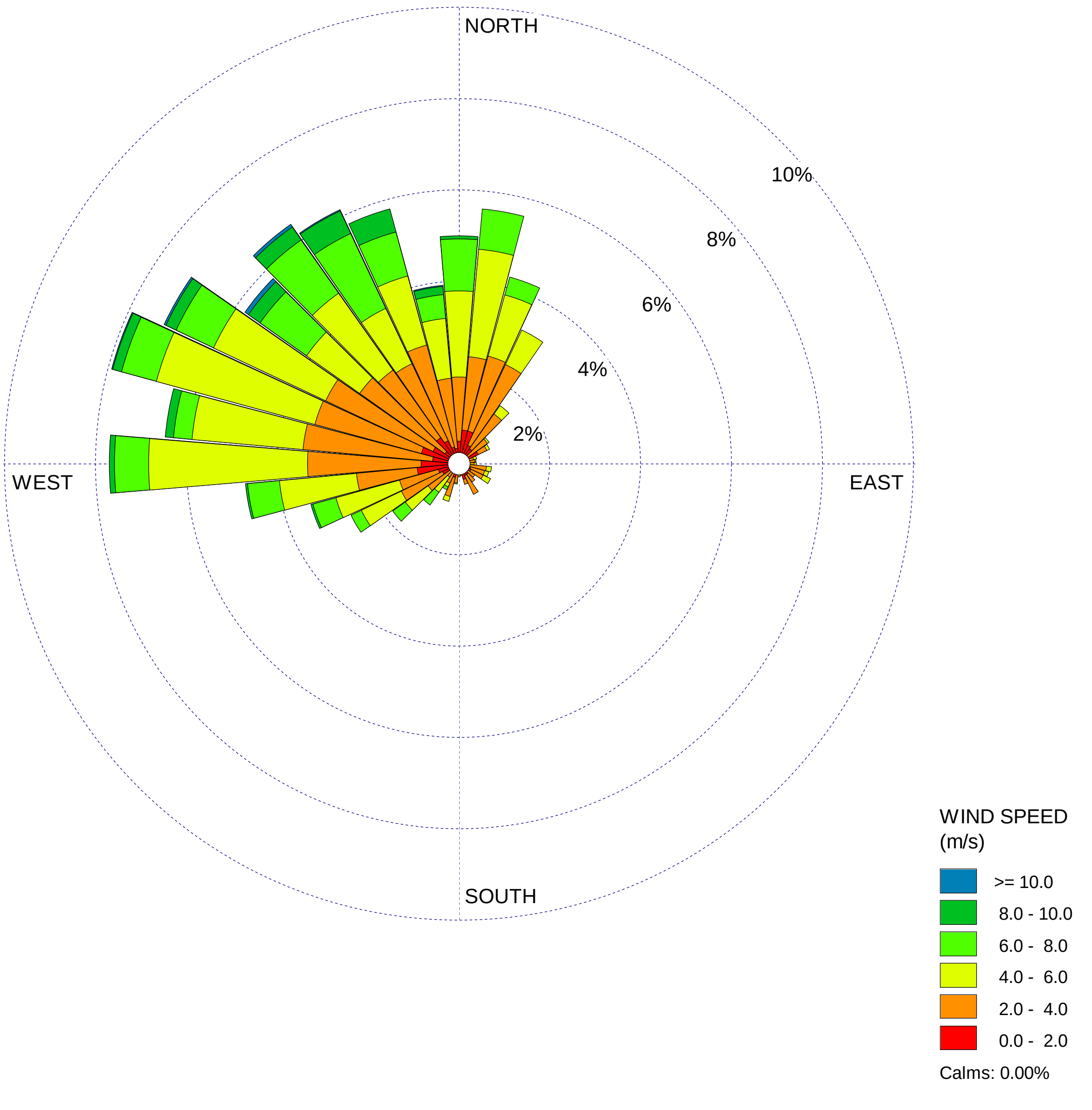
COMMENTS: 2009	DATA PERIOD: **Start Date: 3/1/2009 - 00:00** **End Date: 5/31/2009 - 23:00**	COMPANY NAME: **Sinclair Knight Merz**	
		MODELER: **Michelle Hall**	
		TOTAL COUNT: **4416 hrs.**	
	AVG. WIND SPEED: **3.19 m/s**	DATE: **8/7/2013**	PROJECT NO.: **VE23730**

WIND ROSE PLOT:

IRD Cape Hardy 2009: TAPM Model Results
Winter (all hours)

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS: 2009	DATA PERIOD: **Start Date: 6/1/2009 - 00:00** **End Date: 8/31/2009 - 23:00**	COMPANY NAME: **Sinclair Knight Merz**	
		MODELER: **Michelle Hall**	
		TOTAL COUNT: **4416 hrs.**	
	AVG. WIND SPEED: **4.02 m/s**	DATE: **8/7/2013**	PROJECT NO.: **VE23730**

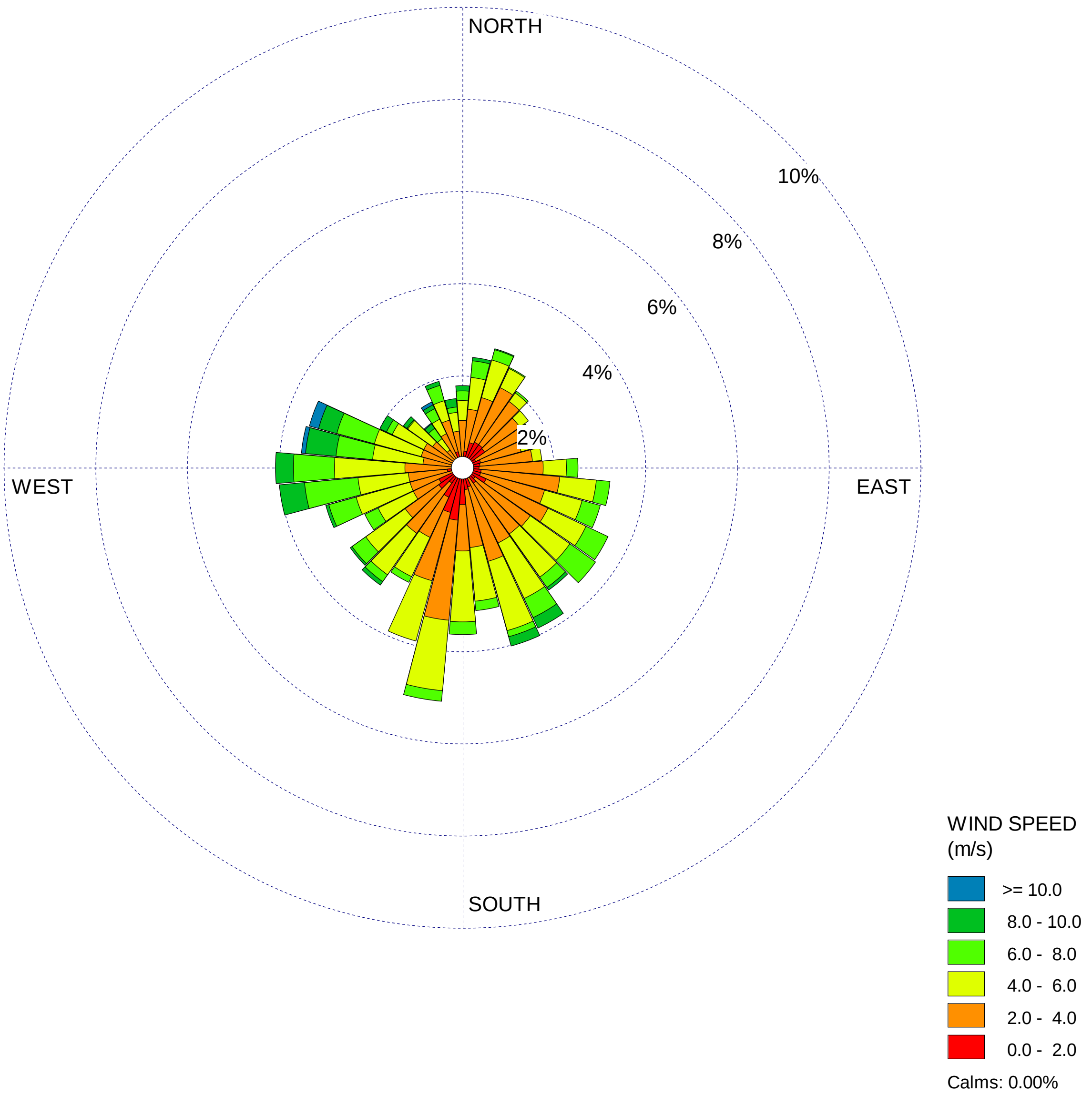
WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:

