DustScan

Dust Monitoring and Dust Assessment

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DUSTSCAN DIRECTIONAL DUST MONITORING AND ASSESSMENT

Data Summary, Analysis and Interpretation

This discussion document sets out criteria for attributing significance to directional AAC and EAC data from routine analysis. Included is a description of available methods for summarising and reviewing this data and displaying it graphically. Possible uses of this information and its interpretation are also covered.

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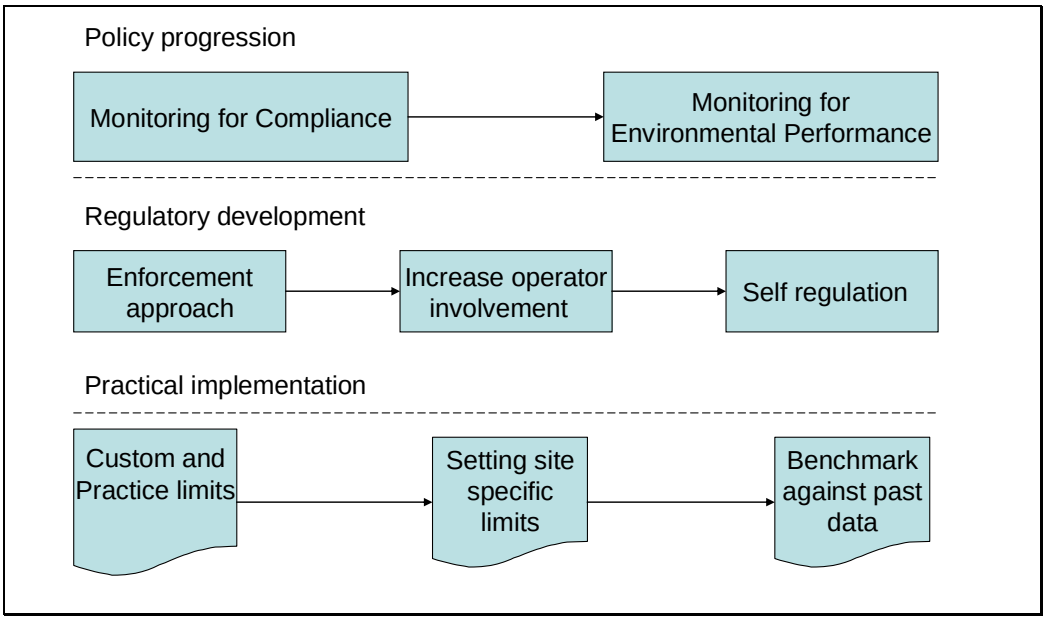
1 INTRODUCTION

This document outlines the rationale behind the use of DustScan directional dust monitoring techniques and how the analytical results can be used. The results can be ranked or classified and then the significance of dusting evaluated for single or multiple samples. From this directional data specific sources and the nuisance potential of those sources can be assessed in a uniform, consistent and reliable manner. This approach is required when assessing dust data from baseline monitoring as well as from routine monitoring of specific industrial operations. Performance targets can then be set before operations commence or periodically during these operations.

'Nuisance dust' relates to a range of visual effects, generally in relation to the perception of some loss of amenity to an observer. It can range from the long-term, chronic, soiling of surfaces such as windowsills and paintwork to short-term, acute, dust events such as dust clouds, which can be short-lived[1].

Currently there is a movement away from strict compliance monitoring, where fixed standards are applied, towards site-specific environmental management schemes (EMS) that evaluate environmental performance[2]. This often involves changes to the design of monitoring regimes and to the interpretation of environmental monitoring data in order to establish performance targets. These targets can be developed by site operators, through consultation with regulatory authorities such as EHO's and the EA and should provide a more effective means of monitoring site emissions and potential nuisance to off-site receptors than the application of a 'blanket' dusting limit. The development process for policy, regulation and implementation are summarised below in Figure 1.

