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REPORT

TARRAWONGA PRP – IDENTIFICATION OF ADVERSE WEATHER CONDITIONS FOR OVERBURDEN HANDLING

Whitehaven Coal Limited

Job No: **7487A**

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1 INTRODUCTION

Whitehaven Coal Limited (WCL) holds Environmental Protection Licence (EPL) 12365 for the Tarrawonga Coal Mine (Tarrawonga). Condition U2 (*Particulate Matter Control Best Practice Implementation - Disturbing and Handling Overburden under Adverse Weather Conditions)* requires Tarrawonga to alter or cease the use of equipment on overburden and the loading and dumping of overburden during adverse weather conditions. The licence must:

- Undertake daily visual dust level assessments, continuously record real-time PM_{10} levels and continuously measure and record real-time meteorological conditions, and
- Record changes to mining activities due to adverse weather conditions.

The purpose of this report is to define "adverse conditions" that may result in unacceptable dust levels beyond the site boundary. Trigger levels will be identified for these adverse conditions to inform a Trigger Action Response Plan (TARP) for overburden handling activities in critical locations.

1.1 Scope of Work

The following methodology is used to identify adverse conditions:

- Identify critical locations where overburden (OB) handling may result in elevated dust concentrations at or beyond the site boundary.
- Represent each location using two sources to simulate dozer and loading/unloading operations simultaneously occurring in one location. A TSP emission rate of 1,000,000 kg/y has been assumed, with loading and dumping emissions varying with wind speed according to the US EPA AP-42 emissions factor.
- Use a screening level atmospheric dispersion model to predict dust plume behaviour under various meteorological conditions (using site representative data).
- At boundary locations where the highest impacts are predicted, analyse the meteorological conditions that correspond to the highest 1-hour dust concentrations.
- Based on these "adverse" meteorological conditions, determine appropriate trigger values to inform a TARP.

2 METHODOLOGY

2.1 Critical locations

The locations of current OB activities are shown in **Figure 1** and were determined in consultation with Tarrawonga. Dust sources are released from the OB dump at the location shown and the resultant dust concentration predictions are made at each of the numbered boundary locations shown.

