Report

Lyttelton Port of Christchurch Coal Stockyard Expansion Project

Response to Further Information Request – Dust Matters

Prepared for Lyttelton Port Company Ltd

By Beca Infrastructure Ltd (Beca)

21 July 2010

Revision History

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Action	Name	Signed	Date
Prepared by	Joanna Mazur, Tracy Freeman	Tracy Freeman	21 July 2010
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on behalf of	Beca Infrastructure Ltd		

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1 Introduction

Lyttelton Port Company (LPC) has applied for a suite of resource consents to expand the coal stockyard and the quarrying at Gollans Bay.

The Canterbury Regional Council has requested further information under Section 92 of the Resource Management Act, 1991.

The purpose of this report is to provide answers to those questions relating to the assessment of environmental effects of dust emissions from the coal stockyard. These are questions 4 to 20 of the further information request, dated 10 March 2010. The report answers the questions in the order contained in the Request.

A technical assessment of actual and potential effects of dust was presented in a report by Beca Infrastructure Ltd (Beca), dated 10 July 2009 – "Lyttelton Port Company Ltd Coal Stockyard Expansion – Assessment of Effects of Discharges to Air". Herein, this will be referred to as the "Beca Report".

2 Dust Nuisance Effects: Response to Questions 4 – 6

Question 4

The general area of reported dust nuisance effects is described in the application but a more clear visual definition of the dust nuisance zone is required. Please provide an indication of the zone of reported dust nuisance effects by highlighting locations on a map so that the boundaries of the zone of historical nuisance effects can be clearly identified.

Response

Historic knowledge from LPC indicates that the area most affected by dust nuisance is approximately as shown in the ellipse in Figure 1. A number of houses were visited on 20 April 2009 – namely 2, 2A, 3 and 4 Gilmore Tce, and 4 and 6 Randolph Tce. A comment was made by one of those residents during the site visit that the residents at 20 Randolph Tce are not affected by dust.

There were eight submissions on the resource consent applications from local residents that considered themselves directly affected by coal dust. Whilst other submissions mentioned the coal dust issue generally, they were not directly affected. The addresses of the eight submissions were as follows:

Submitter no.	*Name*	*Address*
27005	Shaw, (Dr) A & Lamont, S	4 Randolph Tce
27008	McKelvey, Elizabeth	3 Gilmour Tce
27018	Penn, M & L	2 Gilmour Tce[1]
27019	McKelvey, Helen	6 Randolph Tce
27020	Morrison, Ken	22 Reserve Tce
27021	Hinds, Jenny	43 Reserve Tce
27022	Junk, Hugh	4 Gilmour Tce
27023	Jenkins, Mark	26 Reserve Tce

The majority of these addresses are located within the area marked on Figure 1. The submitters houses at 22, 26 and 43 Reserve Tce are outside of the area historically thought to be most affected by coal dust and it is understood that no complaints have previously been received from that vicinity.

[1] The address was not provided in the submission, but is on record in Environment Canterbury (ECan) files on the existing coal stockyard resource consent for air discharges.

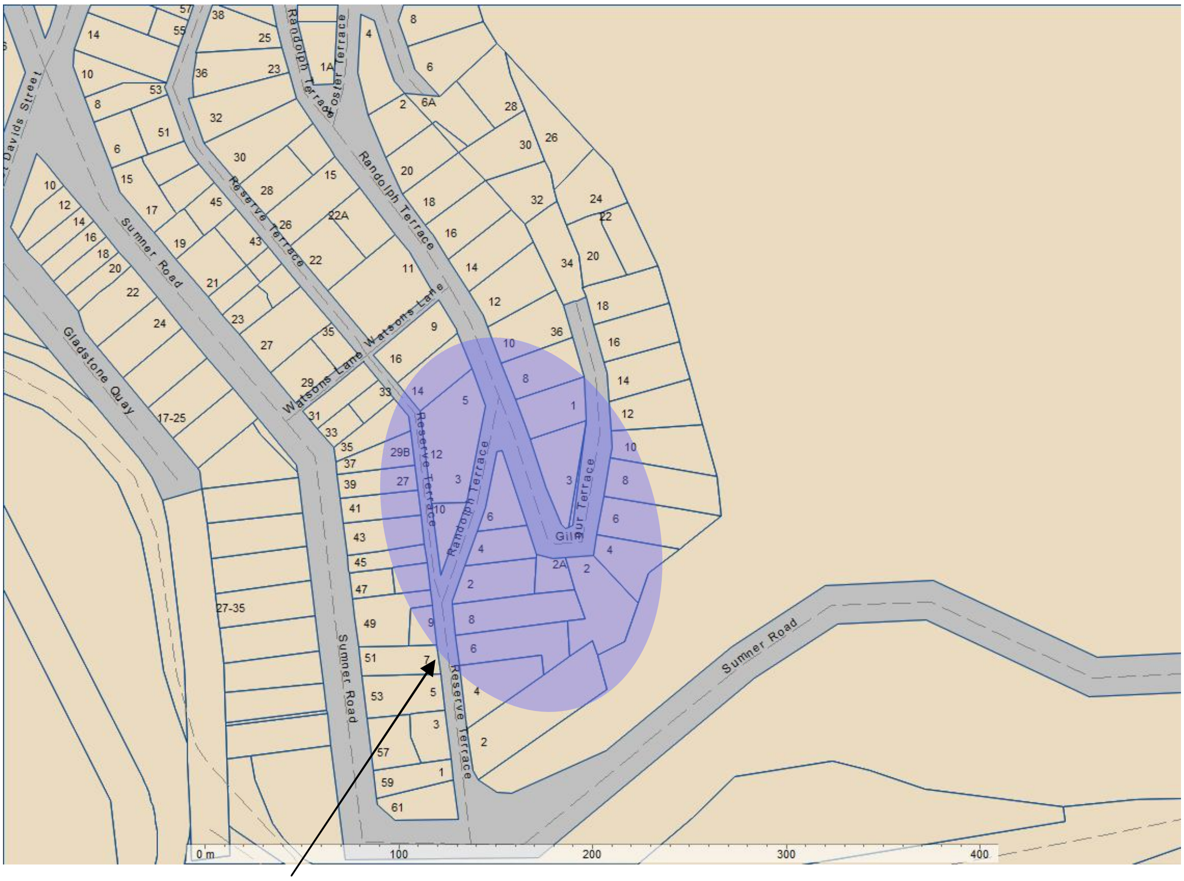


Figure 1: Approximate area historically thought to be most affected by coal dust.

Question 5

A general summary of nuisance effects is provided in the application, suggesting that the effects are episodic in nature. However, detailed information of the actual visual fouling (by dust deposition) of surfaces is not provided, and the assumption regarding the infrequent occurrence of peak impacts does not seem to be consistent with at least one submission from a Randolph Terrace resident that describes a more cumulative dust effect and visible deposits reoccurring within a few days of surface cleaning. If available please provide a more detailed summary of community feedback regarding the character and frequency of dust nuisance effects. Please also comment on whether this supports a chronic nuisance effect or more of an acute type of effect due to infrequent high exposures to ambient dust.

Response

Photographs taken during the site visit to some of the apparently worst affected properties on 20 April 2009 (described in the Beca Report, section 8.5.1) illustrating the typical degree of dust accumulation seen on that day are shown in Figures 2 to 4 below. The length of time over which this dust had deposited is not known.

Figure 2: Examples of dust accumulation at 6 Randolph Terrace.

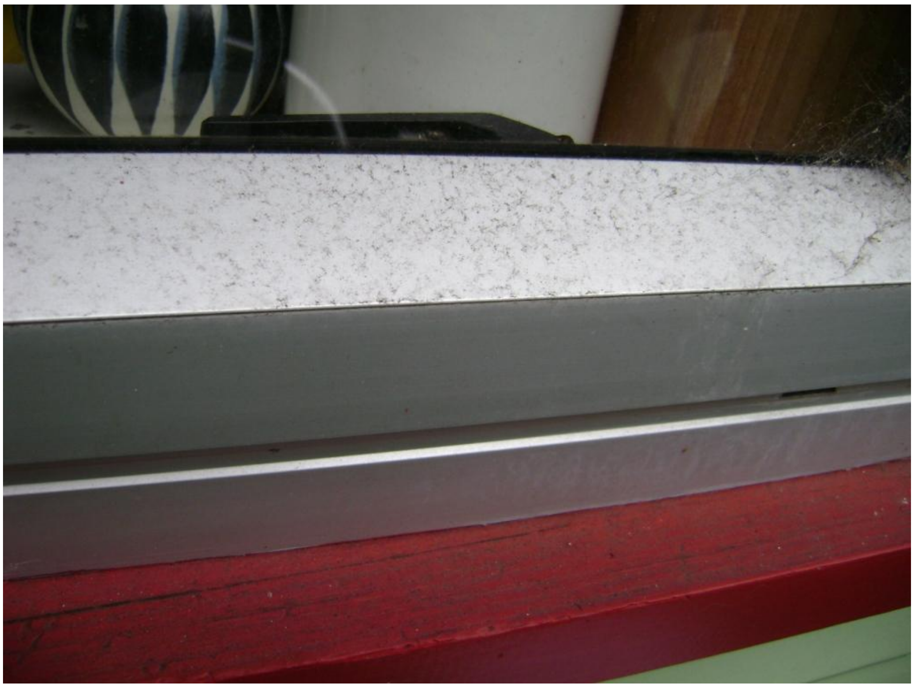


Figure 3: Example of dust accumulation at 4 Randolph Terrace.

Figure 4: Example of dust accumulation at 2 Gilmour Terrace.

The magnitude of the amount of dust deposited in any single hour depends predominantly on the activities being carried out at the stockyard, and wind speed and direction. Clearly this will vary from hour to hour. Therefore the dust is not deposited in a gradual manner each day. Instead, our understanding is that there are periods of the day during unfavourable wind conditions where the majority of the dust is deposited.

The wind speed analysis in Figure 5 shows that higher wind speeds are more frequent during afternoons. For example, if a strong easterly wind pattern is present then wind speeds may be high for several hours in the afternoon for several days in a row. Whilst these strong easterly winds can continue into the night, in Lyttelton Harbour it is not uncommon in such climatic conditions for wind speeds to die down over night and then increase again during the following afternoon. During such wind conditions a quantity of dust may be deposited each afternoon while the wind is strong, for several days in a row. This type of dust deposition pattern could result in dust accumulating within days of cleaning during this type of weather pattern and so would be consistent with the description provided by submitters.

It is difficult to categorise the deposition of dust at those affected properties in Reserve, Randolph and Gilmore Terrace as acute or chronic because the deposition of dust, as described above, is likely to accumulate over a few days during strong easterlies.

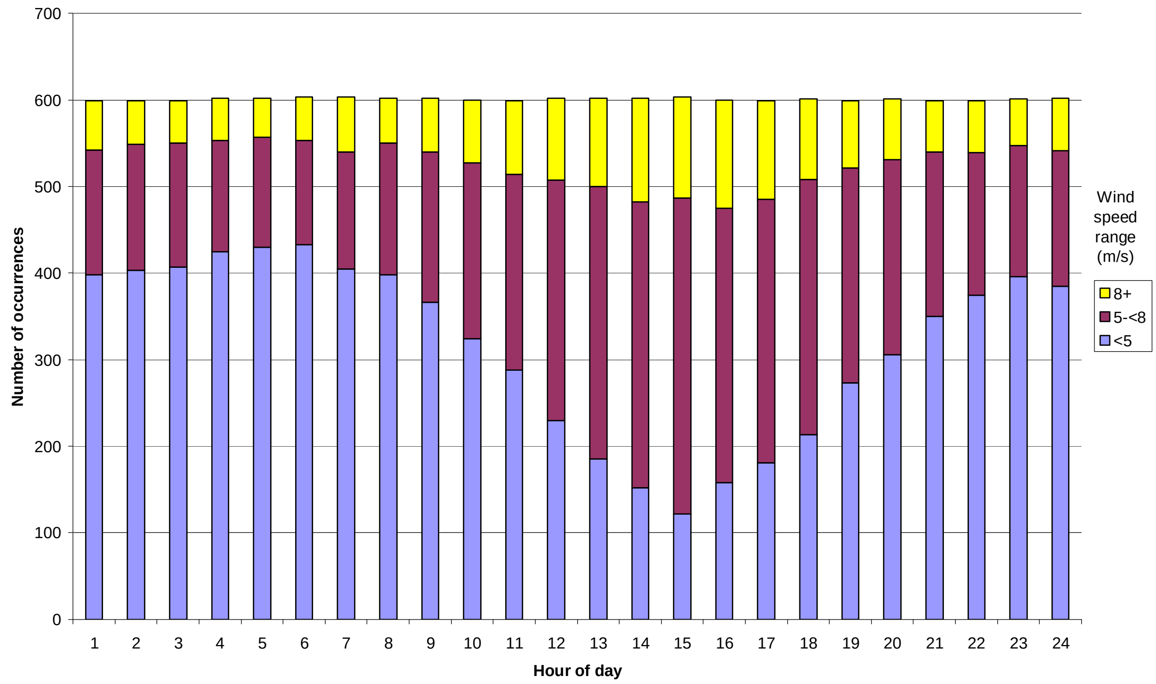


Figure 5: Wind speed range occurring for each hour of day over the November-March period from 2004 to 2008.