IRD Cape Hardy 2009: TAPM Model Results
Spring (all hours)

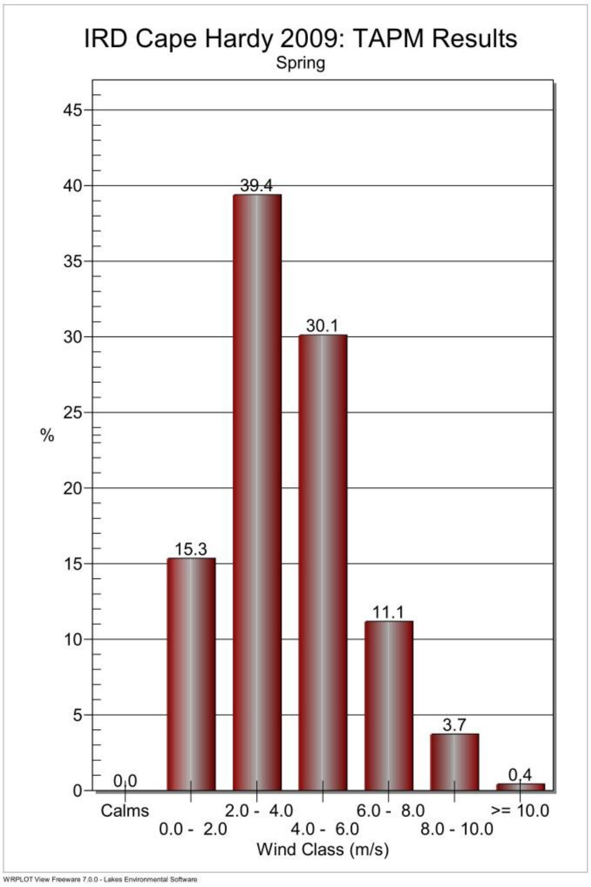
DISPLAY:

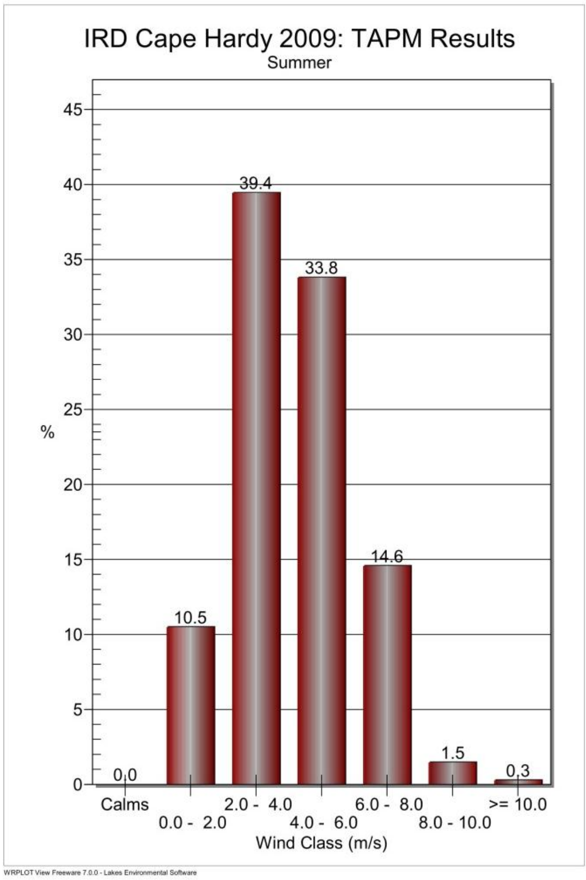
Wind Speed
Direction (blowing from)

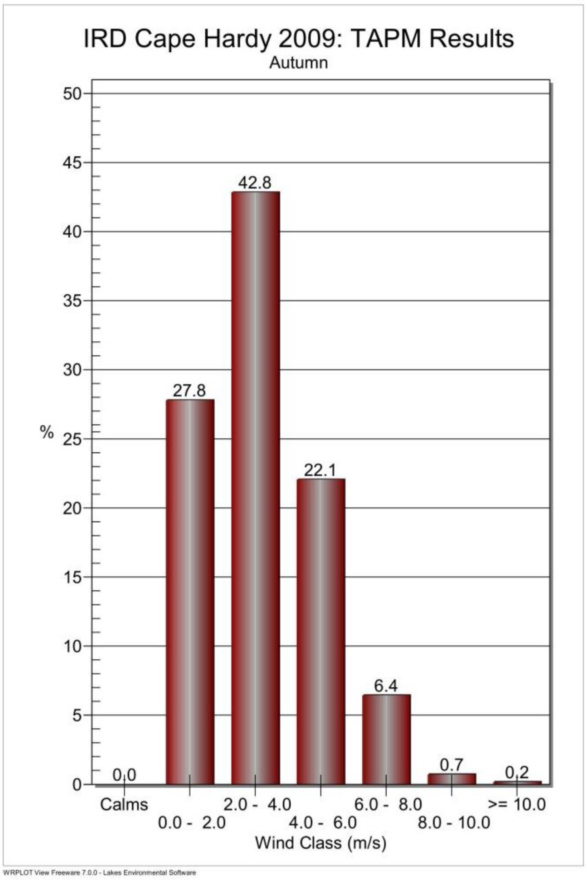


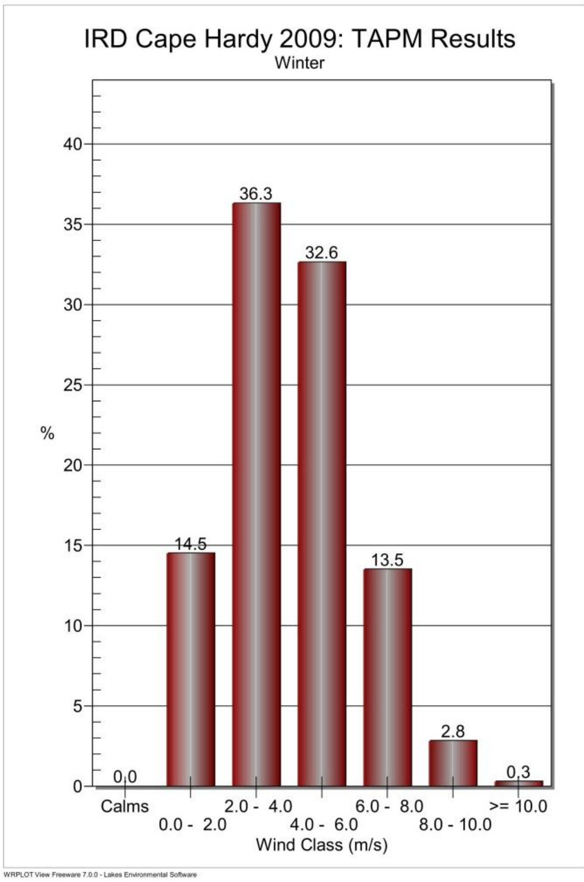
COMMENTS:	DATA PERIOD:	COMPANY NAME:	
2009	**Start Date: 9/1/2009 - 00:00** **End Date: 11/30/2009 - 23:00**	**Sinclair Knight Merz**	
		MODELER: **Michelle Hall**	
		TOTAL COUNT: **4368 hrs.**	
	AVG. WIND SPEED: **3.92 m/s**	DATE: **8/7/2013**	PROJECT NO.: **VE23730**