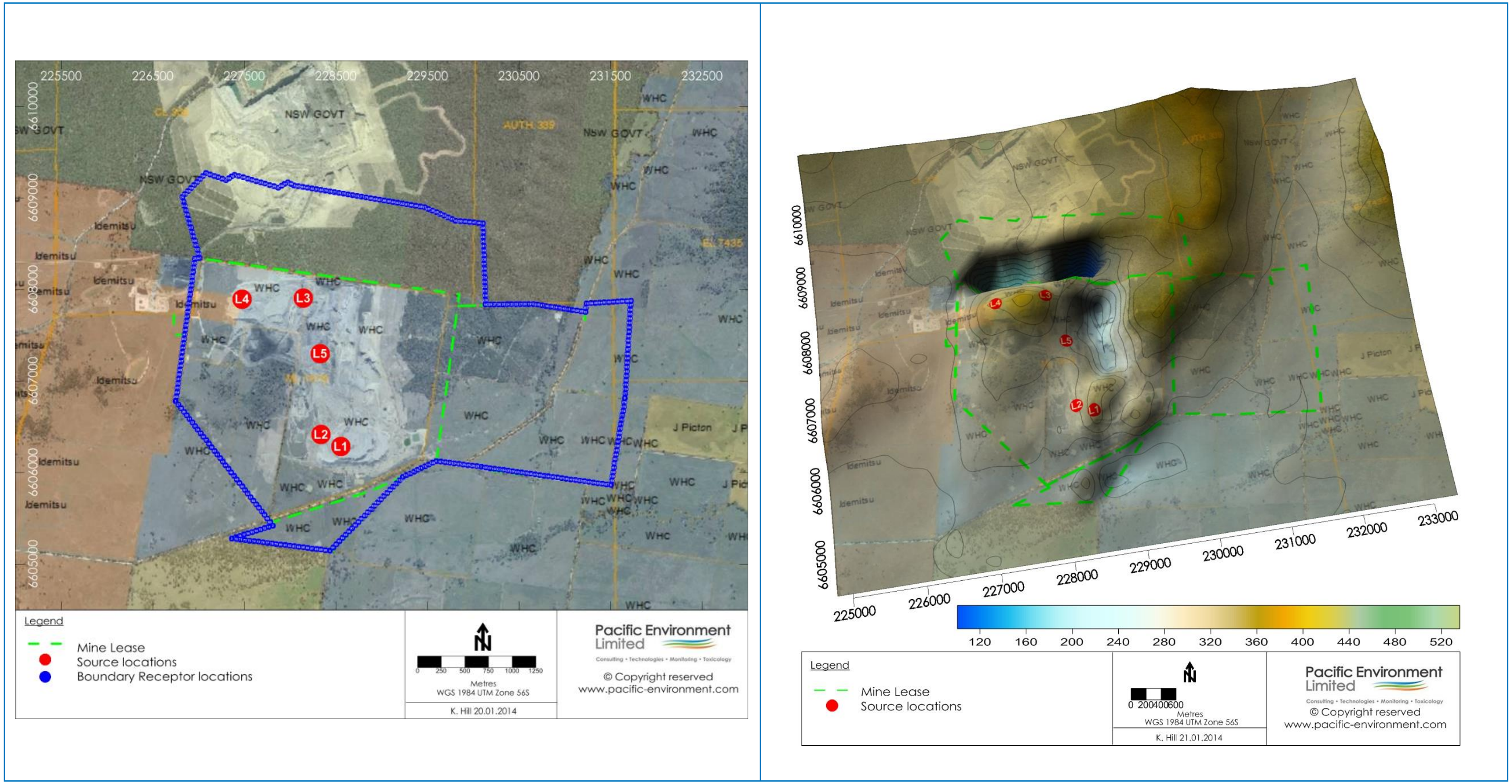

Figure 1: Overburden Activity Source Locations

2.2 Model Inputs

Overburden handling activities are assumed to include loading / unloading of OB, dozers operating on OB and wind erosion from the disturbed surfaces. Each activity is assumed to operate simultaneously and an emission rate for total suspended particulate (TSP) is assumed to be 1,000,000 kg/y from each source.

Adjustments are made to hourly emissions as follows:

- **Loading/dumping OB**. Emissions are assumed to be dependent on wind speed to account for wind dependency in the overburden handling emission factor equation and hourly emissions are adjusted for wind speed as follows (**US EPA, 1987**):

$$Emission_{adjusted} = Emission_{unadjusted} \times \left({Hourly\ Wind\ Speed}/{2.2} \right)^{1.3}$$

- **Dozers**. Emissions are independent of wind speed, as per the dozer emission factor equation.

By varying emissions in this way, "adverse conditions" will not only be influenced by the meteorological conditions under which dust disperses but also include those conditions under which higher emissions are generated at source (i.e. high wind speeds).

A meteorological modelling file was compiled using measured data from the Tarrawonga meteorological station from 2009 to April 2012. The source and receptors heights took mine terrain into account. The scenarios modelled are as summarised in **Table 1**.

Table 1: Modelling Scenarios

ID	Elevation (m)	Distance from nearest boundary (m)	Comments for selection
L1	330	700	Highest dumping area close to southern boundary
L2	296	960	Elevated dumping area close to southern boundary
L3	342	1230	Elevated dumping area close to northern boundary
L4	344	550	Highest dumping area close to western and northern boundaries
L5	303	1480	Elevated central dumping area

3 ANALYSIS OF MODELLING RESULTS

The location of the 10 highest TSP boundary predictions for each OB activity location were, as expected, at locations closest to, or in a prevailing direction of, the active OB areas. The ten boundary receptors for each OB location (shown in **Figure 2**) were selected for analysis of the meteorological conditions under which these high concentrations occur.

An hourly time series of predicted TSP concentrations at each of these top ten receptors was extracted for each scenario. The time series data were then normalised to enable the different scenarios to be directly compared with each other. The aim of normalisation of the predicted TSP concentrations across the scenarios was to enable identification of the scenarios (or locations) where the highest concentrations occur. In other words, the focus is on relative concentrations rather than actual concentrations.

Normalisation takes a large number of data sets that are on different scales and consolidates them to a single common scale. In this case, the activities were modelled with the same emissions and therefore the predicted levels at the receptors are not a reflection of actual levels which will be experienced, but rather how the results relate to one another. The concentrations determined from dispersion modelling have been normalised to the maximum predicted TSP concentrations for the parameter investigated (i.e. wind speed or wind direction). This enables all the data from the different scenarios to be compared on a scale of 0 to 1, across all scenarios. The plots therefore represent normalised levels not actual TSP concentrations.

It is important to note that the data were analysed separately based on wind speed and wind direction and therefore the graphs shown for wind speed and wind direction do not relate to each other.