Question 6

Please assess whether the existing and expected future dust nuisance effects on residential properties near the Lyttelton Time Ball station have been or would be considered to be objectionable or offensive, with reasons to support the assessment.

Response

LPC has acknowledged that at times the coal dust has been a nuisance for at least some of the properties shown in Figure 1. LPC is not aware of any systematic assessment, following the FIDOL factors (discussed in section 8.1 of the Beca Report), that has been carried out to determine whether the existing nuisance effects could be considered to be objectionable. Nevertheless, it is likely that at least some residents, judging from their submissions, consider the nuisance to be objectionable.

As discussed in section 9.8.1 of the Beca Report, from the dispersion modelling it was concluded that the potential for coal dust nuisance to occur at nearby residences is likely to be reduced in future once the coal stockyard is extended. The degree of coal dust control at the stockyard will be progressively improved over time as the new control equipment is installed and as information from the proposed real time monitoring system is analysed to identify remaining causes of dust generation and appropriate mitigation measures. This “Management Plan” approach to the control of dust emissions was described in section 11.1.4 of the Beca Report.

3 Ambient Air Monitoring: Response to Questions 7 – 11

Question 7

Please outline the rationale for the coal dust deposition guideline of 80 mg/m^2/day being protective against nuisance of coal dust deposition within residential areas. This guideline was set as a condition in the existing consent, however its origin and basis for protecting against nuisance effects of coal dust is not clear.

Response

The basis of the original deposition guideline of 80 mg/m^2/day is explained in the Officer's Report prepared by John Iseli in 1996 on the consent applications made by LPC in 1995 for the coal stockyard, where it is recommended in paragraph 50 that "*an initial guideline of 80 mg/m^2/day deposited particulate be adopted as a basis for continued monitoring of coal dust deposition in Lyttelton. This guideline is applied to monitoring of a comparable coal handling operation in Merseyside, United Kingdom and is considered more relevant to coal dust deposition than a guildeine of 4 g/m^2/30 days.*"

This recommendation appears to be based on personal communication between the reporting officer and the Team Leader Environment and Pollution Group in Merseyside (as listed in the references at the end of the Officer's Report).

As a 30-day average this deposition rate of 80 mg/m^2/day corresponds to 2.4 g/m^2/30 days, and relates only to the coal fraction of the total collected dust. Appropriate average deposition guidelines were investigated during the preparation of the Beca Report. These were summarised in section 8.4.1 of the Beca Report and are reproduced below for convenience with some added detail for the New South Wales and Victoria guidelines:

In New Zealand there are no environmental standards or guidelines for deposited dust. However the MfE Dust Guide recommends a "trigger" level for deposited dust of not more than 4 g/m^2/30 days above background levels. Deposition rates of more than 4 g/m^2/30 days above background levels in some industrial and sparsely populated areas may not cause a nuisance, but conversely in residential areas deposition rates in the order of 2 g/m^2/30 days above background levels may cause a nuisance.

Other dust guidelines used in Australia are as follows:

- *New South Wales:* *4 g/m^2/30 days (dispersion modelling guideline) or no more than 2 g/m^2/30 days above background. Annual averaging period. Dust is assessed as insoluble solids. The assessment criteria must be applied at the nearest existing or likely future off-site sensitive receptor. The criteria are based on a 1988 report: NERDDC 1988, Air Pollution from Surface Coal Mining: Measurement, Modelling and Community Perception, Project No. 921, National Energy Research Development and Demonstration Council, Canberra. The criteria are therefore assumed to be applicable to coal dust, although the original 1988 report is not available and the NERDDC no longer exists.*
- *Queensland:* *120 mg/m^2/day as an annual average applicable to residential areas (equivalent to 3.4 g/m^2/30 days, but averaged over a year rather than a month – the equivalent 30 day limit would be higher than 3.4 g/m^2/30 days).*
- *Victoria:* *4 g/m^2/month, or no more than 2 g/m^2/month above background.*

The value of 2.4 g/m^2/30 days used in the existing consent is more stringent than both the Queensland guideline and the New South Wales guideline (when the annual averaging period in the NSW guidelines is taken into account). It is slightly less stringent than the Victoria guideline of 2 g/m^2/month above background, although it is noted that this guideline is based on research published more than 20 years ago. The original paper is not available to allow the context of the original recommended guidelines to be ascertained, and to determine whether the guideline of 2 g/m^2/month above background is applicable to the Lyttelton example.

The value of 2.4 g/m^2/30 days is also more stringent than the MfE Dust Guide recommendation of 4 g/m^2/30 days above background –the deposition rate of 2 g/m^2/30 days for residential areas in the MfE Dust Guide is approximate (ie "in the order of") and should be regarded as indicative only.

It is considered appropriate to continue to monitor monthly deposition rates in proximity to the LPC Coal Stockyard, to provide long term information about trends in deposition patterns. For this purpose, LPC proposes to retain the existing consent limit of 80 mg/m^2/day. In the period from summer 2004/05 to November 2009 there was only one exceedence of this limit at the 30-day monitoring sites – this was a result of 80.2 mg/m^2/day collected at Site 11 on 4 December 2007. Any trend towards more frequent exceedence of this limit could indicate that dust emission controls are not performing as expected, although this information would also likely be obtained from community feedback and the proposed real-time dust monitoring system.

No merit is seen in reducing this limit, as the monthly average deposition rate is not a direct measure of the potential for adverse effect. However, it is considered prudent to continue to monitor average deposition rates to enable analysis of trends in future years. Therefore the applicant has proposed to continue monitoring monthly deposition rates, albeit at a reduced number of representative sites.

Question 8

Please provide details of the prevalent weather conditions at the three monitoring sites (including wind directions, speed and ambient temperature) when dust nuisance complaints occurred (if any) during the ambient monitoring period. For complaints occurring outside of the ambient monitoring period, can the above analysis be provided against weather conditions that were monitoring in the Christchurch area, which can be used to infer the likely conditions in Lyttelton?

Response

For the purposes of responding to this question, only complaints since the installation of the bucket wheel reclaimer (November 2005) have been assessed. An updated list of complaints was obtained from ECan on 29 April 2010. Descriptions associated with complaints made to ECan are listed in Table 1. All complaints are non-specific in terms of details of when the dust was deposited (for example none of the complaints narrow down a day or afternoon, say, when dust deposition was noticed). Therefore it is difficult to provide any specific analysis of prevalent weather conditions on, say, a single day when peak dust deposition occurs.

Deposition rates are a function of wind speed and direction and the activities being carried out at the site. The complaints are all made in November through to February, which are the warmer, drier months that also coincide with the more prevailing strong easterly wind patterns.

Table 1: Complaints made to ECan about dust from coal stockyard since November 2005

Date of complaint	Location of complainant	Description of complaint
24/01/2006	Gilmour Terrace	Coal dust from the port company operation entering property, has been building up in intensity over the past 10 days, wind has not been strong at all.
01/02/2006	Reserve Terrace	Coal dust is still a problem have to continually wash terrace paintwork.
02/11/2006	Reserve Terrace	All the time affecting from coal dust, no let up.
16/11/2006	Not Specified	Dust discharge from the Lyttelton coal piles.
22/02/2007	Reserve Terrace	Regarding the coal dust at Lyttelton (no specific details provided).
11/12/2007	Reserve Terrace	Coal dust still being dumped on her property, last 3 months has been bad. Continuous in summer.
29/01/2009	Randolph Terrace	Been shovelling the coal dust up today, it is ongoing, comes from the easterly. 29/1/09 email to Mike Day, LPC from Joy Bier, ECan: "there has been a complaint about coal dust on a residential property. I am not sure of the location of any further facts except it appears it has been happening for a while".
12/02/2010	Reserve Terrace	Coal dust is all over her courtyard and window sills and they are black. She has just swept it up but it will be back in two days anyway.

Appendix F shows windroses from the Officer's Point met station at Lyttelton Harbour for the two week period leading up to the date of each complaint in Table 1. For the purpose of comparison, the Appendix also shows a summary windrose for the full summer (November to March) period for the years 2004 to 2008. In the days leading up to some of the complaints, there is clearly an increase in frequency of winds from the easterly direction, however this is not the same for all of the "pre-complaint" periods.

For the complaint dated 11 December 2007, two windroses are provided in Appendix F. One shows wind patterns for the two-week period leading up to the complaint, and the other shows wind patterns for the three-month period leading up to the complaint as this was the time period referred to in the complaint itself. The three-month windrose shows very similar wind patterns to the longer term 2004-2008 windrose, although the two-week windrose shows an increased frequency of easterly winds.

Periods where there is an increase in frequency of easterly winds may indicate an increased potential for dust deposition at the houses in the vicinity of Reserve/Randolph/Gilmour Terrace, particularly at higher wind speeds. Figure 6 shows an analysis of the percentage of all wind records in the fortnight leading up to each complaint where the wind was blowing from the easterly sector (defined as 60-150 degrees) and at speeds greater than either 5 m/s or 8 m/s. In some of the "pre-complaint" periods there is an increase in frequency of these high wind speeds, which would indicate a potential for increased dust generation and deposition particularly if certain activities were being carried out at the coal yard which carry a greater potential for dust emissions.

It is noted that the complaint detail for 1 Jan 2006 described the weather as "wind has not been strong at all" (Table 1). However the fortnight leading up to this complaint showed the greatest proportion of winds from the east over 5 m/s and over 8 m/s out of any of the periods analysed. This apparent contradiction may be due to the ridge between the Reserve/Randolph/Gilmour Terrace area and the stockyard, which is known to provide shelter from easterly winds. It is possible that dust generated in windy conditions at the stockyard is carried towards these houses and then deposited in eddy flows on the lee side of the ridge.

Overall, the analysis of wind strengths in this section suggests a potential relationship between periods of increased frequency of high speed easterly winds and dust deposition in the Reserve/Randolph/Gilmour Terrace area.

Other potential contributing factors such as coal import and export-related activities being carried out in the stockyard at the time of complaints were assessed, but no conclusions were able to be drawn.