Appendix D. Cape Hardy wind speed distributions 2009 (TAPM model)


IRD Cape Hardy 2009: TAPM Results
Spring
%
Wind Class (m/s)
Calms
0.0 - 2.0
2.0 - 4.0
4.0 - 6.0
6.0 - 8.0
8.0 - 10.0
>= 10.0
0.0
15.3
39.4
30.1
11.1
3.7
0.4
WRPLOT View Freeware 7.0.0 - Lakes Environmental Software


IRD Cape Hardy 2009: TAPM Results
Summer
%
Wind Class (m/s)
Calms
0.0 - 2.0
2.0 - 4.0
4.0 - 6.0
6.0 - 8.0
8.0 - 10.0
>= 10.0
0.0
10.5
39.4
33.8
14.6
1.5
0.3
WRPLOT View Freeware 7.0.0 - Lakes Environmental Software


IRD Cape Hardy 2009: TAPM Results
Autumn
%
Wind Class (m/s)
Calms
0.0 - 2.0
2.0 - 4.0
4.0 - 6.0
6.0 - 8.0
8.0 - 10.0
>= 10.0
0.0
27.8
42.8
22.1
6.4
0.7
0.2
WRPLOT View Freeware 7.0.0 - Lakes Environmental Software


IRD Cape Hardy 2009: TAPM Results
Winter
%
Wind Class (m/s)
Calms
0.0 - 2.0
2.0 - 4.0
4.0 - 6.0
6.0 - 8.0
8.0 - 10.0
>= 10.0
0.0
14.5
36.3
32.6
13.5
2.8
0.3
WRPLOT View Freeware 7.0.0 - Lakes Environmental Software

Appendix E. Wind roses Cleve (BoM observations 1996-2010)

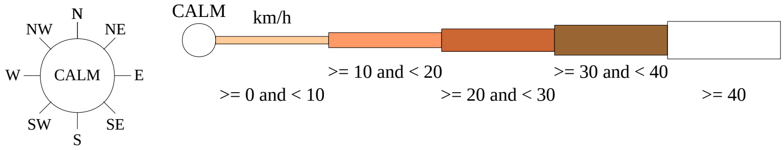
Rose of Wind direction versus Wind speed in km/h (16 Jul 1996 to 30 Sep 2010)

Custom times selected, refer to attached note for details

CLEVE AERODROME

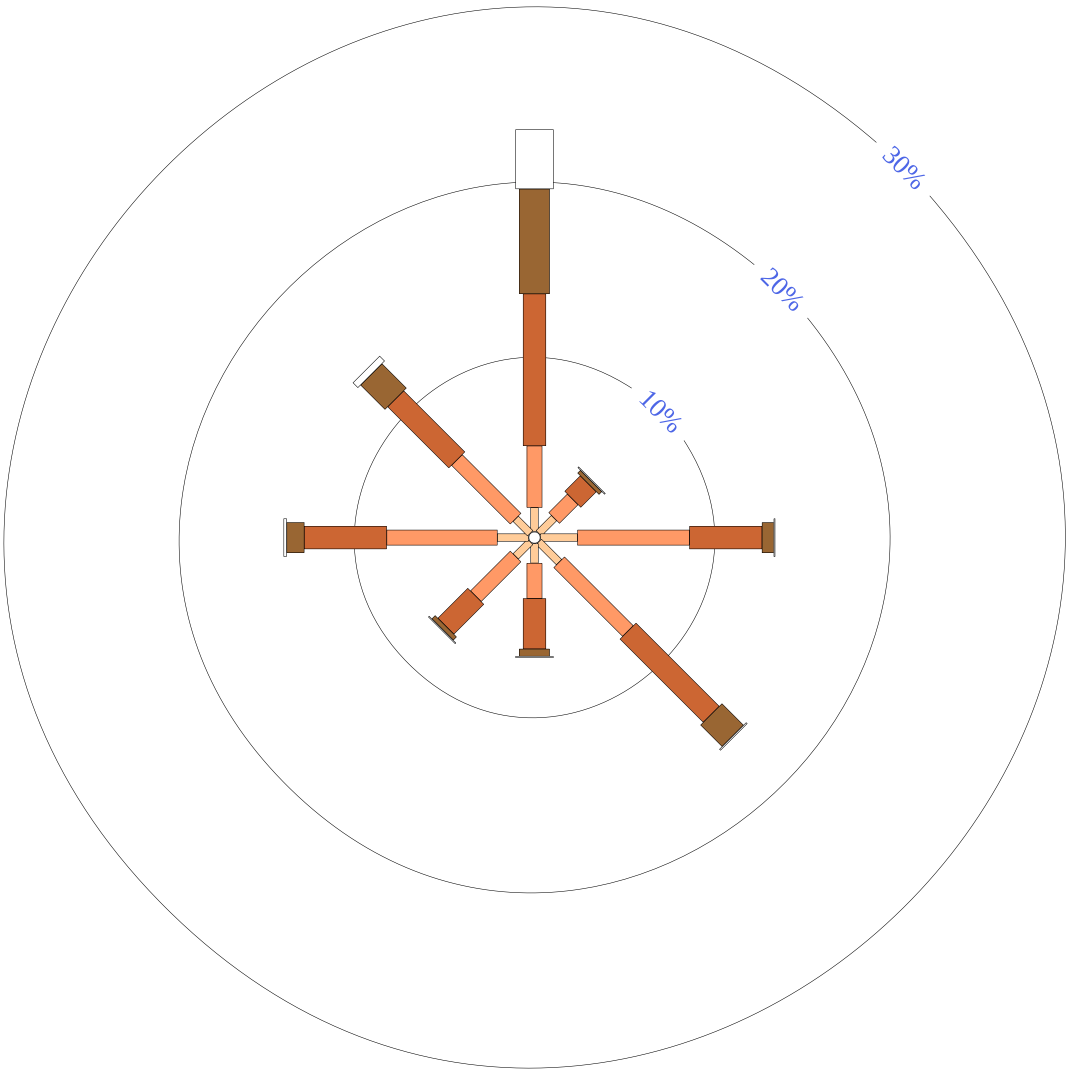
Site No: 018116 • Opened Jan 1963 • Still Open • Latitude: -33.7081° • Longitude: 136.5026° • Elevation 175m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



9 am
5069 Total Observations

Calm 2%



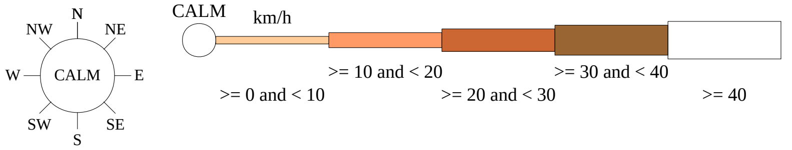
Rose of Wind direction versus Wind speed in km/h (16 Jul 1996 to 30 Sep 2010)