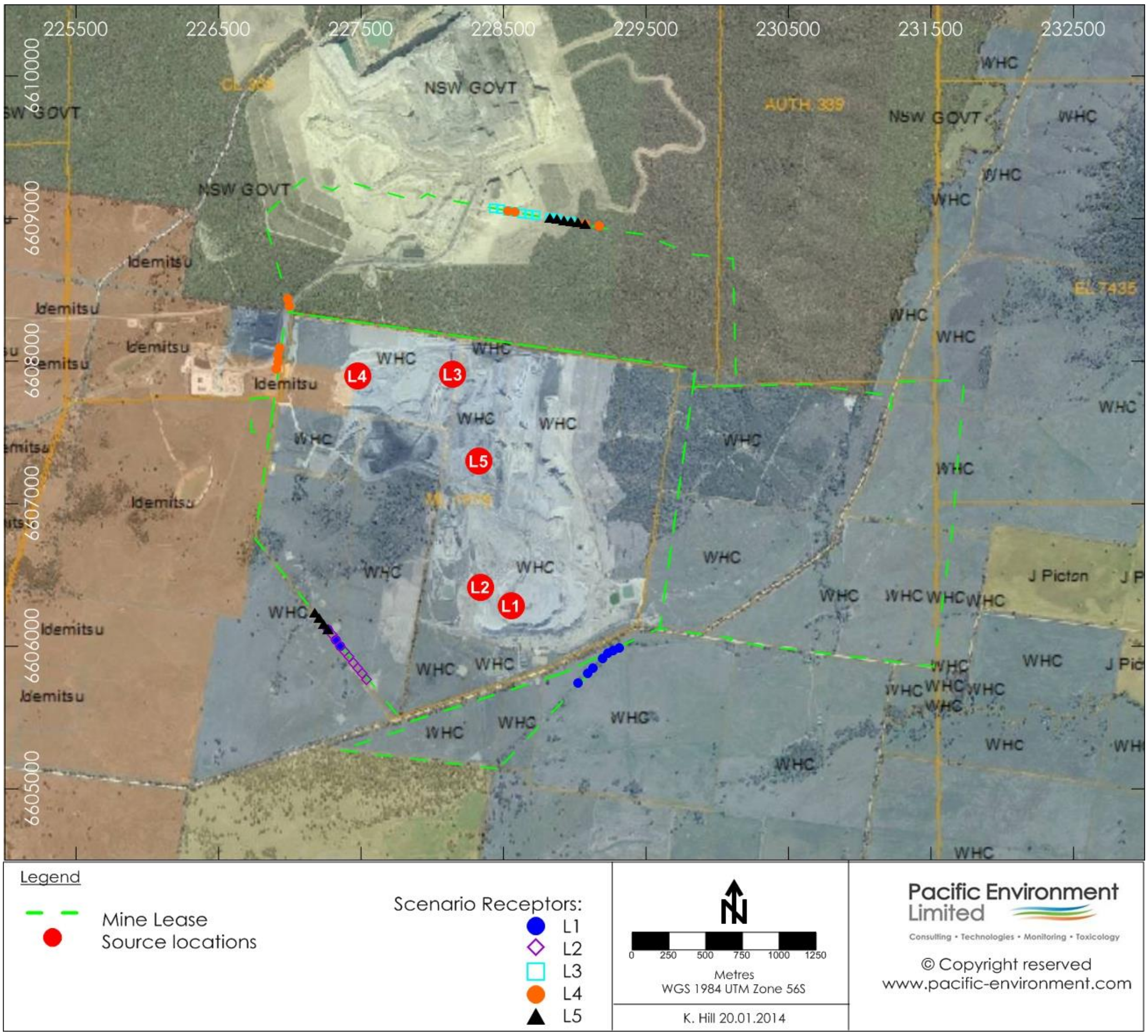

Figure 2: Location of highest boundary predictions for each OB activity location

3.1 Wind speed analysis

The normalised 1-hour TSP concentration for each hour of the year were averaged into a corresponding wind speed bin (at 0.1 m/s increments) and the results are presented in **Figure 3**, for the scenarios L1 to L5. Each line shows the hourly prediction (averaged by wind speed) for each of the 10 highest boundary receptors for each scenario, as identified in **Figure 2**.

With the exception of scenarios L3 and L4, there appear to be peaks in boundary predictions at wind speeds of approximately 7 m/s and 10 m/s, with almost negligible levels predicted between 8 – 9.5 m/s. It is noted also, that at L2 there are some elevated levels experienced at lower wind speeds, around 0 - 3 m/s. These higher concentrations generally occur at night when the atmosphere is stable and winds are lighter. At these times, it is not the emissions that are critical, but rather dispersion conditions for those particles already airborne. In other words, emissions will be low for wind speed dependant sources, but dispersion conditions will be less favourable. These conditions are therefore not as relevant for management issues and determining trigger levels, but rather the peaks at higher wind speeds.