Figure 1 Developments in Environmental Assessment



[1] Quality of Urban Air Review Group, 1996
[2] Environment Agency, 2006

2 DIRECTIONAL DUST DATA

2.1 Description of the data

Directional dust data is provided in a standard format. This shows AAC and EAC levels and the directions from which that dust has come. The measures are:

- Absolute Area Coverage (AAC%) – the presence of dust *irrespective* of colour
- Effective Area Coverage (EAC%) – the *darkness* or *potential soiling* of dust

It is recognized that AAC primarily identifies and ranks the **significance of dust sources** whereas EAC rates a **nuisance potential** that may be caused by the dust. Dust nuisance is not just restricted to specified high levels of EAC or AAC; the relationship of one to the other may also be significant. Sites with a typically pale dust may have a high nuisance potential due to one highly significant source and the associated quantity of dust, even though it may never reach critical EAC limits. In this situation it is possible, through a review of the data, to use source specific EAC trigger levels that more accurately represent thresholds of nuisance and recognises excessive dust build-up.

2.2 Potential uses of directional dust data

2.2.1 Compliance Monitoring

Agreed dust nuisance limits can be tested by applying trigger or threshold values to EAC and AAC data on a sample-by-sample basis to highlight any immediate directional concerns. Dust data can be classified by setting different AAC and EAC levels and displaying this information so that persistent directional concerns can be readily seen and acted upon.

2.2.2 Rating Environmental Performance

The environmental performance of a site can be assessed on either a site-wide or on a point by point basis to cover particular location or periods of concern. The use of rating criteria helps to rapidly identify potential problems. Site direction can be recorded and distinctions made between on-site and off-site sources. Off-site dust sources are often quite important.

2.2.3 Setting Site Performance Targets

Sites can monitor their own performance by setting site performance targets or thresholds once background data has been collected. This can be summarised to determine the contribution of the site and associated activities to ambient dust levels. Site specific thresholds, based on historic data, could be set at the 95th percentile for directional EAC levels. Such thresholds would relate directly to the likely conditions at the individual site and provide a 5% margin of flexibility allowing sites the occasional acute dust episode. Likewise, reducing the number of MaxAAC instances by a determined percentage can form location or source specific targets.

2.2.4 Improving Site Performance

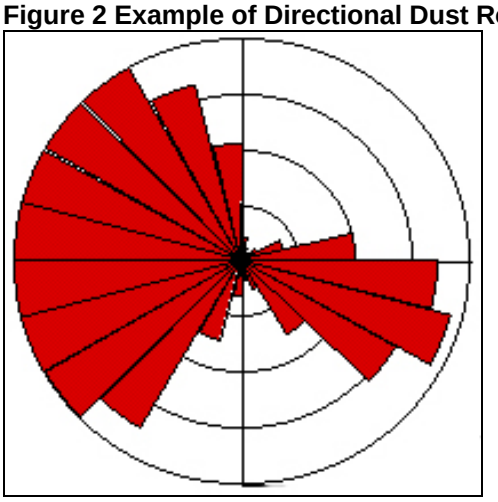
Comparing directional data against known site parameters can be used to improve dust suppression plans and increase the efficiency of those measures used. Dust action plans can be written to adapt to changes in working method, weather conditions and times of the year.

3 DATA ANALYSIS

3.1 Source Identification and Significance

As AAC is the more sensitive measure it is most appropriate to identify dust sources. A source is easily identified, visually, by the segment direction of the reported dust roses as demonstrated below (see Figure 2). The radius of each 15º segment represents the magnitude of AAC from that direction; the greater the radius of the segment the more pronounced the source.

Figure 2 Example of Directional Dust Rose



To attribute a level of significance to an identified source the following threshold values used as indicated in Table 1. In addition, the angle of dust spread at AAC saturation point (100%) can be used to further assess the significance of the source.

Table 1 AAC Criteria

Source Significance		%AAC Value
Very Low	0	<80%
Low	1	80% - 95%
Medium	2	95% - 99%
High	3	99% - 100%
Very High	4	100% for 45º

3.2 Rating Potential Nuisance

AAC may reach 100% quite frequently. EAC is more widely and readily used to assess the likelihood of nuisance due to visual soiling effect. The following general assessment criteria (Table 2) are based on complaint thresholds suggested by Beaman and Kingsbury (1981) and an upper most limit suggested by Schwar (1994).