Custom times selected, refer to attached note for details

CLEVE AERODROME

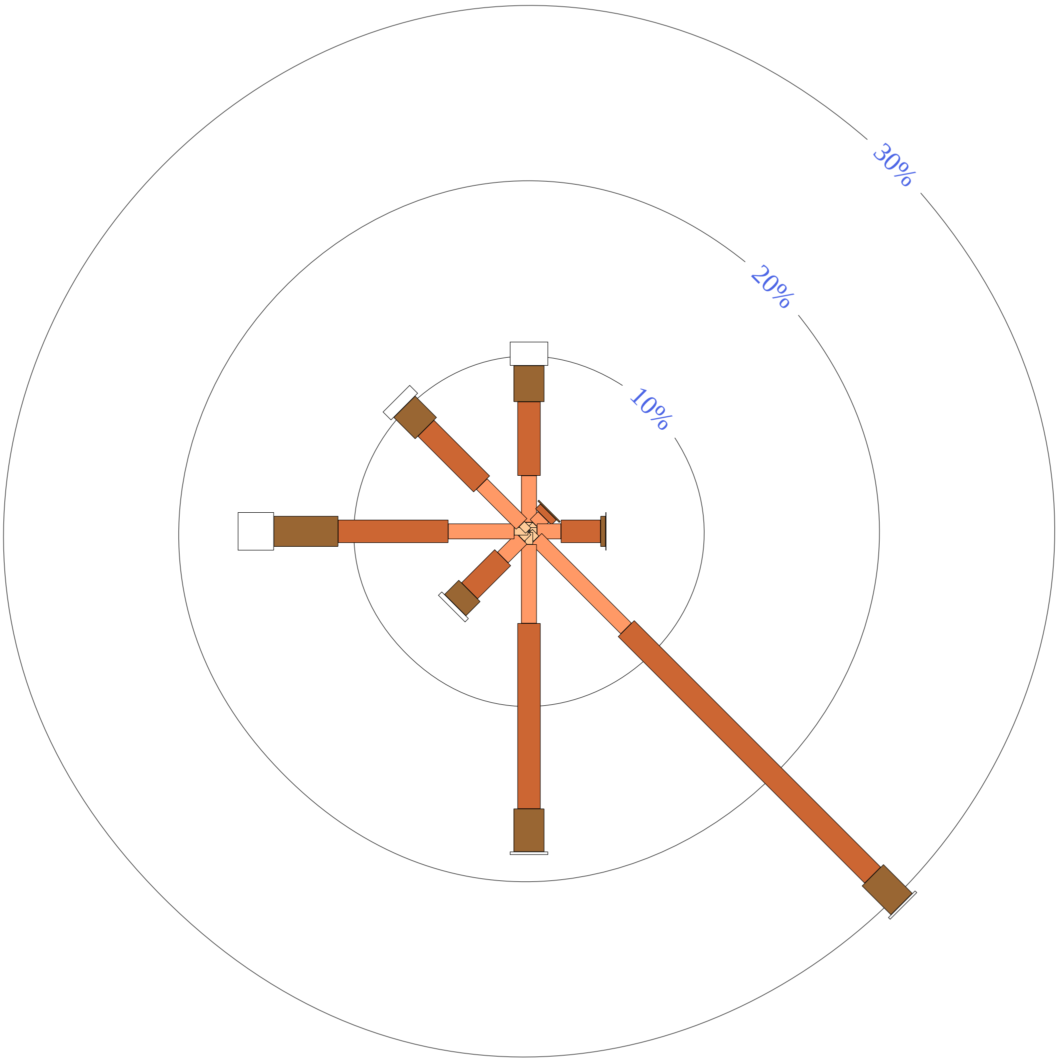
Site No: 018116 • Opened Jan 1963 • Still Open • Latitude: -33.7081° • Longitude: 136.5026° • Elevation 175m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm
5079 Total Observations

Calm *



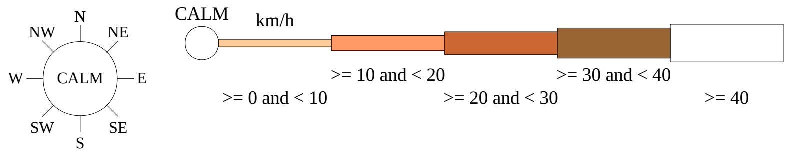
Rose of Wind direction versus Wind speed in km/h (01 Jan 1957 to 30 Sep 2010)

Custom times selected, refer to attached note for details

CLEVE

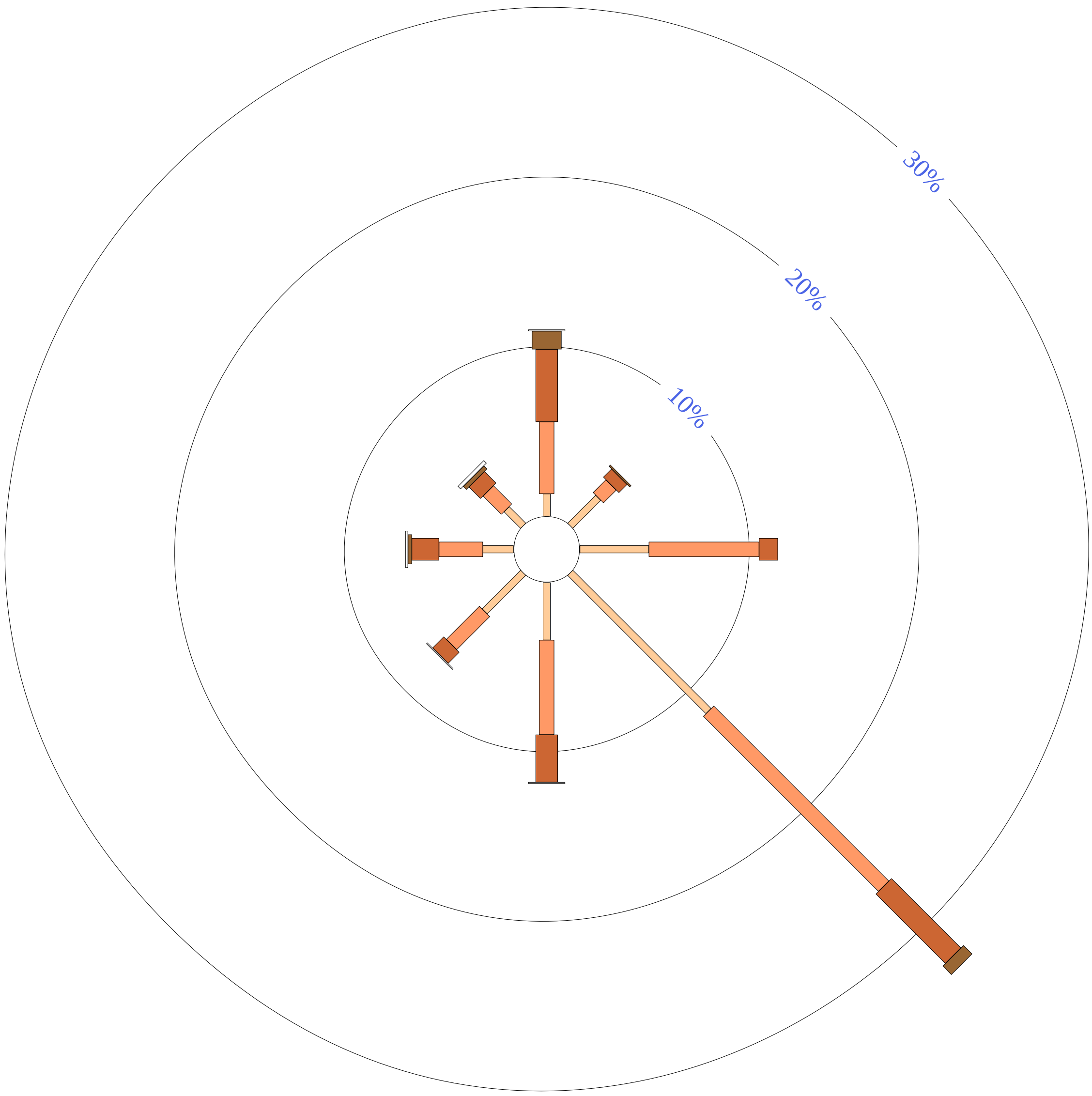
Site No: 018014 • Opened Mar 1896 • Still Open • Latitude: -33.7011° • Longitude: 136.4937° • Elevation 193m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



9 am Jan
1395 Total Observations

Calm 10%



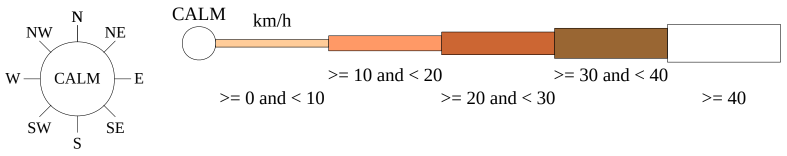
Rose of Wind direction versus Wind speed in km/h (01 Jan 1957 to 30 Sep 2010)