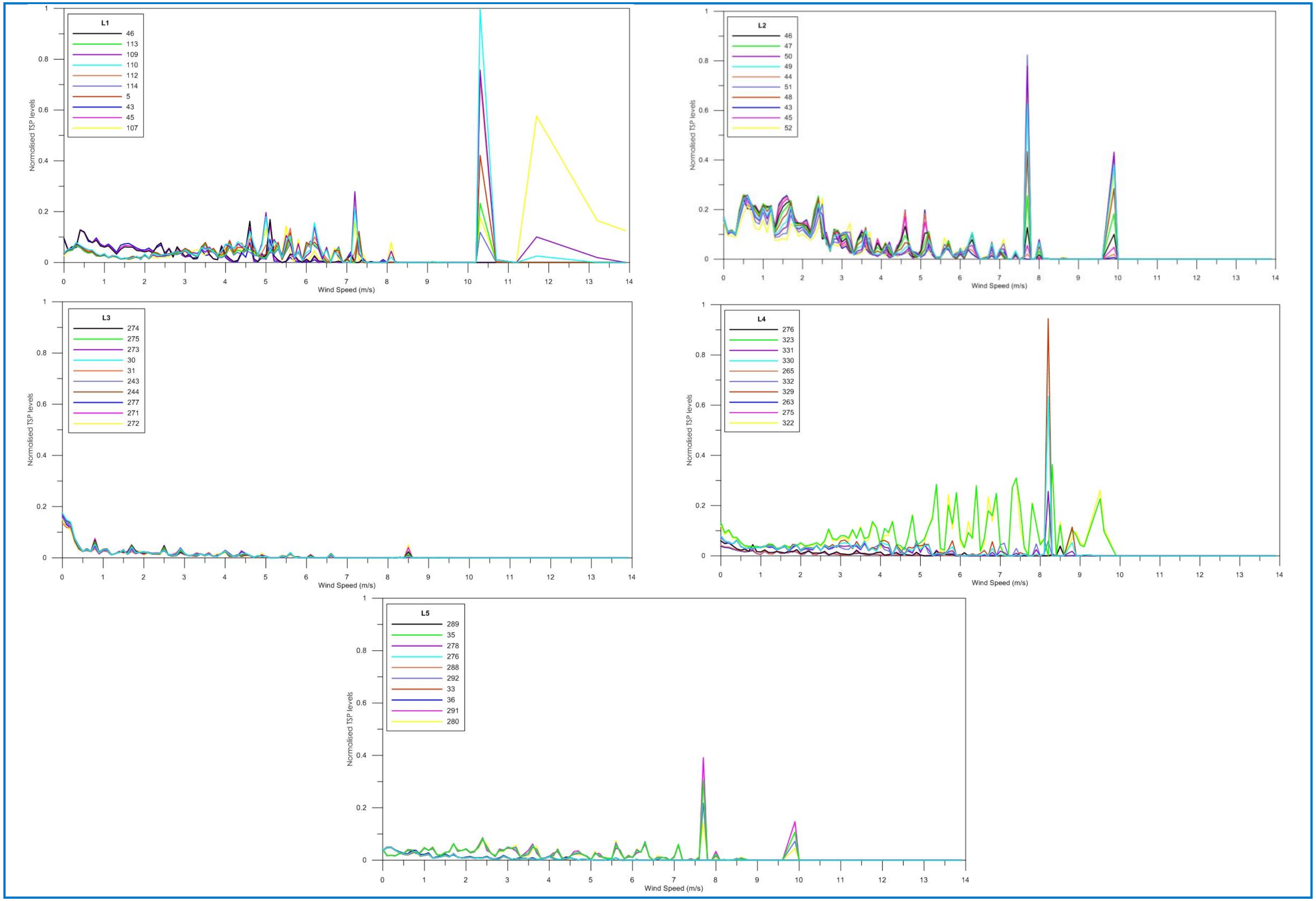

Figure 3: Normalised TSP concentration by wind speed at each dump area

3.2 Time of day analysis

An analysis of the 1-hour TSP concentrations by hour of the day is presented in **Figure 4** for predictions normalised against all other sites and then against wind speeds. This analysis has been carried out for L2 which predicted to experience highest levels for dump scenarios. A clear pattern is evident with higher concentrations at the boundaries during night-time conditions.

Hour of the day can be used as a surrogate for atmospheric stability, an indicator of turbulence or dispersive capacity. A descriptor of turbulence, known as Monin-Obukhov length (L), can be interpolated from the modelling files and used to describe whether conditions are unstable (enhanced dust dispersion) or stable (dust dispersion is suppressed). The inverse of Monin-Obukhov length (1/L) is plotted below the time of day analysis, showing highest concentration during stable conditions (when Monin-Obukhov length is positive).

What is evident from the time of day analysis is that the relative TSP contributions are significantly lower (**Figure 4**) when plotted against time of day, when compared to those presented for the wind speed analysis (**Figure 3**). This means that although boundary concentrations increase during stable atmospheric conditions, they would not necessarily be considered "adverse" based on the relatively low normalised dust concentration. In other words, wind speed is a more significant driver of elevated dust levels that time of day is.