Table 2 EAC Criteria

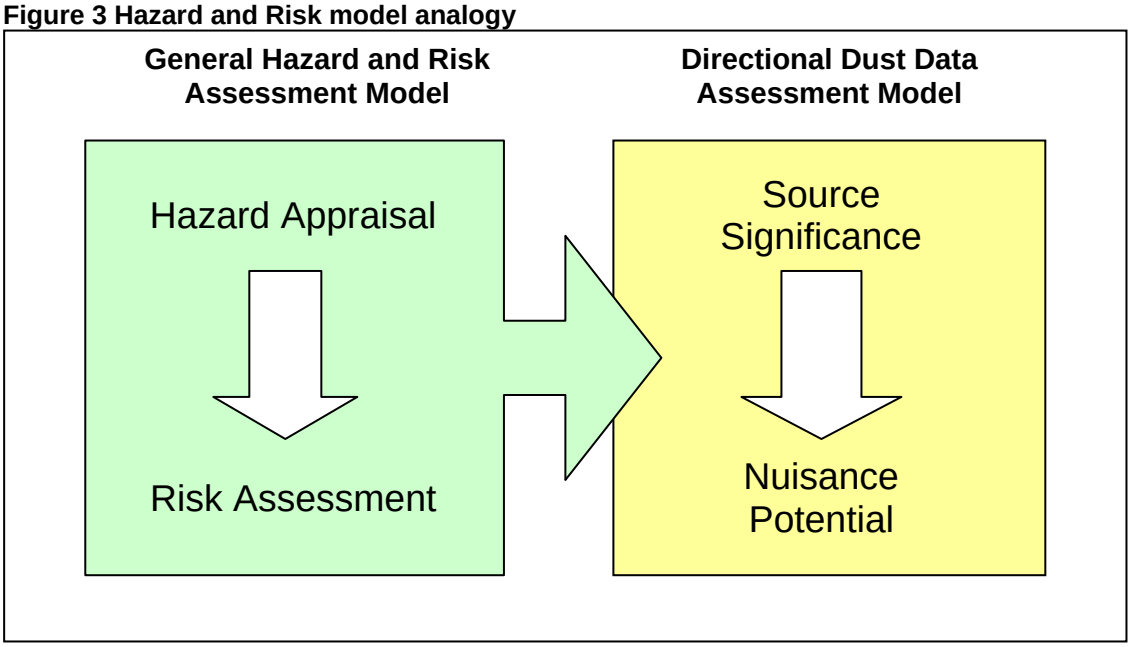
Nuisance Potential		%EAC Value
Very Low	0	<2.5%
Low	1	2.5-5%
Medium	2	5-15%
High	3	15-25%
Very High	4	>25%

The soiling effect of dust measured as an EAC value depends on the type of dust and the colour and contrast of that dust, but it does not directly relate to the quantity of dust.

3.3 Data evaluation criteria

This technique naturally forms a two tiered assessment approach to the quantification of the impact of nuisance dust, very much like a hazard appraisal and risk assessment (see Figure 3). AAC thresholds can be used to identify the dust source and its magnitude (**Hazard**). EAC thresholds can be used to rate the nuisance potential (**Risk**) of the dust.

Figure 3 Hazard and Risk model analogy



The significance levels for AAC and EAC may be combined in an assessment matrix for potential impact as shown below in Table 3.

Table 3 Assessment Matrix for Potential Impact

		AAC – Source Significance Level				
		0	1	2	3	4
EAC – Nuisance Potential	0	V Low	V Low	V Low	Low	Med
	1	Low	Low	Low	Med	High
	2	Med	Med	Med	High	High
	3	High	High	High	High	V High
	4	V High	V High	V High	V High	V High

The central section of the above matrix with a bold outline may be regarded as a warning of approaching critical dust conditions. For single samples warning levels are shown as illustrated in the report sheet shown in Figure 5.