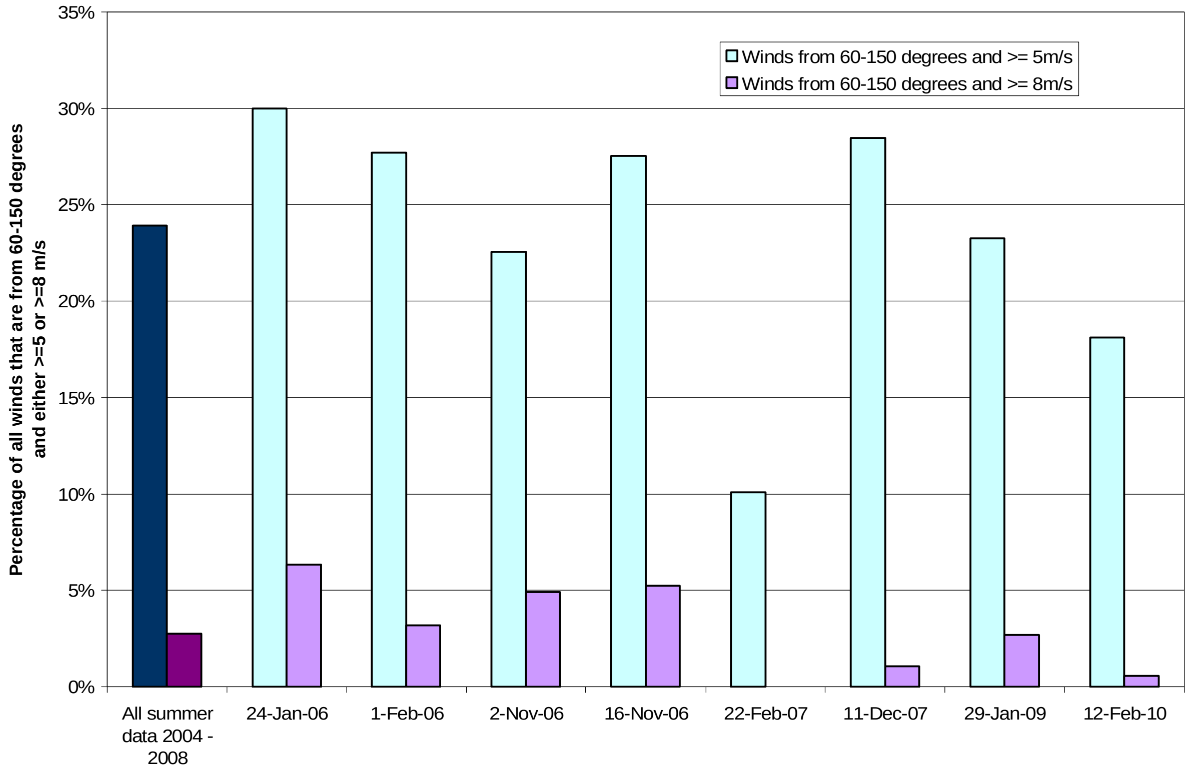


Figure 6: Wind speed range occurring for each hour of day over the November-March period from 2004 to 2008.

Question 9

It is not clear in the application how the total suspended particulate (TSP) monitoring data provided correlates to weather conditions. Therefore, please provide details of the prevalent weather conditions at the three monitoring sites (including wind directions, speed and ambient temperature) that were associated with the days and specific hours of peak hourly ambient TSP levels as measured near the Timeball Station during the ambient monitoring period of 19th January to 31st March 2009.

Response

This question was assessed by isolating a number of the highest 1-hour TSP concentrations measured when load out activities (ie conveyors, vehicles, and ship loading all occurring) were being carried out at the stockyard (as this has been shown to be an activity with the potential for occurrence of the highest TSP concentrations, and is also the most relevant category for comparison with the model results for peak emissions). Concentrations occurring when the wind had little potential to have come from the stockyard were then filtered out (ie if the wind vector on the hour[2] was from approximately 180-360 degrees at all of the three measurements sites – Officer's Point, Stockyard, and Timeball Station).

The resultant data is shown in Table 2. The table shows the 1-hour average TSP concentration measured, and the average wind speed during the same hour. The wind speeds measured at the stockyard during these hours range from 3.2 to 8.7 m/s. This is a wide range of speeds which indicates that some factors other than just wind speed (ie dust emission rates and/or contribution from non-coal background dust sources) contributed to the concentrations measured.

This analysis is not able to distinguish short-term (<< 1 hour) events occurring within these hours where some coincidence of wind speed, direction and activities being carried out may have resulted in high concentrations of TSP being measured over a period of a few minutes.

[2] Initially, average wind directions calculated from a vector average over the entire hour of 1-minute frequency readings were assessed, however this was considered to be misleading in terms of the actual direction from which dust was received during the hour. Using the vector measured on the hour is also potentially misleading or erroneous, but was considered to be the best possible starting point for the analysis.

Table 2: Wind speeds occurring when 12 highest 1-hour TSP concentrations were measured at Timeball Station (19 January to 8 May 2009); wind direction from stockyard and load out activities occurring.

Date/Time	TSP concentration, µg/m^3	Wind speed, m/s (1-hour average) at various stations		
		Timeball Station	Stockyard	Officer's Point
28/02/2009 04:00	254	1.8	3.2	4.6
27/03/2009 21:00	178	2.3	8.7	9.3
21/01/2009 15:00	123	5.1	7.3	6.7
11/04/2009 01:00	113	2.5	3.6	4.6
25/01/2009 15:00	110	5.0	5.6	6.2
4/04/2009 15:00	92	4.1	No data	6.7
21/01/2009 14:00	90	5.2	6.4	7.2
25/01/2009 10:00	65	3.2	4.5	7.2
4/04/2009 13:00	60	2.8	No data	4.6
9/02/2009 19:00	58	1.5	3.6	6.7
25/01/2009 16:00	56	4.5	6.0	6.7
4/04/2009 12:00	55	1.5	No data	3.6

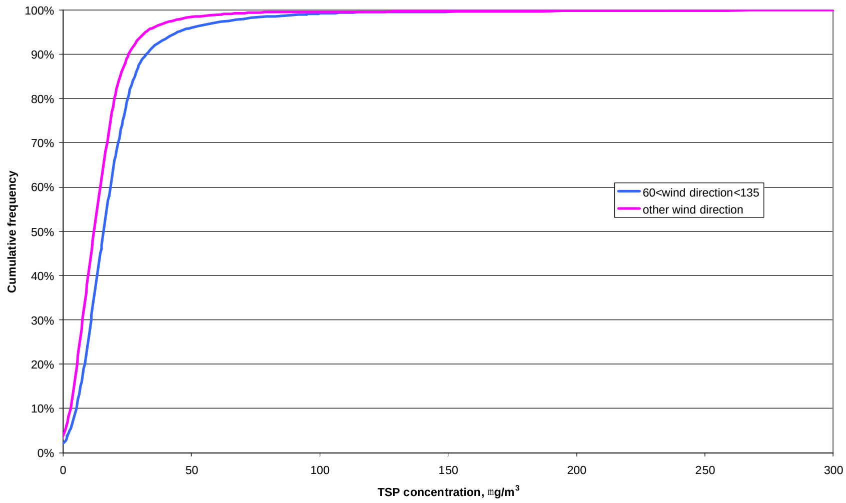
Question 10

Can you please provide an analysis similar to that given in Figure 9, Appendix 3 of the report submitted as Appendix 12 to the application, for wind directions of 60 to 100 degrees and 100 to 150 degrees of north as measured at the Timeball Station site as a function of stockpile activities as shown in Figure 10 of the same report? This would help further clarify the potential impact of other sources of coal dust.

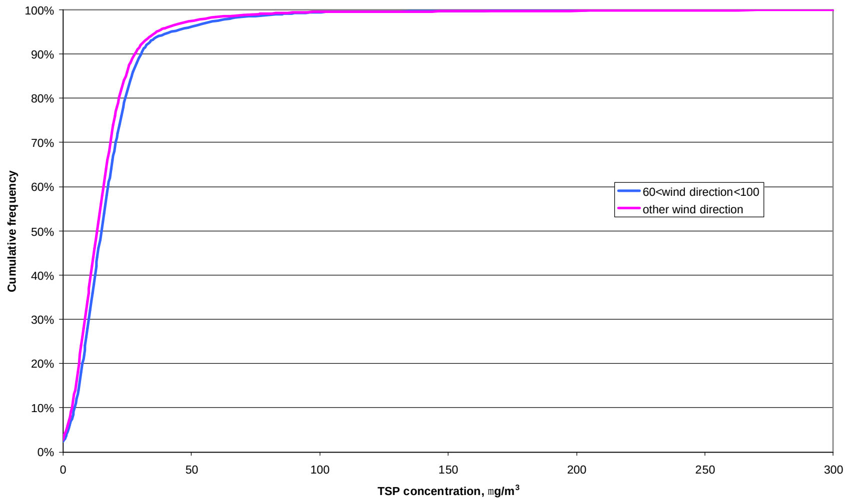
Response

This analysis is presented in Figure 7 (a) to (c) and Figure 8 (a) to (c). In each of these series of graphs, the (a) graph shows the analysis for wind directions of 60 to 135 degrees (as presented in Figure 9, Appendix 3 of the Beca Report but updated with the full data set to 8th May 2010 when the monitoring was stopped). The (b) graphs show the analysis for wind directions of 60 to 100 degrees, and the (c) graphs show the analysis for wind directions of 100 to 150 degrees.

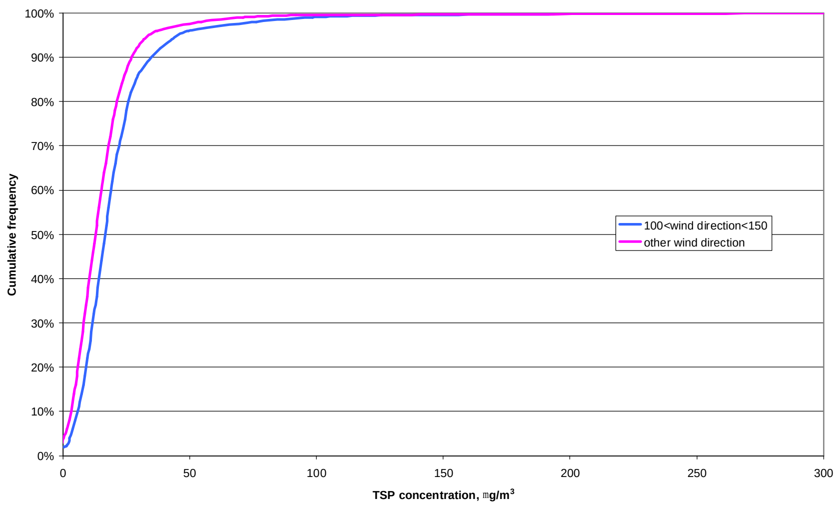
There is very little difference between the analyses for each of the three wind direction subsets.