It should be noted when making these comparisons that these TSP concentrations are not actual values but rather those which have been normalised so as to be compared to each other (see discussion regarding normalisation in **Section 3**).

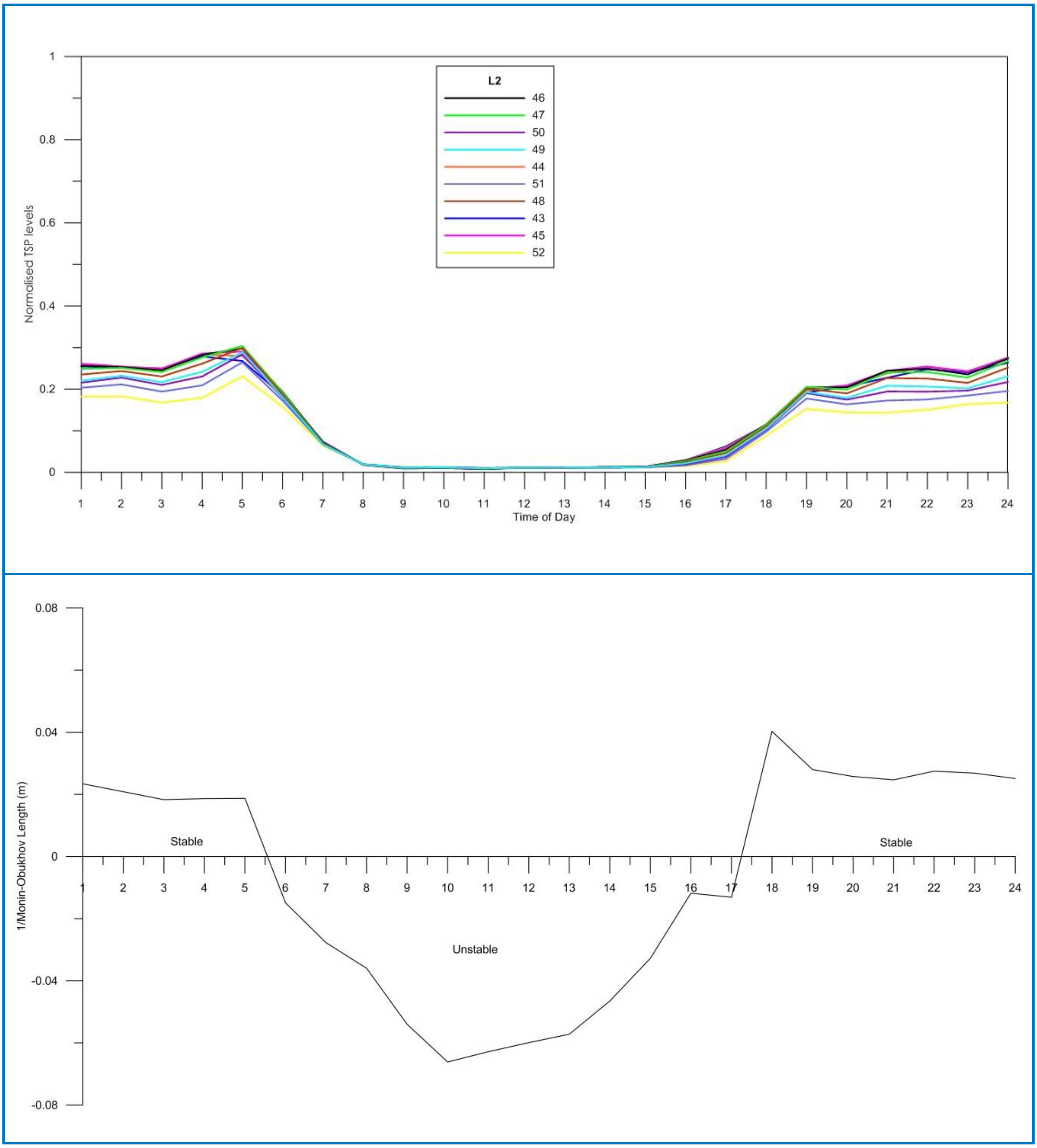

Figure 4: Normalised TSP concentrations and Monin-Obukhov length by hour of the day at L2

3.3 Wind direction analysis

Normalised TSP concentrations for scenarios L1 to L5 are plotted against wind direction for the same top 10 boundary receptors discussed previously (**Figure 5**). The wind directions which result in the highest relative TSP concentrations are clearly dependent on the location of the dump relative to the boundary. For example, for L2 where the relative concentrations are highest and occur at the southwestern boundary, winds are nearly all between 45 – 90 degrees (east-northeastern quadrant). Similarly, for L3 closest to the northern boundary, the winds which contribute to the highest levels at that boundary are from the south-southwestern quadrant. This is clearly what would be expected and so because the dumping areas are varied in terms of location, there will be different wind direction triggers for different dumps.