Custom times selected, refer to attached note for details

CLEVE

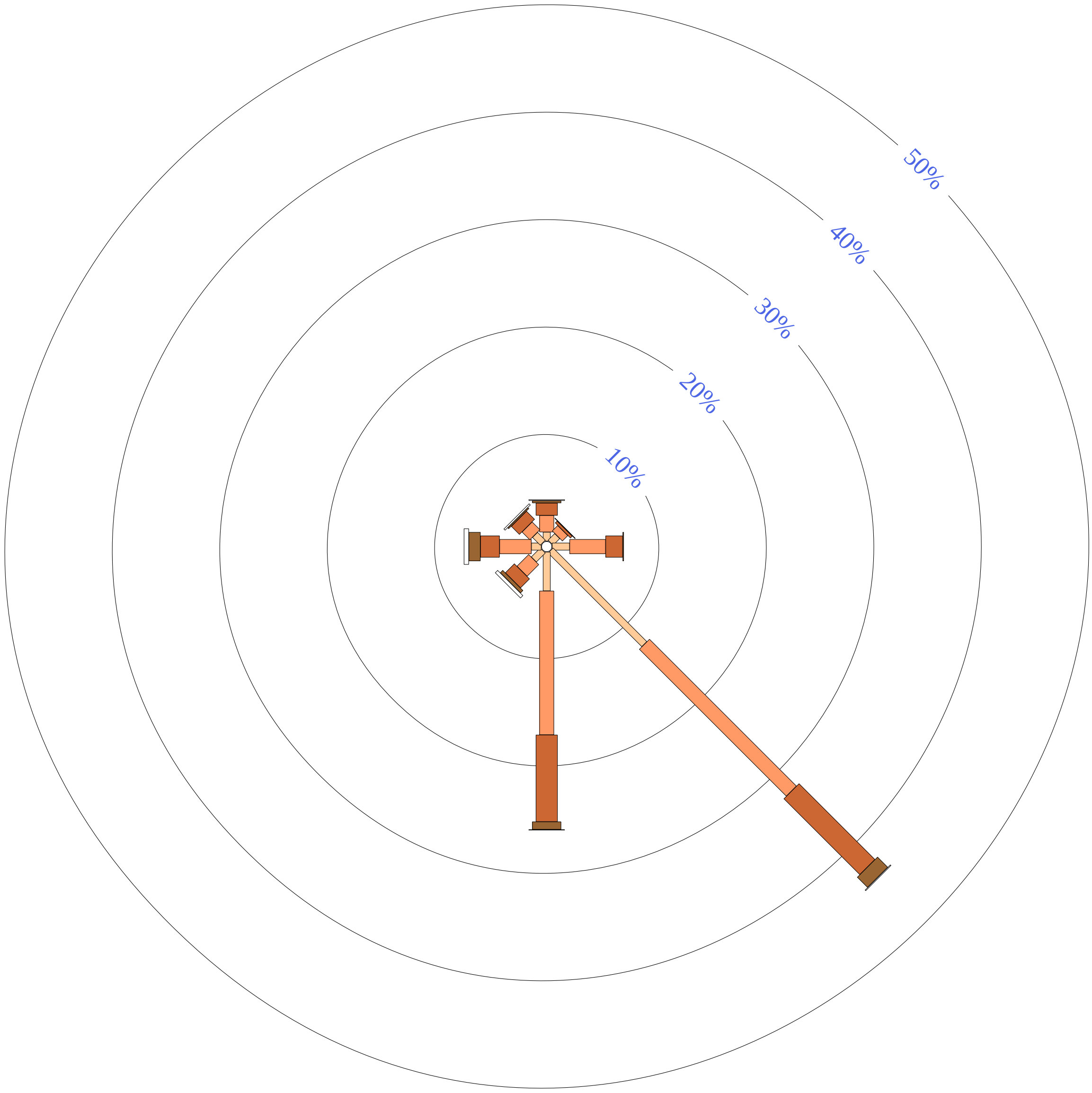
Site No: 018014 • Opened Mar 1896 • Still Open • Latitude: -33.7011° • Longitude: 136.4937° • Elevation 193m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm Jan
1256 Total Observations

Calm 2%



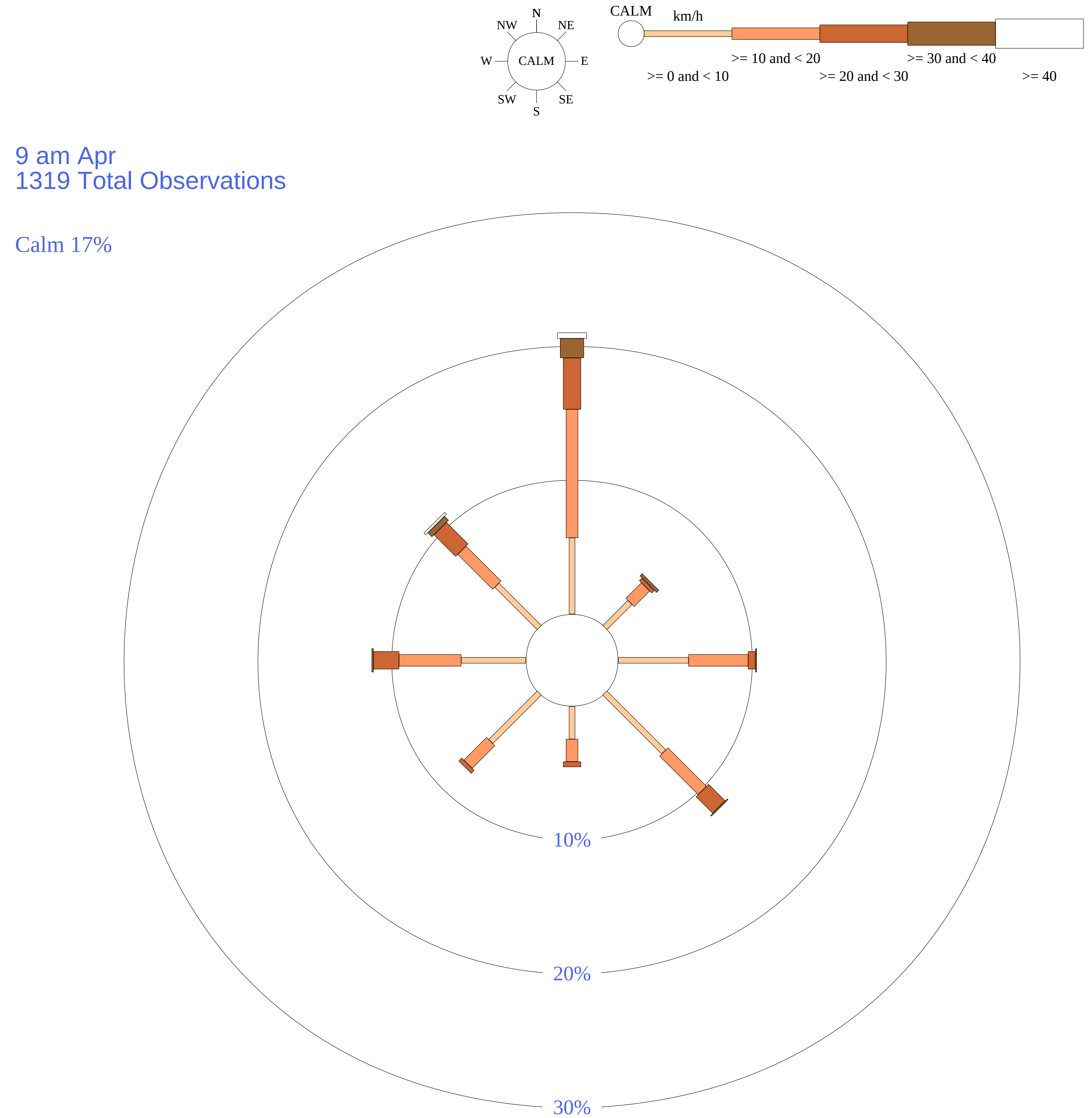
Rose of Wind direction versus Wind speed in km/h (01 Jan 1957 to 30 Sep 2010)