Figure 4 Example of directional report sheet with warning levels

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FACTUAL DUST MONITORING REPORT

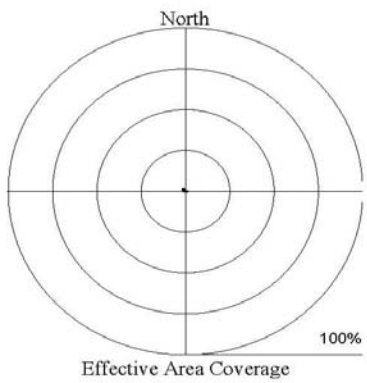
Client:	A N Other Quarries	**Site:**	Pebbleton Quarry
Point Ref:	2 (Located near site entrance on screening bund)		
Date Out:	10 October 2003	**Date In:**	17 October 2003
Duration:	7 days	**Our Ref:**	00121

STATEMENT OF RESULTS

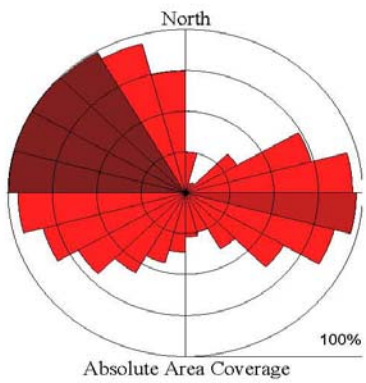
% Effective Area of Coverage / period = 0.83 % Effective Area of Coverage / day = 0.12

% Absolute Area of Coverage / period = 63.77 % Absolute Area of Coverage / day = 9.11

Segment	%EAC /Period	%AAC /Period	%EAC /Day	%AAC /Day	EAC Warning level	AAC Warning level	Nuisance Dust Warnings
000°-015°	0.192	24.940	0.027	3.563			
015°-030°	0.087	6.024	0.012	0.861			
030°-045°	0.038	7.317	0.005	1.045			
045°-060°	0.426	33.479	0.061	4.783			
060°-075°	0.715	73.578	0.102	10.511			
075°-090°	1.260	94.326	0.180	13.475			
090°-105°	1.425	96.416	0.204	13.774		AAC > 95	
105°-120°	0.953	86.922	0.136	12.417			
120°-135°	0.596	64.030	0.085	9.147			
135°-150°	0.284	39.443	0.041	5.635			
150°-165°	0.183	24.796	0.026	3.542			
165°-180°	0.131	27.078	0.019	3.868			
180°-195°	0.194	36.243	0.028	5.178			
195°-210°	0.186	44.302	0.027	6.329			
210°-225°	0.246	56.278	0.035	8.040			
225°-240°	0.398	69.830	0.057	9.976			
240°-255°	0.779	83.086	0.111	11.869			
255°-270°	1.409	94.459	0.201	13.494			
270°-285°	1.961	99.730	0.280	14.247		AAC > 99	High AAC
285°-300°	2.183	99.952	0.312	14.279		AAC > 99	High AAC
300°-315°	2.329	99.889	0.333	14.270		AAC > 99	High AAC
315°-330°	1.894	99.288	0.271	14.184		AAC > 99	High AAC
330°-345°	1.436	94.480	0.205	13.497			
345°-360°	0.643	74.711	0.092	10.673			



Effective Area Coverage



Absolute Area Coverage

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It is common, especially at a site with pale dust sources, that an AAC significance level of 4 is reached without any corresponding EAC significance level. In such situations it is necessary to examine the identified source(s) of dust and what factors may have contributed to the observed significant levels. This may be best achieved by considering several monitoring periods to determine if this is a re-occurring dust source or a temporary, isolated event.

4 DATA SUMMARY

Summarising data over a predetermined interval such as a month, a quarter or a year is a common practice in environmental monitoring and provides a more representative example of on going environmental conditions. Summarising data in a meaningful manner can allow for both directional trends and isolated incidents to be identified.

With multiple monitoring points large quantities of data become available. The more samples taken the more robust and reliable the data are likely to be. However each monitoring point is examined individually to maintain the validity of directional data.

EAC or AAC data may be summarized by the appropriate ranking criteria described in Section 3 for every 15º. The frequency of the occurrence of different significance levels of dusting for either AAC or EAC can be used to assess the nature of directional dust movement over time i.e. whether a dust source is chronic or acute (see section 1). Site wide performance may also be assessed though the application of this technique at other monitoring points across a site.