Emissions from the remaining three dumping locations, L1, L4 and L5, showed that their highest predictions on two different boundaries, depending on wind direction. However, as can be seen in **Figure 5**, these levels are generally low relative to those for L2 and L3. There are some higher relative values at L4 predicted on the western boundary, but these occur at elevated wind speeds around 8 - 9 m/s (shown in **Figure 3**) and due to winds in the east-southeast quadrant (90 – 135 degrees).

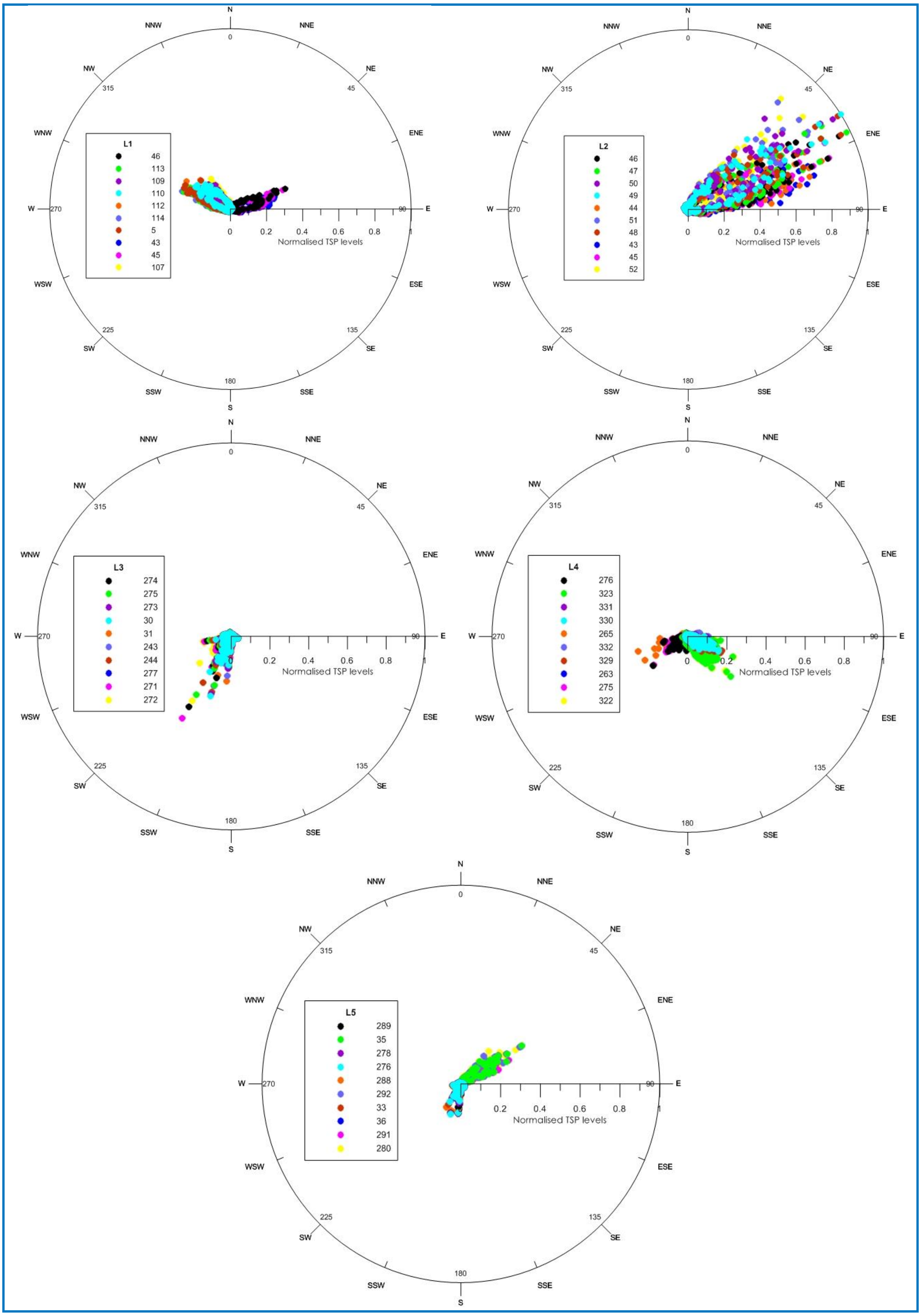

Figure 5: Normalised TSP concentrations against wind direction

4 DEVELOPMENT OF TRIGGER LEVELS

Based on the analysis presented above, adverse conditions for elevated dust levels beyond the site boundary are identified as wind speeds greater than 7 m/s. Predicted concentrations were highest for scenario L1, L2 and L4.