Custom times selected, refer to attached note for details

CLEVE

Site No: 018014 • Opened Mar 1896 • Still Open • Latitude: -33.7011° • Longitude: 136.4937° • Elevation 193m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



Prepared by National Climate Centre of the Bureau of Meteorology.
Contact us by phone on (03) 9669 4082, by fax on (03) 9669 4515, or by email on climatedata@bom.gov.au

Australian Government
Bureau of Meteorology

Rose of Wind direction versus Wind speed in km/h (01 Jan 1957 to 30 Sep 2010)

Custom times selected, refer to attached note for details

CLEVE

Site No: 018014 • Opened Mar 1896 • Still Open • Latitude: -33.7011° • Longitude: 136.4937° • Elevation 193m

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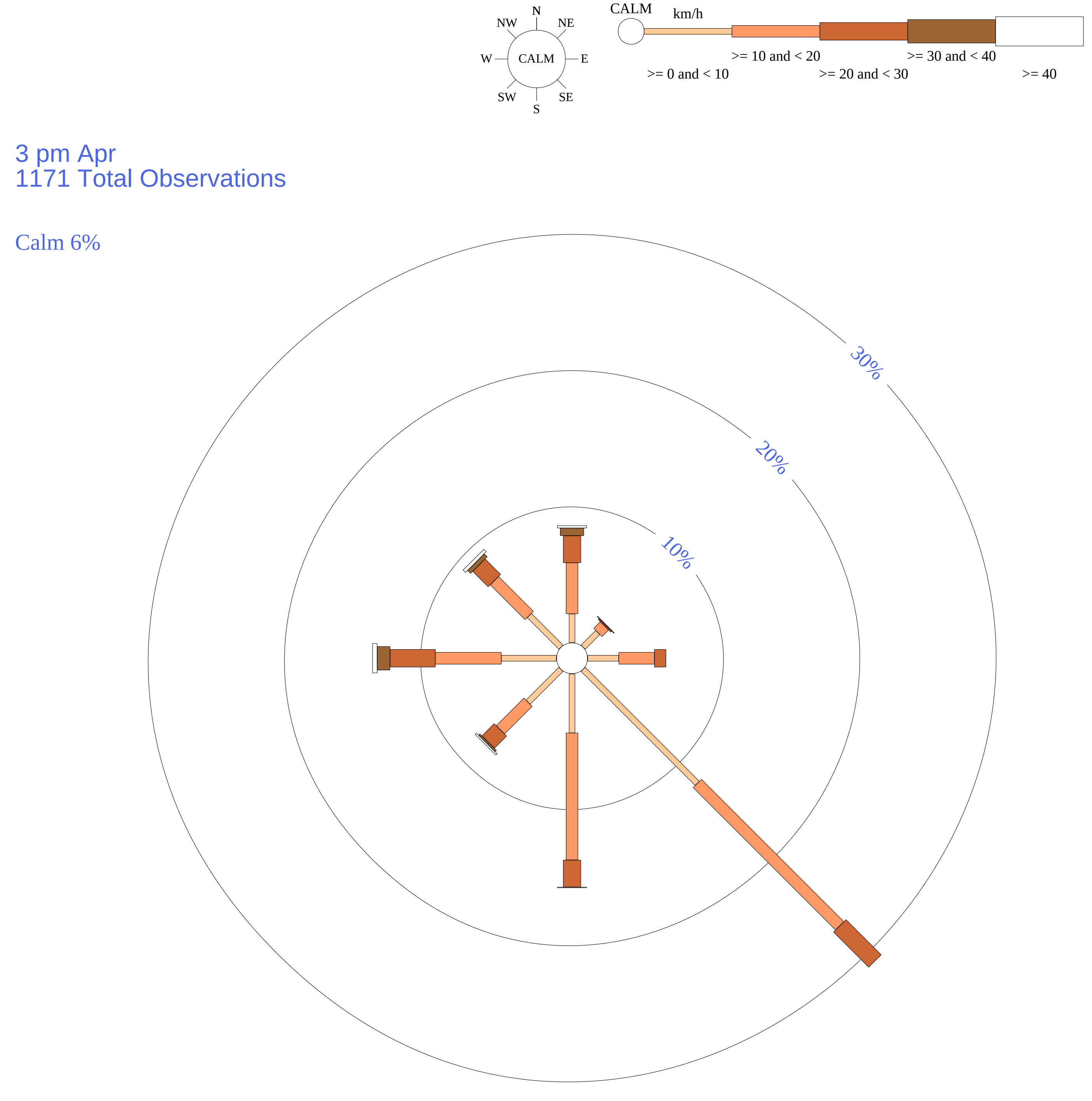

Prepared by National Climate Centre of the Bureau of Meteorology.
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Australian Government
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Rose of Wind direction versus Wind speed in km/h (01 Jan 1957 to 30 Sep 2010)

Custom times selected, refer to attached note for details

CLEVE

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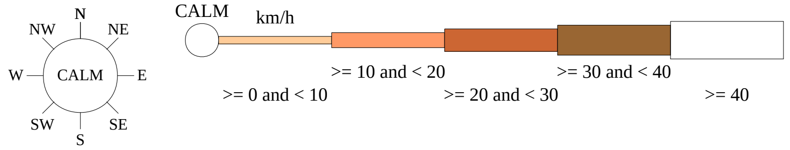
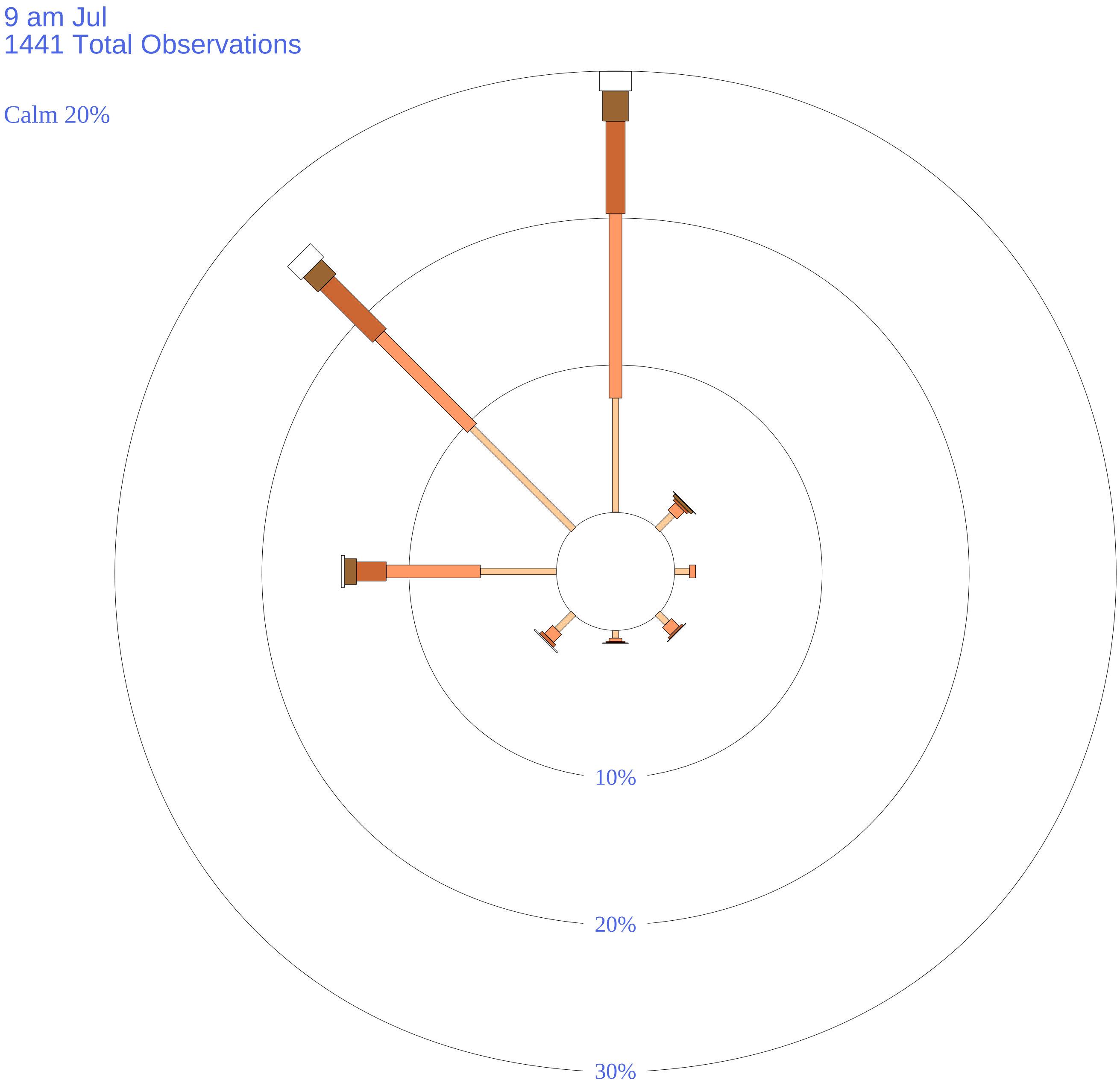
Other important info about this analysis is available in the accompanying notes.