(a) 60-135 degrees

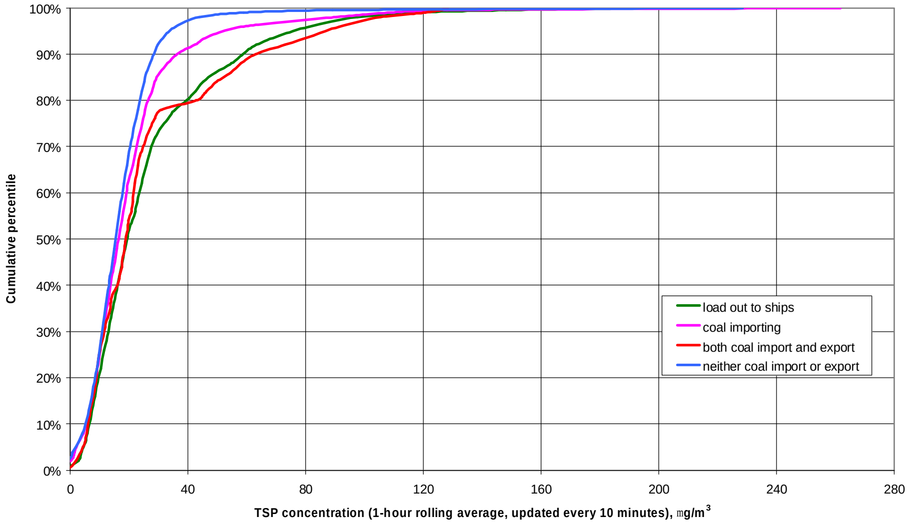


(b) 60-100 degrees

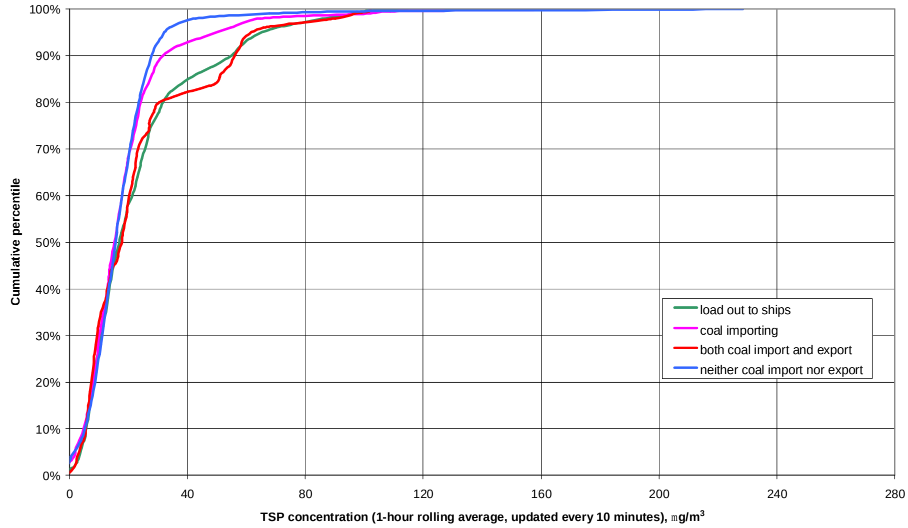


(c) 100-150 degrees

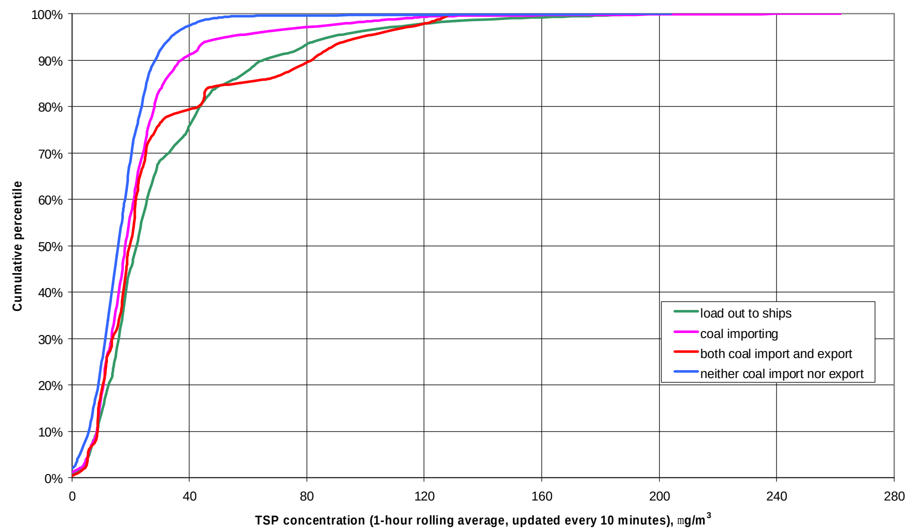
Figure 7: Analysis of measured TSP concentrations at Timeball Station (19 Jan – 8 May 2009) as a function of wind direction. Wind direction measured at stockyard until 18th April, and then at Timeball Station from 18th April to 8th May.



(a) 60-135 degrees



(b) 60-100 degrees



(c) 100-150 degrees

Figure 8: Analysis of measured TSP concentrations at Timeball Station (19 Jan – 8 May 2009) as a function of wind direction and stockyard activities. Wind direction measured at stockyard until 18th April, and at Timeball Station from 18th April to 8th May.

Question 11

Please provide details of other sources of coal dust in the area (if any) and assess whether the stockpiles of coal are likely to be the main source of nuisance dust effects experienced in the residential area of Lyttelton in the vicinity of the Timeball Station.

Response

The stockyard is the only known source of uncombusted coal dust in the area. Lyttelton Main School in Oxford Street uses diesel for classroom heating. It is possible that soot or ash from domestic fires could cause dust deposits that at times could be confused with the uncombusted coal dust from the stockyard, however this is unlikely during summer when dust from the stockyard is understood to be most noticeable.

4 Dispersion Modelling: Response to Questions 12 – 16

Question 12

The CALMET meteorological data set and dispersion modelling do not appear to correlate well with observed dust impacts in the area of the Timeball Station. Therefore please provide the following[3] :

a) *An analysis of the meteorological data set and dispersion modelling results in terms of predicted dust deposition rates and patterns of spatial impacts against actual dust impacts that have occurred (based on complaints by residents and monitoring results) to demonstrate whether the modelling is appropriate for predicting future effects.*

b) *An analysis of modelled peak hourly ambient TSP levels and the corresponding meteorological conditions that they occurred under, against monitored peak ambient levels and the meteorological conditions that they were observed under.*

c) *It is considered that running the CALMET model at a finer terrain and time-step resolution may result in direct trajectories through the modelled wind field between stockpile and residential areas. Therefore, please provide the reasons for the terrain resolution and model time step used for the CALMET modelling, and a comment on the outcome of running CALMET at a finer resolution and shorter time step in relation to gaining an accurate representation of terrain effects on the wind field and therefore predicted impacts at the Timeball Station.*

Response

(a) As explained above in the response to Question 8, it is not possible to link maximum actual deposition rates with actual short-term (in the order of 24 hours or less) meteorological conditions.

One potential factor that may lead to a difference in model predictions versus actual dust impacts is the potential influence of sheltering and contribution of downwind eddies to dust deposition on the lee side of the ridge between the stockyard and the houses of Reserve/Randolph/Gilmour Terraces (as discussed earlier in response to Question 8). This is unlikely to be adequately simulated by the model, if this is a mechanism that assists with dust deposition. This is not a weakness in the predictions as the amount of deposition during downwind eddies will reduce in proportion with the reduction in suspended particulate concentrations in the air.

(b) There is considered to be no value in carrying out this analysis. As explained in the response to Question 9 above, it is very difficult to determine any relationship between monitored peak TSP concentrations and meteorological conditions. Further, any analysis to determine such relationships must assume a constant rate of dust emissions at the stockyard, constant equipment usage within the hour, and no fluctuation of wind speed and direction within the hour. Therefore such analysis is not practical.

Of the two model types that were run for the existing stockyard (ie the “average” and “peak” emission scenarios), only the “peak” model could possibly be used in the type of analysis requested. However, it is not possible to directly compare model results with the ambient data,

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[3] bulleted list in original information request letter has been converted to an alphabetically-numbered list for the purpose of responding to the question

because even the "peak emissions" model assumes a constant, maximum activity usage rate. In addition, a stockpile moisture content is assumed, which may over- or underestimate actual stockpile moisture on any given hour.

(c) The terrain resolution was considered before the modelling was commenced. Grid resolutions of 100m and 200m were considered. The ultimate decision on the most appropriate grid resolution is typically a compromise between the domain extent desired for the model, the number of grid points required for that domain range, the size of the resultant CALMET data files and the consequential running speed for the CALPUFF models. It was considered desirable to have a domain range that covered the full Lyttelton Harbour area and the surrounding Banks Peninsula hill terrain, so that the wind channelling up and down the harbour and drainage flows through the valley where Lyttelton township is situated would be simulated. This required a domain size of 21 km east-west and 16 km north-south as summarised in Table 4.2 of the Beca Report. Whilst this domain size is not generally regarded as unmanageable in terms of file size and computer running times with a 100m grid resolution, in this case the number and type of sources meant that computer run times were substantial even at 200m grid resolution, with most model runs taking approximately two days to complete (this would have been approximately eight days with the 100m grid resolution). Many model iterations were carried out during the assessment of effects that resulted in the final Beca Report, and model run times of a week or longer each would have been completely impractical.

Figure 9 shows the CALMET grid data points for 200m resolution. The grid location coordinates and elevations used to plot this map were extracted from the PRTMET utility associated with the CALMET model.

It was considered that the 200m grid resolution was suitably representative of the terrain surrounding the coal stockyard as all of the main terrain elevations and features were recognised.

With regards to time step, the model was run with a 1-hour time step because all of the available meteorological data, except for the breakwater site, was only available at 1-hour intervals. In addition, given that the effect to be modelled was long term deposition (measured over days or weeks), the selection of a 1-hour resolution rather than a shorter period was considered to be appropriate.

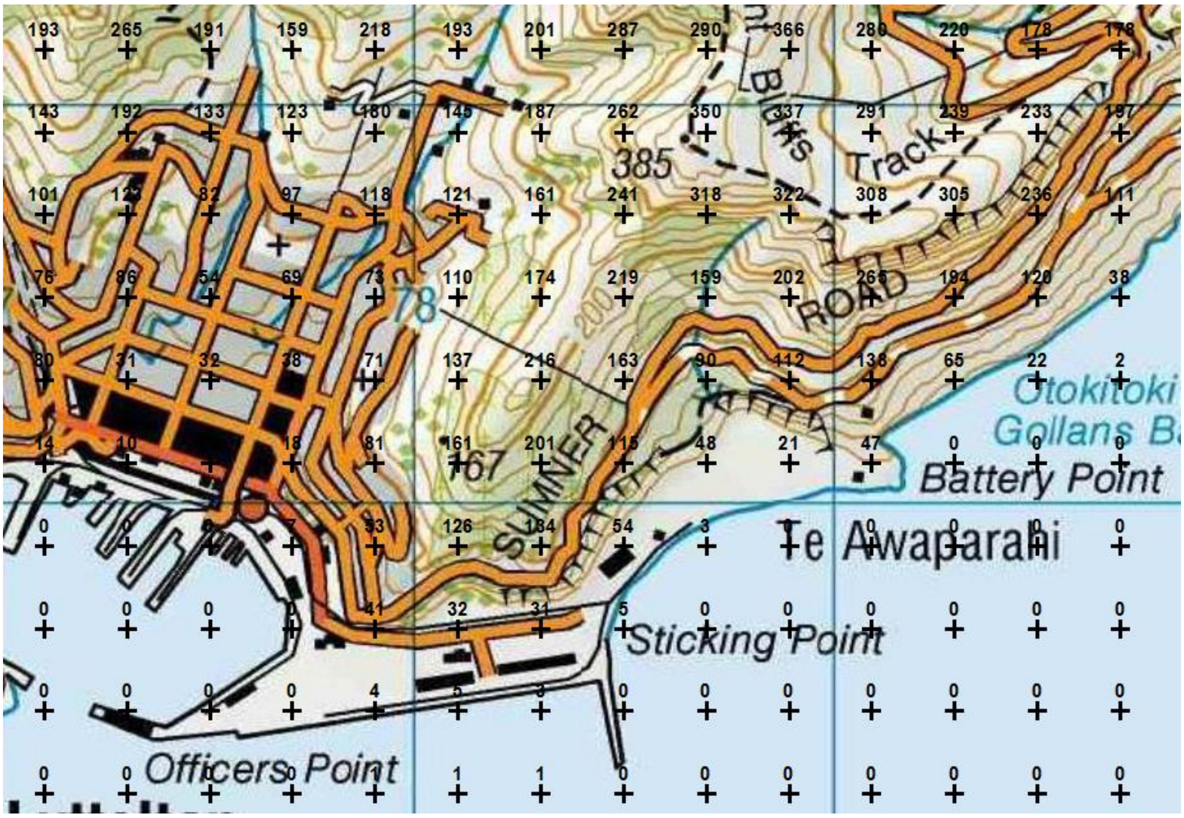


Figure 9: Terrain elevation data used in CALMET, at 200m grid resolution. Map in NZTM projection, from TUMONZ v5.

Question 13

Please provide a modelling assessment that accounts for TSP emission rates from sources that are adjusted for wind velocity. Alternatively, demonstrate that the TSP emission rates used in the modelling are sufficiently conservative and reflective of worst case dust emissions under strong wind conditions.

Response

The modelling assessment provided in the Beca Report already accounts for variable TSP emission rates. The sources that were adjusted for wind velocity are identified in footnote "b" to each of the Tables 7.1 to 7.4 of the Beca Report.

Question 14

It is expected that for any hour, the wind speed will typically be far greater for new areas of stockpile that are built further out onto reclaimed land, consequently affecting TSP emission rates used in the modelling assessment. Therefore, please clarify the physical location on site where wind data was generated for use calculating TSP emission rates.