The pollution roses for the various OB areas (refer to **Figure 5**) identify that the wind directions where the highest boundary levels may occur are from the east-northeastern quadrant (approximately 45° to 90°), due to OB activities at L2. **Figure 5** also shows that, unlike for the wind speed analysis, predicted levels are not as significant for scenarios L1 and L4 (approximately 30% of those predicted for L2) based on wind direction. In other words, scenario L2 shows elevated normalised concentrations when considered in terms of both wind speed and wind direction and any reductions that can be achieved through implementation of trigger levels developed from the results for scenario L2 will also benefit the other scenarios.

It is wind speed that is more critical in determining the level of emission from loading and dumping activities on OB dump areas, but the wind direction will determine where those emissions are transported to.

The following trigger levels are therefore defined for the Tarrawonga TARP:

- Investigation Level – wind speed ≥ 7 m/s
- Action Level – wind speed ≥ 10 m/s

4.1 Analysis of the frequency of "adverse conditions"

The percentage occurrence of adverse conditions at Tarrawonga is presented in **Table 2**, based on a review of the meteorological data from 2009 to April 2012. The frequency distribution of wind speeds is presented in **Figure 6** and the wind rose (**Figure 7**) shows the occurrence of wind speeds for different directions. These plots and the data presented in **Table 2**, show that while the higher wind speeds are infrequent, they are predominantly from the eastern quadrant. In other words, when the wind speed is such to activate a trigger the wind will often be from the eastern quadrant.

This explains why scenario L2 resulted in higher relative concentrations at the boundary for both the wind speed and wind direction analyses, and also why scenarios L1 and L4 showed their peaks at the boundary receptors to their west.

However, the data in **Table 2** also shows that winds above 7 m/s (in any direction) only occur very infrequently, for a little over l % of the time, and that only half of those (approximately 54%) will be from the eastern quadrant (between 45° and 135°).

Table 2: Frequency distribution of wind speeds and direction

Wind Direction		Wind Speed (m/s)		
		< 7	>7 - 10	>10
>=0 – 22.5	N	4.8%	0.0%	0.00%
>22.5 – 45	NNE	4.3%	0.0%	0.00%
>45 – 67.5	NE	5.0%	0.1%	0.01%
>67.5 – 90	ENE	5.1%	0.2%	0.02%
>90 – 112.5	E	7.2%	0.2%	0.01%
>112.5 – 135	ESE	9.3%	0.2%	0.01%
>135 – 157.5	SE	8.5%	0.2%	0.01%
>157.5 – 180	SSE	6.6%	0.1%	0.00%
>180 – 202.5	S	6.4%	0.0%	0.00%
>202.5 – 225	SSW	6.4%	0.0%	0.00%
>225 – 247.5	SW	5.0%	0.0%	0.00%
>247.5 – 270	WSW	6.2%	0.0%	0.00%
>270 – 292.5	W	7.8%	0.0%	0.00%
>292.5 – 315	WNW	6.1%	0.0%	0.00%
>315 – 337.5	NW	4.5%	0.0%	0.00%
>337.5 – 360	NNW	5.6%	0.0%	0.00%
Total	**All directions**	**98.8%**	**1.1%**	**0.1%**