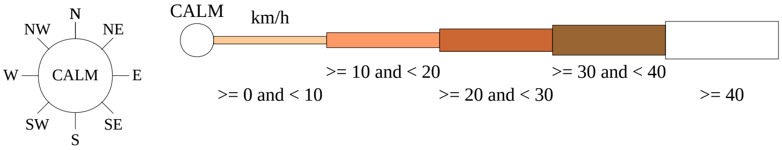
Rose of Wind direction versus Wind speed in km/h (01 Jan 1957 to 30 Sep 2010)

Custom times selected, refer to attached note for details

CLEVE

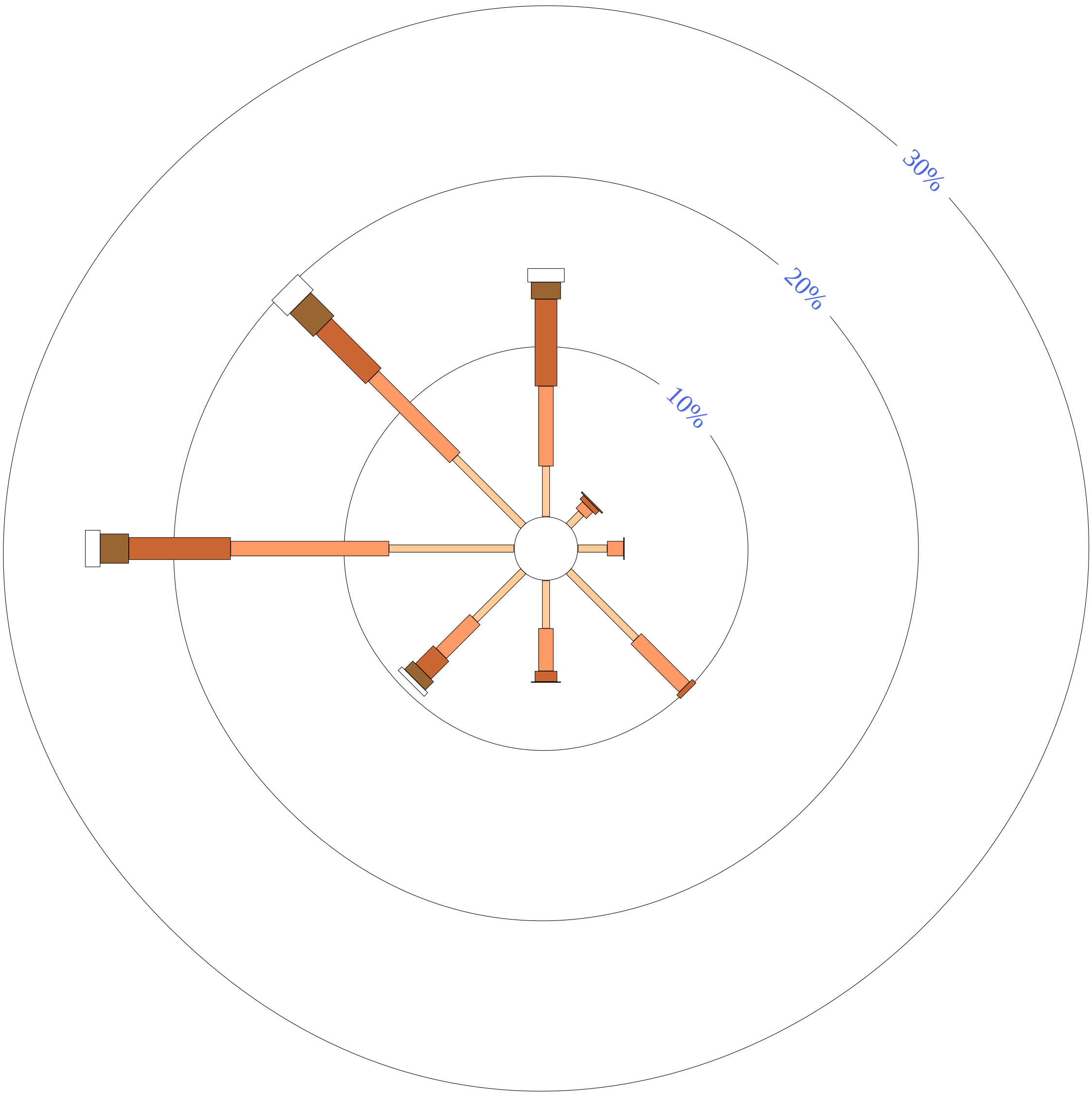
Site No: 018014 • Opened Mar 1896 • Still Open • Latitude: -33.7011° • Longitude: 136.4937° • Elevation 193m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm Jul
1302 Total Observations

Calm 9%



Rose of Wind direction versus Wind speed in km/h (01 Jan 1957 to 30 Sep 2010)

Custom times selected, refer to attached note for details

CLEVE

Site No: 018014 • Opened Mar 1896 • Still Open • Latitude: -33.7011° • Longitude: 136.4937° • Elevation 193m