Response

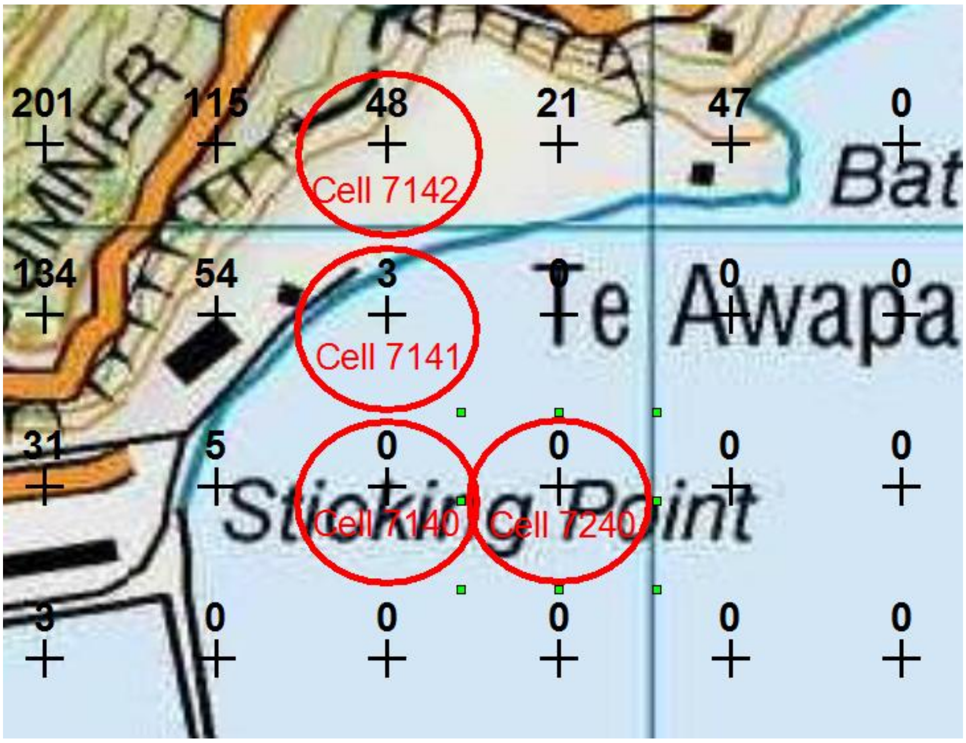


Figure 10: Grid locations (and their associated terrain height values) for wind speed extractions for calculating hourly-varying emission rates.

Wind speeds were compared at four different grid points from the CALMET model, as shown on Figure 10. Windroses extracted from each of these locations are shown in Figure 11. The cumulative frequency of wind speeds for each site are compared in Figure 12.

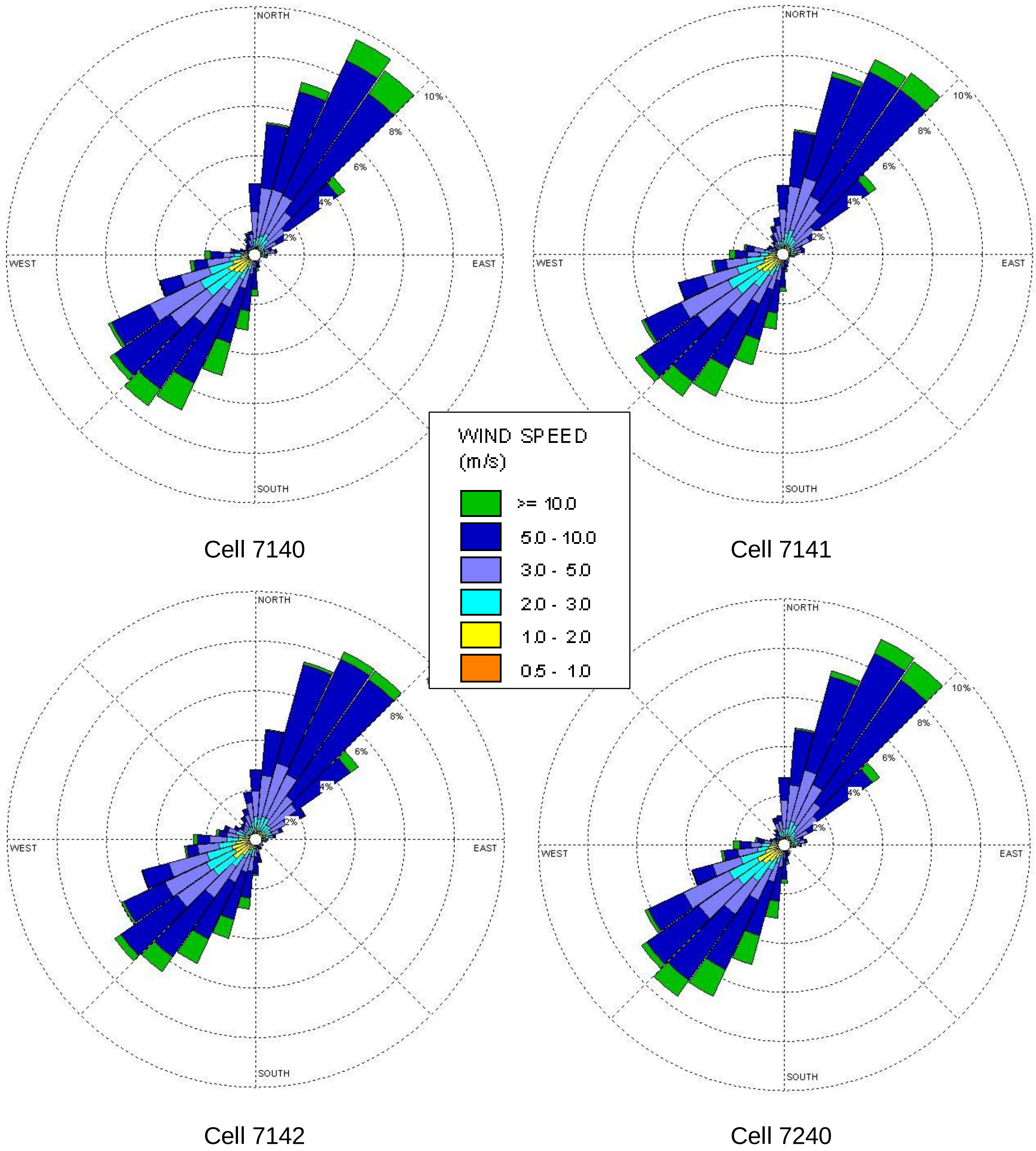


Figure 11: Comparison of windroses for four different CALMET grid cells near the stockyard

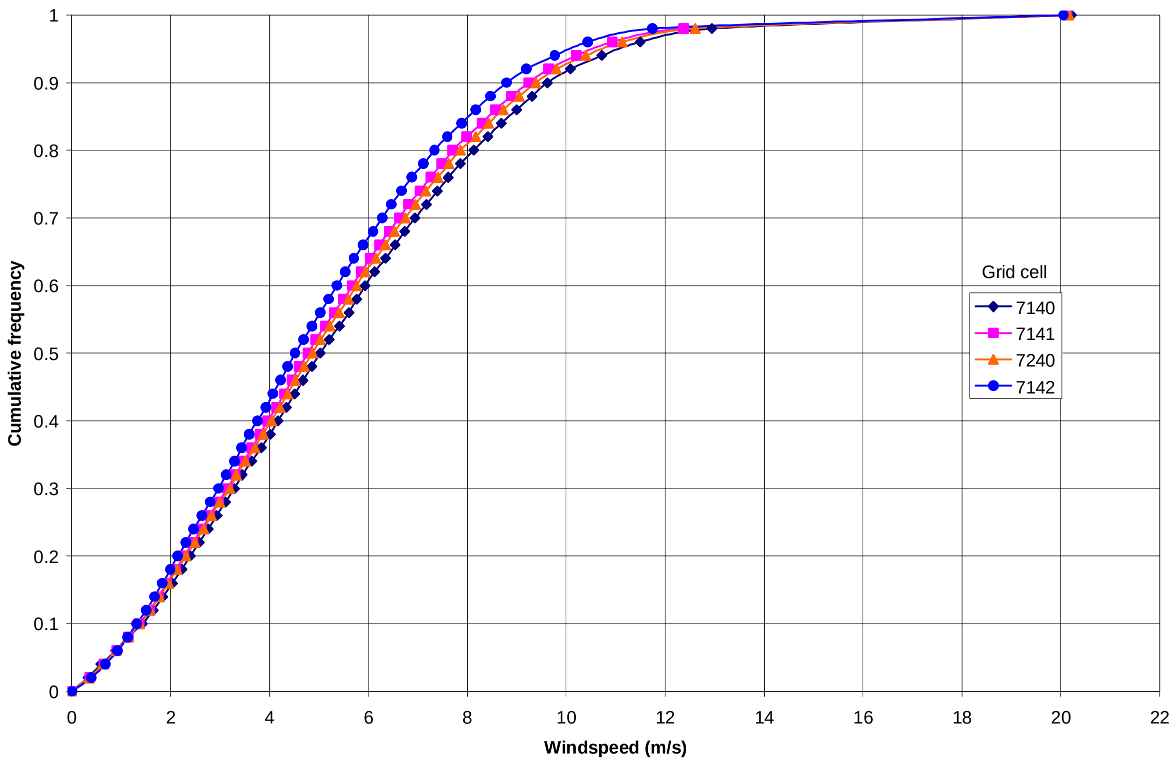


Figure 12: Comparison of wind speed distributions for four different CALMET grid cells near the stockyard

As can be seen from these figures, there is very little difference in the windrose plots and wind speed frequencies at each site, perhaps with the exception of grid cell 7142 which is closest to the hillside (and has a terrain elevation of 48m) and appears to have a slightly lower frequency of high wind speeds compared to the other cells

Because of the small difference in wind speeds for the other sites, and also because the full stockyard area is spread over a wide area, the same wind speeds were used in the emission rates calculation for both the "existing" and "expanded" stockyard layouts. The wind speeds from grid cell 7141 were used and assumed to be representative of the full stockyard area, noting that in each scenario some piles will be actually be more exposed to the wind than others. This is a conservative approach as it does not account for lower emissions from more sheltered parts of the stockyard.

Question 15

Please provide a full copy of CALMET and CALPUFF modelling configuration files that were used to generate the dust deposition and ambient TSP contours as shown in Figures presented in sections 9.6 and 9.7 of Appendix 12 of the application. Please also confirm which Tables of TSP emission summaries in section 7 of the Appendix 12 report the modelling files relate to.

Response

The CALPUFF model configuration files have been supplied separately to this report in electronic format. There are four models – representing the "existing" and "expanded" stockyards both for "average" and "peak" emission rates. These emission rates correspond with Tables 7.5 and 7.6 of the Beca Report. The distribution of these emission rates into sources used in the model is summarised in the tables in Appendix E.

Question 16

Please comment on the reliability of the modelling results for the extended stockpile area, given that they have been shown to underestimate impacts due to present-day operations and that the modelling is subject to the limitations listed after Figure 9.4 of Appendix 12 of the application.

Response

This was explained in section 9.2 of the Beca Report, and is reproduced below:

Dispersion modelling is commonly used in a variety of ways to assist with assessment of environmental effects for air discharges from industrial or trade sites. For the dust emissions from the coal stockyard, it was not possible to use dispersion modelling to present the following approach to assessment: "the discharge was modelled, and concentrations were predicted to be X at the sensitive houses, and the relevant threshold criteria is Y, and because X is less than Y there should be no adverse effect". There are two reasons for this:

- Difficulty estimating the actual magnitude of dust emissions from the site and particle size distributions.
- Anticipated technical difficulties in the model due to the complex terrain close to the site.

In this assessment, dispersion modelling was used to predict the change in observable effects when activities at a site are changed or expanded. The model was used to simulate dispersion from the existing activity, and then the model was rerun with the expanded activity. The results from the two model runs were compared and analysed to determine the relative change in effects likely as a result of implementing the change. It is the relative magnitude of the emissions and the character of each source which is most important for the model inputs.

LPC was aware of these limitations from the outset of the assessment process, and considered not carrying out dispersion modelling in any form. However, the modelling was ultimately carried out for the main objective of giving a comparison on the likely differences between the existing and proposed stockyard operations. It was concluded in the final paragraph of section 9.6.1 of the Beca Report:

Taking the limitations of the model as discussed above into account, the predicted pattern and distribution of deposition is considered to be a reasonable representation of the actual situation. This indicates that the estimated dust emission rates, and the model itself, are appropriate tools for predicting relative comparisons of likely changes in ambient coal dust deposition rates and ambient TSP concentrations as a result of the proposed stockyard extension and upgrade.