4.1 Methods for Summarising Data

The monitoring data can be summarised by using:

- Fixed AAC criteria
- Fixed EAC criteria
- Variable EAC criteria

Over a predetermined period, such as a month, a quarter or a year, it is possible to review the data and count up the number of instances where defined dusting levels were recorded. For the purposes of this exercise only three levels are used (1, 2 and 3 in the tables above). This is shown in the matrix given above where the potential impacts are Low, Medium and High *i.e.* on the boundary of High or Very High impact potential. If it is required to assess the Very High potential impact levels this is best done by inspection of the raw data when any quadrant of the rose shown in example above incorporates a significant proportion of level 3 AAC readings.

Calculations are undertaken using the 5º EAC and AAC values listed in the database for every 15º segment. An example of how data is summarised is shown in Figure 6 below. The aggregated AAC values for each 15º direction can be tallied against the appropriate criteria band (1-3).

Figure 5 Example of AAC data summary to standard criteria

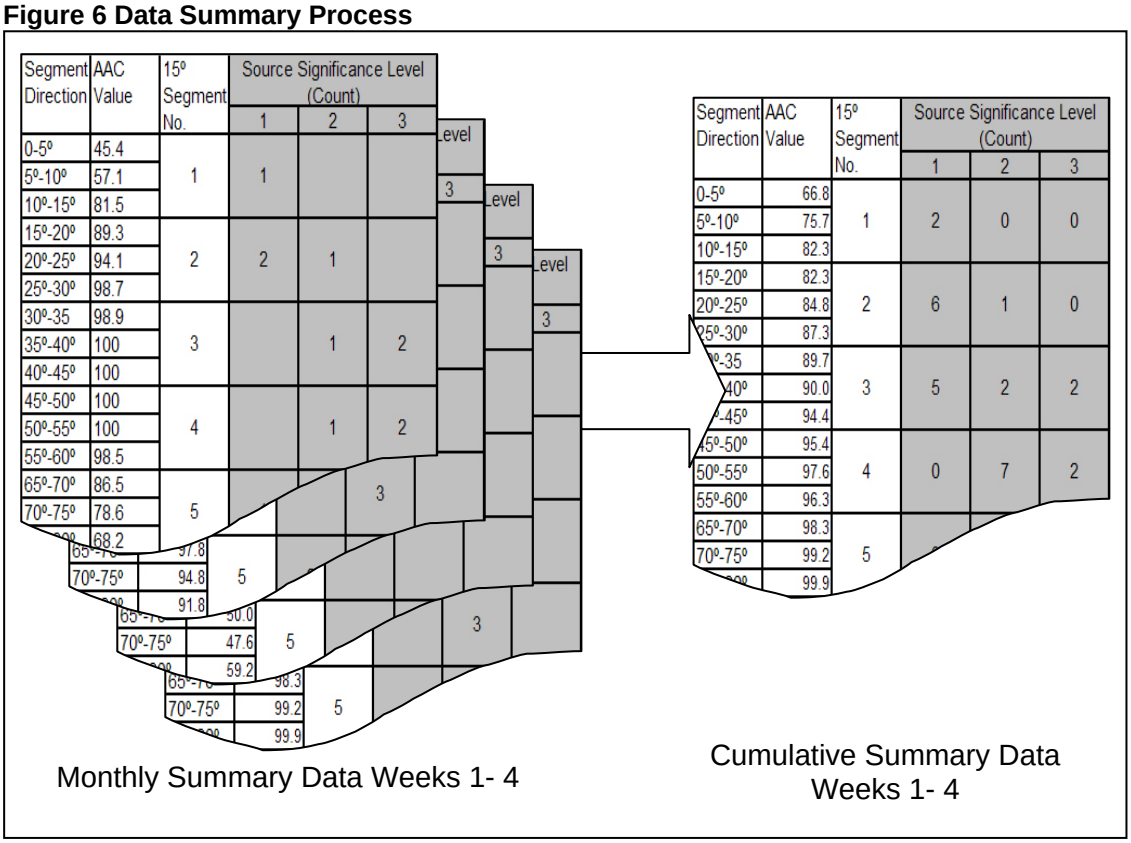
Segment Direction	AAC Value	15º Segment No.	Source Significance Level (Count)		
			1	2	3
0-5º	45.4	1	1		
5º-10º	57.1				
10º-15º	81.5				
15º-20º	89.3	2	2	1	
20º-25º	94.1				
25º-30º	98.7				
30º-35	98.9	3		1	2
35º-40º	100				
40º-45º	100				
45º-50º	100	4		1	2
50º-55º	100				
55º-60º	98.5				
65º-70º	86.5	5			
70º-75º	78.6				
[illegible]	68.2				