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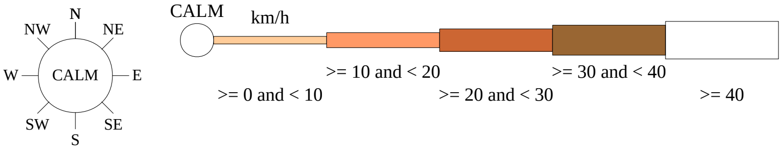
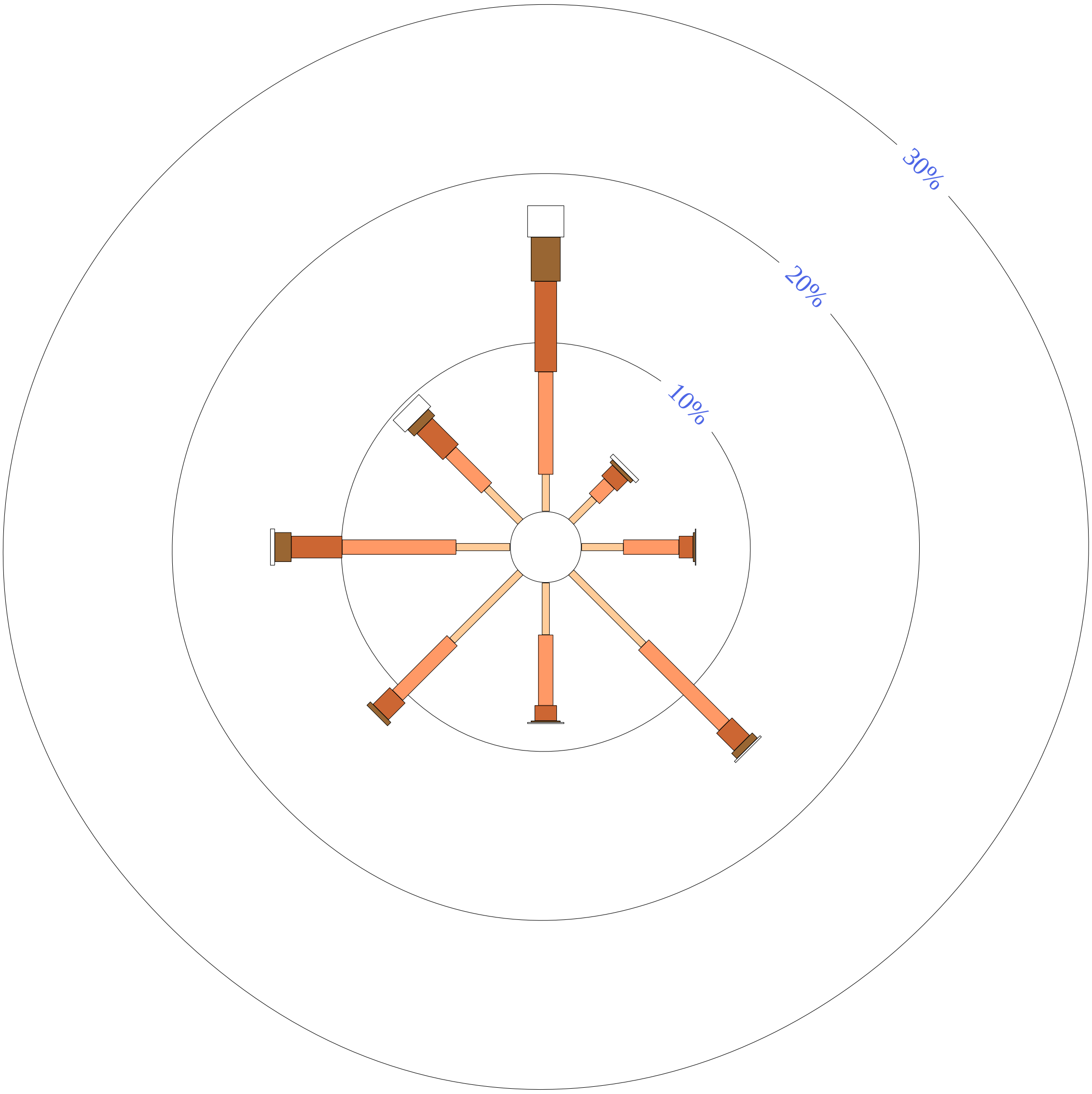


9 am Oct
1380 Total Observations

Calm 11%



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Rose of Wind direction versus Wind speed in km/h (01 Jan 1957 to 30 Sep 2010)

Custom times selected, refer to attached note for details

CLEVE

Site No: 018014 • Opened Mar 1896 • Still Open • Latitude: -33.7011° • Longitude: 136.4937° • Elevation 193m

An asterisk (*) indicates that calm is less than 0.5%.
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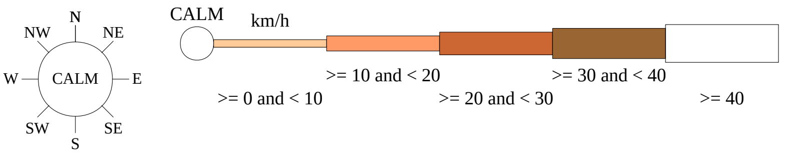
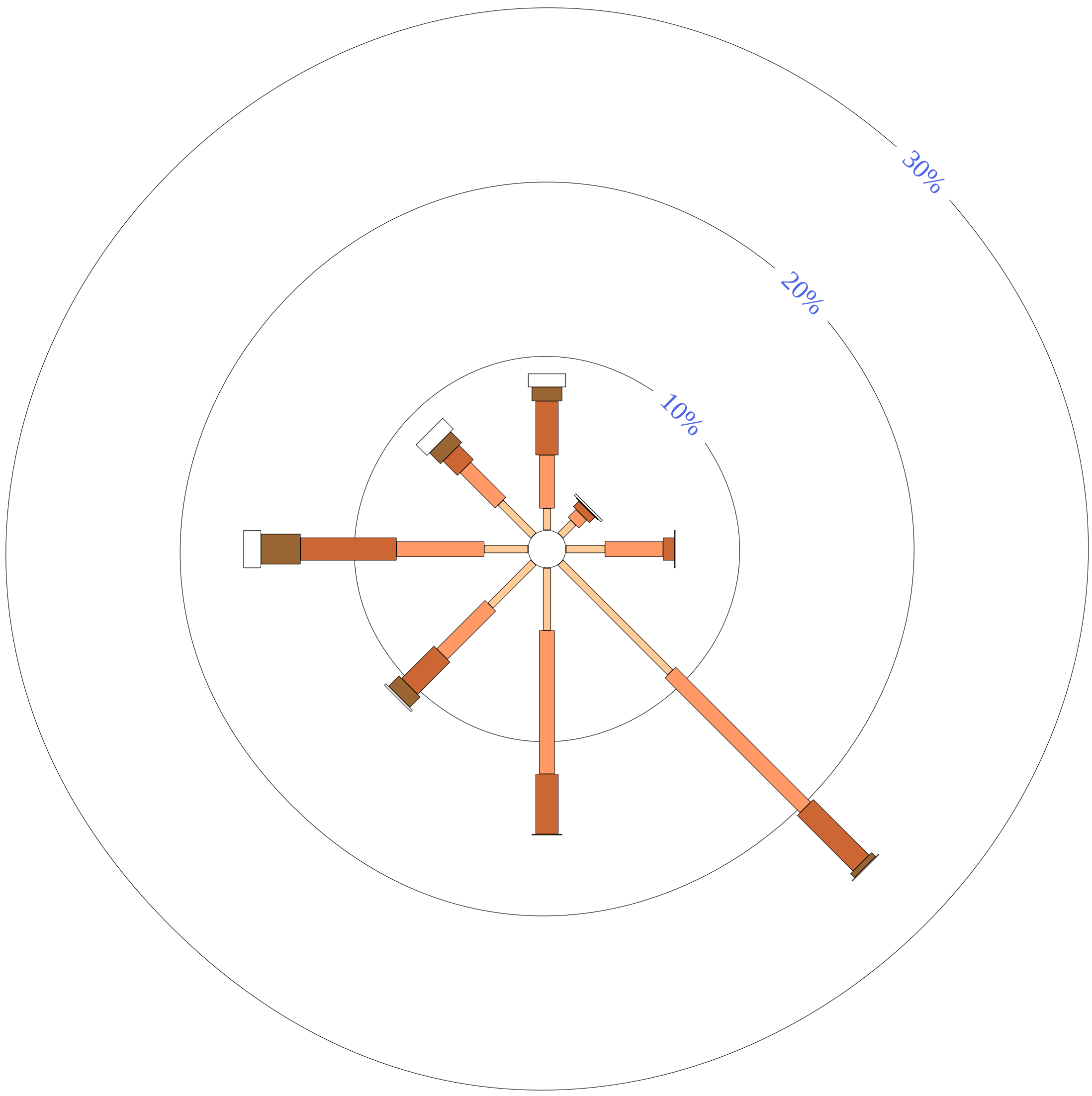


3 pm Oct
1243 Total Observations

Calm 5%



Important note about your report

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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.

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