5 Emission Evaluations, Mitigation and Other Issues: Response to Questions 17 – 20

Question 17

Please provide information about the particle size distribution of the various coal blends that are typically stored at the site. This is required to establish the actual mass fraction of any particulate that is within the silt size range, particularly particulates within the PM_{10} and $PM_{2.5}$ size range.

Response

A report on coal particle size analysis was provided by Solid Energy for establishing silt content for the emissions calculations in the Beca Report. This is attached in Appendix A. The "silt" size fraction was taken to be that fraction less than 0.063mm (63 microns) in size – 5.6% for the Spring Creek coal sample, and 10.5% for the Stockton coal sample.

In addition, Solid Energy has published information (see www.solidenergy.co.nz) on the specifications of New Zealand coking coals for export. This includes the specification of particle size ranges of a "typical Stockton coking coal", as follows:

Particle Size Range (mm)	%
6.3 – 50	31
3.35 – 6.3	13
2 – 3.35	11
1 - 2	18
Below 1mm	27

No additional information is available about the distribution of particle sizes within the "below 1mm" fraction.

No data are available from any source that delineates airborne particulate concentrations in the $PM_{2.5}$ size range. However data on TSP monitoring was provided in the AEE. These data show that airborne concentrations of particulate at various residential monitoring sites in Lyttelton are well below levels at which adverse health effects could be realistically expected (typically from 10-40 $\mu g/m^3$ as a 24-hour average was measured, this includes non-coal dust and all particulate size ranges not just PM_{10} or $PM_{2.5}$).

Only a small proportion of the measured TSP concentrations will be coal particles in the PM_{10} range and a smaller proportion may be in the $PM_{2.5}$ range. In addition, it is considered that the potential for $PM_{2.5}$ formation at the stockyard is very small, because these tiny particles are usually formed as a byproduct of combustion rather than as a result of abrasion during bulk materials handling.

Question 18

For the individual dust sources modelled in Appendix 1 of Appendix 12 of the application please provide details of the proposed mitigation measures to minimise dust associated with each source.

Response

Detailed design of proposed mitigation measures has not yet been carried out. The conceptual mitigation measures are described in the Appendix 1 of the Beca Report. The mitigation design approach is described in Section 10 of the Beca Report.

Question 19

Please provide information about the source of the water that is to be used for dust suppression, and a comment on the availability and amount of water required to adequately suppress coal dust discharges.

Response

LPC advises that the new treatment plant, which is currently being constructed, has been designed to allow recirculation of water for dust suppression whenever climatic conditions allow. However, the majority of the water for dust suppression purposes will come from the municipal supply and on site storage of sufficient capacity will be constructed to minimise the risk of supply restrictions or outages restricting application rates to less than optimal. LPC is currently undertaking studies to determine the amount of on site storage that will be required and the outcomes of this work can be provided if required.

Question 20

Appendix 12 of the application contains an appendix on emission calculations (Appendix 1), which provides details of the emission rates that were used for the dispersion modelling assessment. A number of the emission rate calculations and/or assumptions for various sources could not be resolved when reviewed. Therefore, please provide the following:

a. *Please provide the calculations used to derive the emission rates for train unloading as given in Table 3.1, as the emission rates given do not appear to match the rates expected given the equation and assumptions provided.*

b. *Please provide the calculations used to derive emission rates for the conveyors and transfer points. It is considered that there is insufficient information contained in Section 4.1 of Appendix 1 of Appendix 12 of the application to resolve the emission rates provided.*

c. *Section 5.4.2 of Appendix 1 of Appendix 12 of the application contains an equation for calculating emissions for front end loaders and references an NPI manual for mining. However, this equation does not appear to be contained within the NPI manual for mining. Accordingly, please clarify the source of the equation used.*

d. *A number of dust mitigation measures described in the Appendix 1 of Appendix 12 of the application refer to the use of chemical additives to be added to water used for dust suppression, which is intended to improve the degree of surface crusting. Please provide further information about the chemical additive that is proposed, including information regarding its composition and its ability to improve crusting of surfaces.*

e. *Please confirm the number of bulldozers and/or loaders that are proposed to be operated for the extended coal stock yard.*

f. *Please provide the calculations used to derive emission rates for the bulldozers and front end loaders associated with the stacking and reclaiming operations. It is considered that there is insufficient information contained in Section 5.4 of Appendix 1 of Appendix 12 of the application to resolve the emission rates provided.*

g. *Emission calculations for wind erosion of the stock piles and yards indicate that sweeping will be used as a mitigation measure (estimated at 60% control). Sweeping can be useful where the underlying surface is sealed and in good condition, such as concrete. However, it can exacerbate emissions where this is not the case. Therefore, please clarify whether the areas where sweeping is proposed will be sealed.*

Response

(a) The equation presented in the Appendix 1 contains a typographical error – the coefficient in the question should be 0.0016 rather than 0.00016. The correct coefficient was used in the emission calculations.

To illustrate the emission calculation, using "Existing Average Emissions" case:

- The emission rate of 0.020 g/s is derived directly from transfer point equation with average wind speed of 5.19 m/s, with 30% control, annual averaged throughput.
- Emission calculation = $[0.74\times0.0016\times(5.19/2.2)^{1.3}\times(10.4/2)^{-1.4}] \times [2{,}500{,}000{,}000/31{,}536{,}000] \times 0.7/1000$

  Transfer point equation *kg/yr* *seconds/yr* *uncontrolled factor*

Similar calculations were used for the other emission scenarios.

(b)

The calculations for transfer point and ship loading emissions are shown in Appendix B. The calculations for conveyors are shown in Appendix C. The estimated control factors and utilisation factors were previously supplied in Sections 4.1 and 4.2 of Appendix 1 to the Beca Report.

(c)

The correct reference is quoted, however the power coefficient applied to variable “M” in the equation has been incorrectly detailed in Section 5.4.2 of Appendix 1 of the Beca Report and should be (-0.9) rather than (0.3). The correct equation, as per Table 1 (page 11) of the NPI reference, should be:

$$E = k \times 0.0596/M^{-0.9}\ kg/t$$

where K = 1.56

M = moisture content in % (10.5% assumed)

(d)

There are various commercial dust suppression materials which can be applied to potentially dusty substrates to bind the surface particles and thus prevent wind entrainment of dust. The use of these materials is considered as an option for LPC that could be used if and when necessary over and above the optimised surface watering system. Costs are a consideration in the selection of these materials as dust suppression agents but their effectiveness is well proven.

The choice of the most suitable dust suppressant additive in the case of coal dust release mitigation includes consideration of leaching implications, possible effects on coal combustion and marketability of the treated coal. Chemical options include:

- Salts and brines based on calcium or magnesium chloride which are a variation on conventional water spray systems. They improve dust control effectiveness but introduce significant equipment corrosion issues and may have contamination implications on the stockpiled material.
- Organic non-petroleum additives which include lignosulphonates (by-products of paper manufacture) and other vegetable derivatives. These types of suppressants have limited physical durability and the extent to which such additives might affect the quality of the export coal is unknown. Their commercial availability is also unclear.
- Synthetic polymeric products such as PVA-based acrylic polymers, which are completely water-soluble and which dry to form a physically resistant “skin” on the surface to which they are applied, are widely used in dust suppression. Once dried, the PVA skin is insoluble and “sheds” water.
- Natural organic non-synthetic gum which contains no PVA-based acrylic polymers which dry to form a physically resistant “skin” on the surface to which they are applied, are also widely used in dust suppression. The surface skin has been shown to last for at least three months. The product is naturally bio-degradable and has no detrimental effects on coal properties.

Organic petroleum products such as oils and solvents have been used as roading dust suppressants but would be completely unsuitable for dust control on stockpiled export coal. They would also introduce problems associated with petroleum contamination of stormwater run-off from a stockpile.

Based on the above discussion, the most likely dust suppressant chemical that would be used is a PVA polymeric resin base or a natural organic non-synthetic gum. This will, however, need to be confirmed at a later stage in the design process.

(e)

The assumed operation of bulldozers and front end loaders (FELs) was provided by LPC and Solid Energy. The assumptions were as follows:

- There is one bulldozer on site which operates for approximately 50% of the time at present but is expected to work approximately 85% of the time when the stockyard extension is complete.
- Up to 3 FELs are used at a time in the existing situation - likely to be same in the future but this isn't relevant to emissions as the emission factor for FELs is based on tonnes moved

(f)

The calculations for FEL and bulldozer emissions are shown in Appendix D.

(g)

LPC has confirmed that it is intended that areas to be swept will be sealed.

Appendix A

Coal particulate analyses

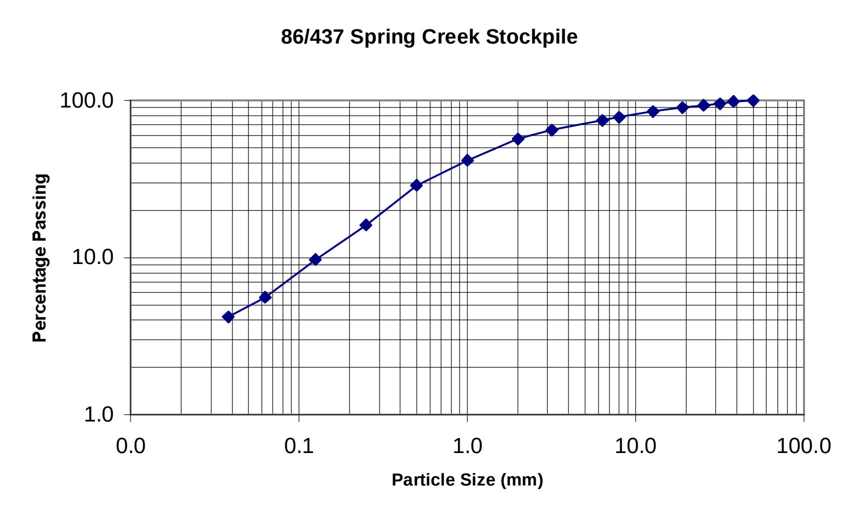
CRL Energy Ltd

Client: Solid Energy New Zealand Ltd

Sample received: 20/01/09

Sample Description: A 15kg sample of coal taken from the Lyttelton "Spring Creek" stockpile on 16/01/09 by N Newman of CRL Energy Ltd

The total moisture of the sample was determined to be **11.4%**



SIZE FRACTION,mm		Fract. % Retained	Cum. % Retained	Cum. % Passing
Upper	Lower	on Lower	on Lower	Upper
50.0	38.1	1.3	1.3	100.0
38.1	31.8	3.1	4.4	98.7
31.8	25.4	2.3	6.7	95.6
25.4	19.0	3.3	10.0	93.3
19.0	12.7	4.7	14.7	90.0
12.7	8.0	6.8	21.5	85.3
8.0	6.35	3.8	25.3	78.5
6.35	3.18	9.6	34.9	74.7
3.18	2.00	8.2	43.1	65.1
2.00	1.00	15.3	58.4	56.9
1.00	0.500	12.8	71.2	41.6
0.500	0.250	12.7	83.9	28.8
0.250	0.125	6.4	90.3	16.1
0.125	0.063	4.1	94.4	9.7
0.063	0.038	1.4	95.8	5.6
0.038	0.000	4.2	100.0	4.2