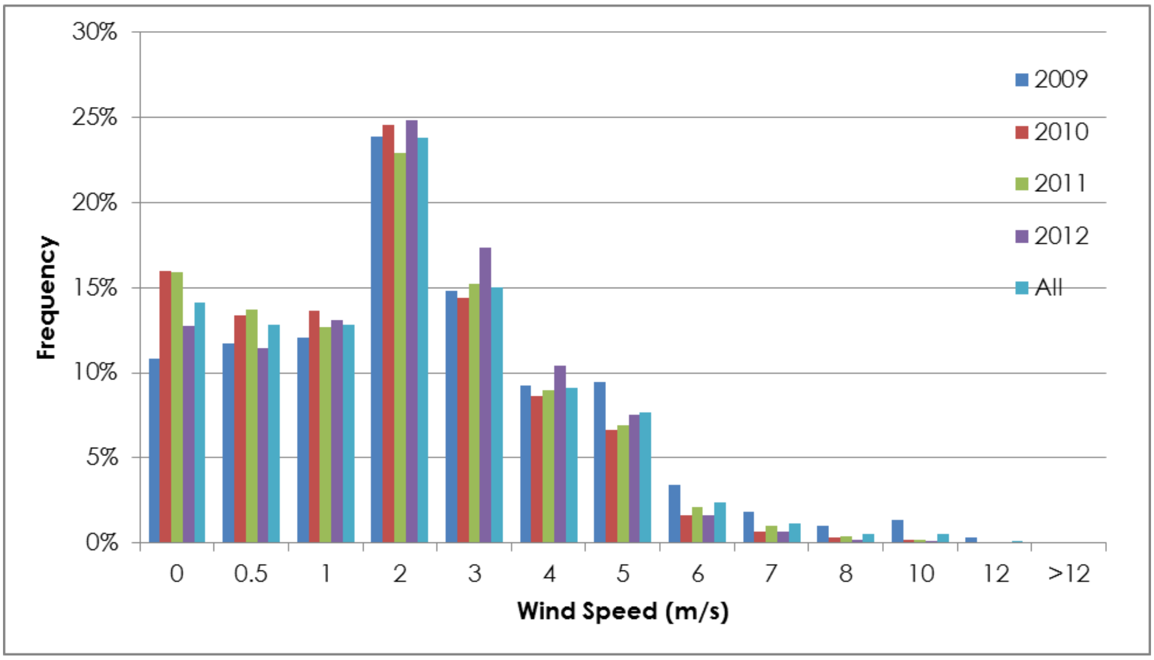

Figure 6: Frequency of wind speeds

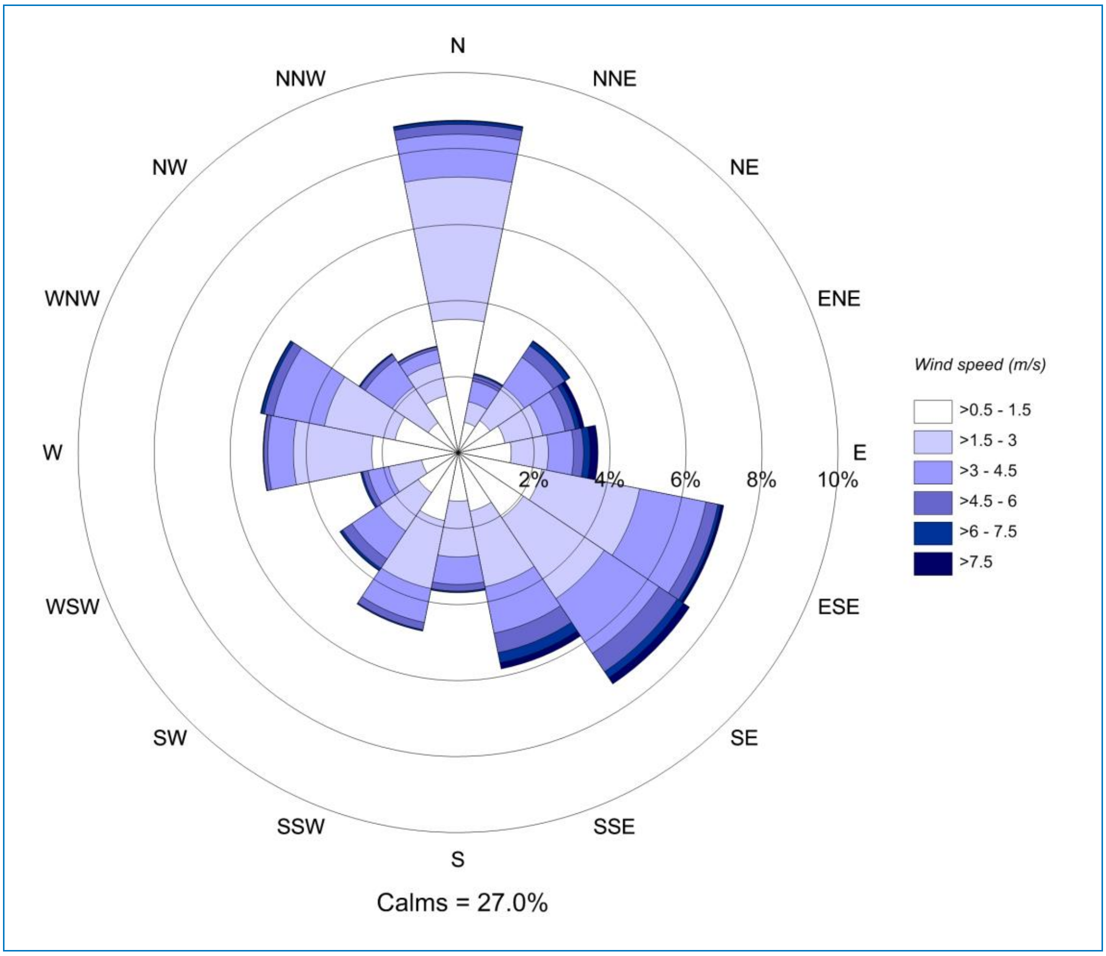

Figure 7: Windrose for all data from 2009 to April 2012

5 REFERENCES

US EPA (1985). Compilation of Air Pollutant Emission Factors, AP-42, Fourth Edition United States Environmental Protection Agency, Office of Air and Radiation Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711.