Thus it can be seen that, for example, there are 2 counts of dusting at the critical level (100% AAC) and one at the warning level (95-99% AAC) in segment 4.

Typically this would be conducted for sample data over a minimum period of 1 or 2 months. If sampling is on a weekly basis then 4-5 samples per point would provide 12-15 data values per 15º segment.

The greyed section of the data shown in Figure 6 (on the right side) can then be aggregated for multiple samples as shown below in Figure 7.

Figure 6 Data Summary Process

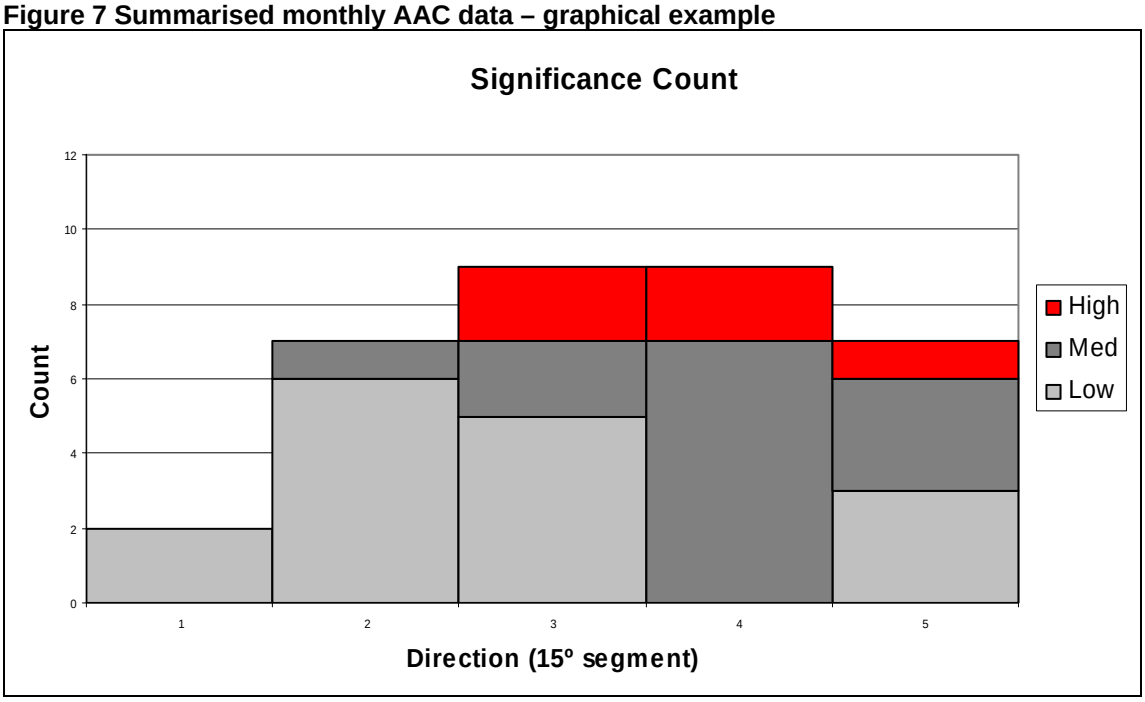


The cumulative count values that are shown in the Summary Data sheet on the right are the sum of each week's data within the four week summary period.

Over four weeks, as there is a potential maximum count of 3 for each significance level per 15º segment, there is a potential summary maximum count of 12. Therefore each count represents 1/12th of the total data and demonstrates the relative significance levels during the month. For example, in Segment No. 1 dust levels were low as there was only a count for significance level 1.