Note: size analysis from 2mm - 0.038 mm was determined by wet screening

Date of Issue: 1-Dec-08

Methods
Total Moisture: ISO 5068-1
Size: ISO 1953

Signature:
Grant Murray
Laboratory Supervisor

THIS REPORT MUST NOT BE QUOTED EXCEPT IN FULL

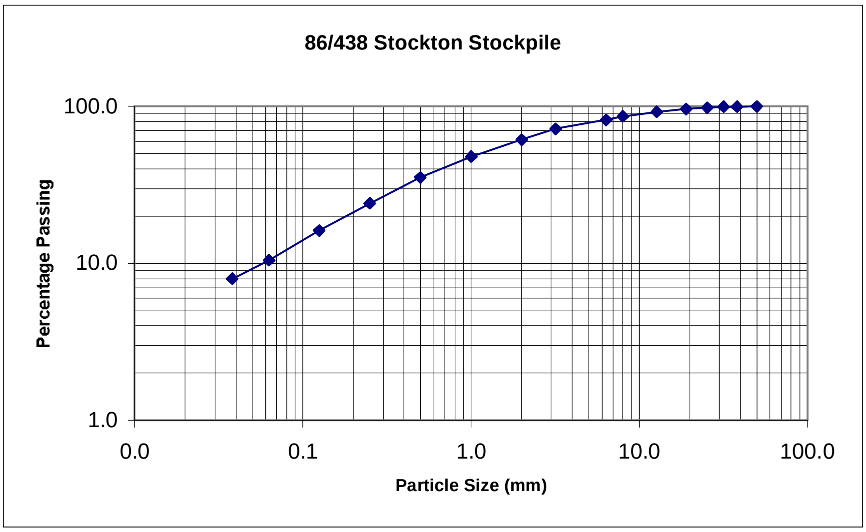
Distribution:
Solid Energy New Zealand Ltd, PO Box 1303, Christchurch.
CRL Energy Ltd, Laboratory

CRL Energy Ltd

Client: Solid Energy New Zealand Ltd Sample received: 20/01/09

Sample Description: A 15kg sample of coal taken from the "Stockton" stockpile at Lyttelton on 16/01/09 by N Newman of CRL Energy Ltd

The total moisture of the sample was determined to be **7.3%**



SIZE FRACTION,mm		Fract. % Retained on Lower	Cum. % Retained on Lower	Cum. % Passing Upper
Upper	Lower			
50.0	38.1	0.4	1.3	100.0
38.1	31.8	0.2	4.4	99.6
31.8	25.4	1.2	6.7	99.4
25.4	19.0	2.1	10.0	98.2
19.0	12.7	3.6	14.7	96.1
12.7	8.0	6.2	21.5	92.5
8.0	6.35	4.1	25.3	86.3
6.35	3.18	10.2	34.9	82.2
3.18	2.00	10.7	43.1	72.0
2.00	1.00	13.5	58.4	61.3
1.00	0.500	12.5	71.2	47.8
0.500	0.250	11.1	83.9	35.3
0.250	0.125	8.0	90.3	24.2
0.125	0.063	5.7	94.4	16.2
0.063	0.038	2.5	95.8	10.5
0.038	0.000	8.0	100.0	8.0

Note: size analysis from 2mm - 0.038 mm was determined by wet screening

Date of Issue: 1-Dec-08

Methods
Total Moisture: ISO 5068-1
Size: ISO 1953

Signature:
Grant Murray
Laboratory Supervisor

THIS REPORT MUST NOT BE QUOTED EXCEPT IN FULL

Distribution:
Solid Energy New Zealand Ltd, PO Box 1303, Christchurch.
CRL Energy Ltd, Laboratory

Appendix B

Transfer points and shiploading emission calculations

TRANSFER POINT EMISSIONS - ASSUMPTIONS

Transfer points equation			
From Katestone Environmental Report on Wiggins Island Coal Terminal			
Barney point			
M	10.4	%	
k	0.74		
Throughput	2000	tph	
u	E kg/t		
3	0.00017622		
6	0.000433905		
10	0.000842942		
15	0.00142796		
5.19	0.000359348		
LPC Data			
mean wind speed at stockpile (from Calmet Layer 1)		5.19	m/s
		Based on 365 days per year	
existing throughput	annual avg per hour	285	tph
stage 2 throughput		571	tph

A4. Transfer points

Transfer points are locations within the coal loading system where coal is transferred from one conveyor to another or from a conveyor to a hopper. The emission rates for any transfer points were calculated using the following equation (NPI 2001):

$$E = k0.0016\left(\frac{U}{2.2}\right)^{1.3}\left(\frac{M}{2}\right)^{-1.4} kg/t$$

k = 0.74 for particles less than 30 µm
k = 0.35 for particles less than 10 µm
U = mean wind speed in m/s
M = material moisture content %.

Tracy Freeman:
Assumed higher wind speed for "slinging" action

SHIP LOADING - JET SLINGER

Ship loading - Jetslinger

	kg/t at 15m/s	kg/hr avg over year	g/s	control factor	utilisation factor	emission (g/s)
Jetslinger - existing	0.00142796	0.407522954	0.113200821	0.5	1	0.05660041
Future throughput	0.00142796	0.815045908	0.226401641	0.5	1	0.113200821

Ship loading - Jetslinger

	kg/t at 15m/s	kg/hr at 2000 tph	g/s	control factor	utilisation factor	emission (g/s)
Jetslinger - existing	0.00142796	2.85592086	0.79331135	0.5	1	0.396655675
Future throughput	0.00142796	2.85592086	0.79331135	0.5	1	0.396655675

AVERAGE EMISSIONS OVER YEAR

Existing transfer points

	kg/t at 5.19m/s	kg/hr	g/s	control factor	utilisation factor	emission (g/s)		emission g/s
Rail unloader to CV22	0.000359348	0.102553622	0.028487117	0.95	1	0.001424356		
CV22 to cv 23	0.000359348	0.102553622	0.028487117	0.95	1	0.001424356		
CV 23 to CV24	0.000359348	0.102553622	0.028487117	0	1	0.028487117		
CV 24 to stacker	0.000359348	0.102553622	0.028487117	0.3	1	0.019940982		
reclaimer to CV13	0.000359348	0.102553622	0.028487117	0.3	0.25	0.004985246		
CV13 to CV12	0.000359348	0.102553622	0.028487117	0.95	0.25	0.000356089		
CV12 to CV8	0.000359348	0.102553622	0.028487117	0.95	0.25	0.000356089	Miscell transfer sources	0.091159
CV9a to CV8	0.000359348	0.102553622	0.028487117	0.7	0.75	0.006409601		
CV9b to CV10	0.000359348	0.102553622	0.028487117	0.7	0.75	0.006409601		
CV9c to CV10	0.000359348	0.102553622	0.028487117	0.7	0.75	0.006409601		
CV10 to CV8	0.000359348	0.102553622	0.028487117	0.7	0.75	0.006409601		
CV8 to CV2	0.000359348	0.102553622	0.028487117	0.7	1	0.008546135		
CV2 to CV1	0.000359348	0.102553622	0.028487117	0.7	1	0.008546135	Incl. with shiploader volume source	0.017092
CV1 to spur	0.000359348	0.102553622	0.028487117	0.7	1	0.008546135		
Spur to shiploader	0.000359348	0.102553622	0.028487117	0.7	1	0.008546135	incl. with jetslinger volume source	0.037033
shiploader to jetslinger	0.000359348	0.102553622	0.028487117	0	1	0.028487117		
			total			**0.145284298**		

New Transfer points

	kg/t	kg/hr	g/s	control factor	untilisation factor	emission (g/s)		
Rail unloader to CV22	0.000433905	0.24766239	0.068795108	0.95	1	0.003439755		
CV22 to cv 23	0.000433905	0.24766239	0.068795108	0.95	1	0.003439755		
CV 23 to CV24	0.000433905	0.24766239	0.068795108	0.7	1	0.020638533		
CV 24 to stacker	0.000433905	0.24766239	0.068795108	0.9	1	0.006879511		
reclaimer to CV13	0.000433905	0.24766239	0.068795108	0.7	0.25	0.005159633		
CV13 to CV12	0.000433905	0.24766239	0.068795108	0.95	0.125	0.000429969		
CV12 to CV8	0.000433905	0.24766239	0.068795108	0.95	0.125	0.000429969		
new CV9a to new inland export conveyor	0.000433905	0.24766239	0.068795108	0.9	0.375	0.002579817		
new feeder to new inland conveyor	0.000433905	0.24766239	0.068795108	0.9	0.375	0.002579817	Miscell transfer sources	0.073095
new CV9b to new inland export conveyor	0.000433905	0.24766239	0.068795108	0.9	0.375	0.002579817		
new CV9c to new inland export conveyor	0.000433905	0.24766239	0.068795108	0.9	0.375	0.002579817		
new CV10 to CV8 equiv	0.000433905	0.24766239	0.068795108	0.9	0.375	0.002579817		
new inland export conveyor to CV2	0.000433905	0.24766239	0.068795108	0.9	0.5	0.003439755		
CV13 to seaward CV12	0.000433905	0.24766239	0.068795108	0.95	0.125	0.000429969		
seaward CV12 to new export conveyor	0.000433905	0.24766239	0.068795108	0.95	0.125	0.000429969		
CV2 to CV1	0.000433905	0.24766239	0.068795108	0.9	1	0.006879511	Incl. with shiploader volume source	0.013759
CV1 to spur	0.000433905	0.24766239	0.068795108	0.9	1	0.006879511		
Spur to shiploader	0.000433905	0.24766239	0.068795108	0.9	1	0.006879511	incl. with jetslinger volume source	0.027518
shiploader to jetslinger	0.000433905	0.24766239	0.068795108	0.7	1	0.020638533		
4 new feeder conveyors to new seaward export conveyor	0.000433905	0.24766239	0.068795108	0.9	1.5	0.010319266		
2 transfer points on new seaward export conveyor	0.000433905	0.24766239	0.068795108	0.9	0.75	0.005159633		
			total			**0.114371868**		

Prue Harwood:
4 x 0.375

Prue Harwood:
2 x 0.375

PEAK EMISSIONS

Existing transfer points

	kg/t at 5.19m/s	kg/hr	g/s	control factor	utilisation factor	emission (g/s)		
Rail unloader to CV22	0.000359348	0.718695784	0.199637718	0.95	1	0.009981886		
CV22 to cv 23	0.000359348	0.718695784	0.199637718	0.95	1	0.009981886		
CV 23 to CV24	0.000359348	0.718695784	0.199637718	0	1	0.199637718		
CV 24 to stacker	0.000359348	0.718695784	0.199637718	0.3	1	0.139746402		
reclaimer to CV13	0.000359348	0.718695784	0.199637718	0.3	0.25	0.034936601		
CV13 to CV12	0.000359348	0.718695784	0.199637718	0.95	0.25	0.002495471		
CV12 to CV8	0.000359348	0.718695784	0.199637718	0.95	0.25	0.002495471	Miscell transfer sources	0.638841
CV9a to CV8	0.000359348	0.718695784	0.199637718	0.7	0.75	0.044918486		
CV9b to CV10	0.000359348	0.718695784	0.199637718	0.7	0.75	0.044918486		
CV9c to CV10	0.000359348	0.718695784	0.199637718	0.7	0.75	0.044918486		
CV10 to CV8	0.000359348	0.718695784	0.199637718	0.7	0.75	0.044918486		
CV8 to CV2	0.000359348	0.718695784	0.199637718	0.7	1	0.059891315		
CV2 to CV1	0.000359348	0.718695784	0.199637718	0.7	1	0.059891315	Incl. with shiploader volume source	0.119783
CV1 to spur	0.000359348	0.718695784	0.199637718	0.7	1	0.059891315		
Spur to shiploader	0.000359348	0.718695784	0.199637718	0.7	1	0.059891315	incl. with jetslinger volume source	0.259529
shiploader to jetslinger	0.000359348	0.718695784	0.199637718	0	1	0.199637718		
			total			**1.01815236**		