Variations that occur in this summarised data are shown in Figure 8. The Y axis is set at a maximum of 12 to show the relative proportion of each significance level.

Figure 7 Summarised monthly AAC data – graphical example

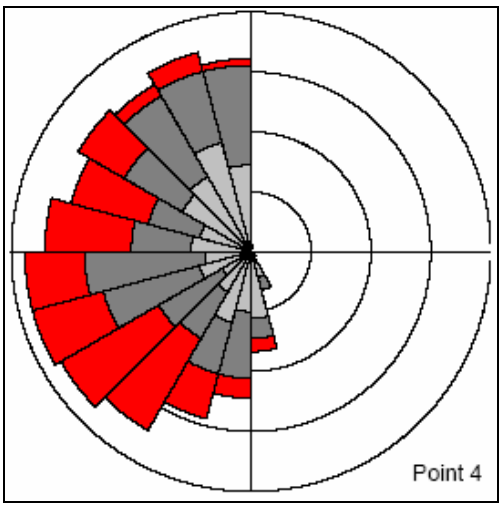


4.2 Data Presentation

The summary for each period is still contains a substantial amount of data, being shown in 15º segments, therefore visual/graphical representation is a convenient method of allowing data to be interpreted and understood rapidly. To maintain the directional value of the data the "bar chart" type of plot demonstrated can be transformed into a rose plot (such as those used for sample reporting). An example is shown below in Figure 8.

Each of the segments shown represents the summarised data from that given direction. The radius of the segment represents the count (Y) axis shown in Figure 8 for all 24 directions over the 360º. The wedge-like representation of each directional segment only denotes the 15º sub-sample analysed and does not infer any greater degree of significance. The colour bands remain the same as shown previously. Displaying the data in only three banded significance levels allows the data to be displayed in a clear and easily interpreted manner.

Figure 8 Summary data displayed as a directional rose plot



The scale used by the rose shows concentric rings at 25%, 50%, 75% and 100% of total possible counts per segment. In the example in Section 4.1 100% would be 12/12$^{th's}$ and 50% would be 6/12$^{th's}$ etc… these percentage values do not represent AAC or EAC but the relative proportions of dust having a high, medium or low significance.

This will allow persistent and intermittent dust sources and dusting trends to be identified, to quantify seasonal variations, and could be used to assess effectiveness of suppression measures and to determine environmental performance targets.

Advanced methods of data interpretation are available to determine the specific contribution of site dust to the general or ambient dust levels recorded. Additional spatial/directional data is required to filter directional data into on-site and off-site dust levels since this is usually a matter of some concern.

5 CONCLUSIONS

The above summary criteria can be used to assess dust data near inherently dusty activities including quarry, waste management, construction and demolition sites. Summarised information can be used to assess, over different periods, baseline and routine dust data. It may also be used to look at the effect that operations have on the ambient dust levels surrounding a site by filtering data for on-site and off-site direction.

The methods outlined above provide a structured approach to the review of directional dust data. How far this is taken depends on individual site and regulatory requirements.

There are three main data summary stages that can be used for varying applications and are listed in Table 4.

Table 4 Applications for Directional Assessment Criteria

Stage	Description	Assessment Tool
1	Site operations and the use of data for designing and testing suitable suppression measures through source identification.	AAC Data
2	Compliance monitoring to assess the potential for dust release to cause nuisance	AAC and EAC Data
3	Evaluate site specific performance using thresholds based on historic directional data	Rankings of AAC and EAC Criteria Site Specific (Variable) Criteria

Levels of dusting depend on several factors including wind direction, wind speed, antecedent rainfall, on-site and off-site materials/soils *etc*. and site and adjacent activities. Over a typical monitoring period of 1-2 weeks the influence of individual constraints will vary.

The assessment criteria and the summaries that are produced for monthly, quarterly or annual reports are a reasonable basis for assessing the sources and the frequency with which different levels of dusting occur over a defined time. To properly assess this data it is important to have additional information on site layout and conditions, site operations, adjacent activities near the site and weather information.