New Transfer points

	kg/t	kg/hr	g/s	control factor	untilisation factor	emission (g/s)		
Rail unloader to CV22	0.000433905	0.867809015	0.24105806	0.95	1	0.012052903		
CV22 to cv 23	0.000433905	0.867809015	0.24105806	0.95	1	0.012052903		
CV 23 to CV24	0.000433905	0.867809015	0.24105806	0.7	1	0.072317418		
CV 24 to stacker	0.000433905	0.867809015	0.24105806	0.9	1	0.024105806		
reclaimer to CV13	0.000433905	0.867809015	0.24105806	0.7	0.25	0.018079354		
CV13 to CV12	0.000433905	0.867809015	0.24105806	0.95	0.125	0.001506613		
CV12 to CV8	0.000433905	0.867809015	0.24105806	0.95	0.125	0.001506613		
new CV9a to new inland export conveyor	0.000433905	0.867809015	0.24105806	0.9	0.375	0.009039677		
new feeder to new inland conveyor	0.000433905	0.867809015	0.24105806	0.9	0.375	0.009039677	Miscell transfer sources	0.256124
new CV9b to new inland export conveyor	0.000433905	0.867809015	0.24105806	0.9	0.375	0.009039677		
new CV9c to new inland export conveyor	0.000433905	0.867809015	0.24105806	0.9	0.375	0.009039677		
new CV10 to CV8 equiv	0.000433905	0.867809015	0.24105806	0.9	0.375	0.009039677		
new inland export conveyor to CV2	0.000433905	0.867809015	0.24105806	0.9	0.5	0.012052903		
CV13 to seaward CV12	0.000433905	0.867809015	0.24105806	0.95	0.125	0.001506613		
seaward CV12 to new export conveyor	0.000433905	0.867809015	0.24105806	0.95	0.125	0.001506613		
CV2 to CV1	0.000433905	0.867809015	0.24105806	0.9	1	0.024105806	Incl. with shiploader volume source	0.048212
CV1 to spur	0.000433905	0.867809015	0.24105806	0.9	1	0.024105806		
Spur to shiploader	0.000433905	0.867809015	0.24105806	0.9	1	0.024105806	incl. with jetslinger volume source	0.096423
shiploader to jetslinger	0.000433905	0.867809015	0.24105806	0.7	1	0.072317418		
4 new feeder conveyors to new seaward export conveyor	0.000433905	0.867809015	0.24105806	0.9	1.5	0.036158709		
2 transfer points on new seaward export conveyor	0.000433905	0.867809015	0.24105806	0.9	0.75	0.018079354		
			total			**0.400759024**		

Prue Harwood:
4 x 0.375

Prue Harwood:
2 x 0.375

Appendix C

Conveyor emission calculations

Conveyor Emissions

Equation to calculate emissions sourced from Katestone Environmental Proposed Wiggins Island Coal Terminal July 2007

$F = c(u_* - u_{*t})$ (g/m/s)

where F is the emission factor (g/metre of conveyor length/s)

c = 0.0082 (g/m2/s2) (from Katestone for conveyors)

u_* is the friction velocity and is equal to the wind speed at 10 m high x 0.11 (from Katestone)

u_{*t} is the threshold wind speed and is typically = 0.34 m/s (from Katestone)

Emissions from conveyor E = F x length of conveyor x dust control efficiency x utilisation rate (g/s)

Info from LPC

length of conveyor is half the total length of the belt

Utilisation (%) = tonnage transported/capacity of the equipment x 100

For example, a conveyor may have a capacity of 8000 tonnes per hour and in 24 hours its job is to transport 57600 tonnes.

The utilisation is therefore: 57600/(8000x24) = 0.3

control factors (from Katestone)

roof and 2 sides	70%	
roof and 1 side	65%	
roof	40	
2 sides	30	assumed
enclosure wth belt washers	90	assumed based (conservative, co

Existing Layout Average Utilisation

Conveyor	total length m	Effective length (half total)	Control type	control efficiency	utilisation factor	Multiplier					
						(length of conveyor x dust control efficiency x utilisation rate)					
C1	468	234	semi enclosed	0.7	1	70.2					
C2	368	184	80% covered	0.7	1	55.2					
C8	822	411	sides and roof	0.5	1	205.5			Hours per year	1250	
C9a	19	9.5	underground	0.95	0.75	0.4			Avg conveyr em (summer only)		
C9b	33	16.5	underground	0.95	0.75	0.6		All conveyors	0.344	g/s	
C9c	33	16.5	underground	0.95	0.75	0.6		Shiploader	0.035		
C10	318	159	sides and roof	0.5	0.75	59.6		Non-shiploader	0.309		
C12	152	76	underground?	0.95	0.25	1.0					
C13	742	371	sides	0.3	0.25	64.9					
C22	14	7	underground	0.95	1	0.4					
C23	220	110	uncovered	0	1	110.0					
C24	776	388	sides	0.3	1	271.6					
shiploader	92	46	sides and roof	0.7	1	13.8					
spur conveyor	46	23	sides and roof	0.7	1	6.9					
stacker	68	34	sides	0	1	34.0					
reclaimer	68	34	sides	0	0.25	8.5					
Total length		2119.5									
Total length - shiploader		2050.5									
			Mean wind speed	5.134538313							

Time						**Average g/s summer**	**0.189**	**0.149**	**0.554**	**0.001**	**0.002**
YEAR	MONTH	DA	Y HOUR	WS		**Average g/s all**	**0.154**	**0.121**	**0.452**	**0.001**	**0.001**
				(m/s)	Negs corr to zero		C1	C2	C8	C9a	C9b
				Layer 1	u*-ut*	F=c(u*-u*t)	E=F*M				
2006	2	11	0	6.5	0.375	0.003	0.216	0.170	0.632	0.001	0.002
2006	2	11	1	4.79	0.1869	0.002	0.108	0.085	0.315	0.001	0.001
2006	2	11	2	4.9	0.199	0.002	0.115	0.090	0.335	0.001	0.001

Calculations continue for multiple rows and cells for all conveyors and all hours

	Stage 2 Layout Average Utilisation										
Conveyor	total length m	Effective length (half total)	Control type	control efficiency	utilisation factor	multiplier					
						(length of conveyor x dust control efficiency x utilisation rate)					
C1	468	234		0.9	1	23.4					
c2	368	184		0.9	1	18.4			Hours per year	**2500**	
c12	152	76		0.95	0.12	0.456			Avg conveyr em (summer only)		
c13	742	371		0.5	0.25	46.375		All conveyors	0.310	g/s	
c22 (relocated)	14	7		0.95	1	0.35		Shiploader	0.023		
C23	220	110		0.9	1	11		Non-shiploader	0.287		
C23a (new train unloader extension)		120		0.9	1	12					
c24	776	388		0.5	1	194					
shiploader	92	46		0.9	1	4.6					
spur conveyor	46	23		0.9	1	2.3					
stacker	68	34		0.5	1	17					
reclaimer	68	34		0.5	0.25	4.25					
new seaward export conveyor (C31)		566		0.9	0.5	28.3					
new inland export conveyor (C32)		442		0.9	0.5	22.1					
new stacker extension (C33)		50		0.9	0.2	1					
new reclaimer extension (C34)		50		0.9	0.2	1					
new import conveyor (C35)		180		0.9	0.2	3.6					
new feeder conveyors (C36)		132		0.95	0.3	1.98					
new C12 equivalent on seaward side (C37)		76		0.95	0.12	0.456					
A	at	gridp			**Average g/s summer**	**0.063**	**0.050**	**0.029**	**0.125**	**0.001**	**0.030**
MONTH	DA	Y HOUR	WS		**Average g/s all**	**0.051**	**0.040**	**0.023**	**0.102**	**0.001**	**0.024**
			(m/s)	Negs corr to zero		C1	C2	C12	C13	C22	C23
			Layer 1	u*-ut*	F=c(u*-u*t)	E = F*M					
2	11	0	6.5	0.375	0.003075	0.071955	0.05658	0.032811	0.142603125	0.001076	0.033825
2	11	1	4.79	0.1869	0.00153258	0.035862	0.028199	0.016353	0.071073398	0.000536	0.016858
2	11	2	4.9	0.199	0.0016318	0.038184	0.030025	0.017412	0.075674725	0.000571	0.01795
2	11	3	6.38	0.3618	0.00296676	0.069422	0.054588	0.031657	0.137583495	0.001038	0.032634
2	11	4	5.43	0.2573	0.00210986	0.049371	0.038821	0.022513	0.097844758	0.000738	0.023208
2	11	5	6.38	0.3618	0.00296676	0.069422	0.054588	0.031657	0.137583495	0.001038	0.032634
2	11	6	7.7	0.507	0.0041574	0.097283	0.076496	0.044361	0.192799425	0.001455	0.045731
2	11	7	5.43	0.2573	0.00210986	0.049371	0.038821	0.022513	0.097844758	0.000738	0.023208

Tracy Freeman:
Adjust this number for annual throughput

Prue Harwood:
8 x 16.5
4 on each side

Calculations continue for multiple rows and columns for all conveyors and all hours

	Existing Layout, All in Use									
Conveyor	total length m	Effective length (half total)	Control type	control efficiency	utilisation factor	Multiplier				
						(length of conveyor x dust control efficiency x utilisation rate)				
C1	468	234	semi enclosed	0.7	1	70.2				
C2	368	184	80% covered	0.7	1	55.2				
C8	822	411	sides and roof	0.5	1	205.5			Avg conveyr em	
C9a	19	9.5	underground	0.95	1	0.5		All conveyors	3.067	g/s
C9b	33	16.5	underground	0.95	1	0.8		Shiploader	0.245	
C9c	33	16.5	underground	0.95	1	0.8		Non-shiploader	2.822	
C10	318	159	sides and roof	0.5	1	79.5				
C12	152	76	underground?	0.95	1	3.8				
C13	742	371	sides	0.3	1	259.7				
C22	14	7	underground	0.95	1	0.4				
C23	220	110	uncovered	0	1	110.0				
C24	776	388	sides	0.3	1	271.6				
shiploader	92	46	sides and roof	0.7	1	13.8				
spur conveyor	46	23	sides and roof	0.7	1	6.9				
stacker	68	34	sides	0	1	34.0				
reclaimer	68	34	sides	0	1	34.0				
Total length		2119.5								
Total length - shiploader		2050.5								
			Mean wind speed	5.134538313						
Time						**Average g/s sun**	**0.189**	**0.149**	**0.554**	**0.001**
YEAR	MONTH	DA	Y HOUR	WS		**Average g/s all**	**0.154**	**0.121**	**0.452**	**0.001**
				(m/s)	Negs corr to zero		C1	C2	C8	C9a
				Layer 1	u*-ut*	F=c(u*-u*t)	E=F*M			
2006	2	11	0	6.5	0.375	0.003	0.216	0.170	0.632	0.001
2006	2	11	1	4.79	0.1869	0.002	0.108	0.085	0.315	0.001
2006	2	11	2	4.9	0.199	0.002	0.115	0.090	0.335	0.001
2006	2	11	3	6.38	0.3618	0.003	0.208	0.164	0.610	0.001
2006	2	11	4	5.43	0.2573	0.002	0.148	0.116	0.434	0.001
2006	2	11	5	6.38	0.3618	0.003	0.208	0.164	0.610	0.001

Prue Harwood:
50 assumed as parts of conveyor have covers off

Prue Harwood:
50% assumed as parts of conveyor have covers off

Calculations continue for multiple rows and columns for all conveyors and all hours

	Stage 2 Layout, all in use										
Conveyor	total length m	Effective length (half total)	Control type	control efficiency	utilisation factor	multiplier					
						(length of conveyor x dust control efficiency x utilisation rate)					
C1	468	234		0.9	1	23.4			Avg conveyr em		
c2	368	184		0.9	1	18.4		All conveyo	0.978	g/s	
c12	152	76		0.95	0	0		Shiploader	0.082		
c13	742	371		0.5	0.25	46.375		Non-shiploa	0.896		
c22 (relocated)	14	7		0.95	1	0.35					
C23	220	110		0.9	1	11					
C23a (new train unloader extension)		120		0.9	1	12					
c24	776	388		0.5	1	194					
shiploader	92	46		0.9	1	4.6					
spur conveyor	46	23		0.9	1	2.3					
stacker	68	34		0.5	1	17					
reclaimer	68	34		0.5	0.25	4.25					
new seaward export conveyor (C31)		566		0.9	0.25	14.15					
new inland export conveyor (C32)		442		0.9	0.25	11.05					
new stacker extension (C33)		50		0.9	0.2	1					
new reclaimer extension (C34)		50		0.9	0.2	1					
new import conveyor (C35)		180		0.9	0	0					
new feeder conveyors (C36)		132		0.95	0.3	1.98					
new C12 equivalent on seaward side (C37)		76		0.95	0	0					
A	at	gridp			**Average g/s sum**	**0.063**	**0.050**	**0.000**	**0.125**	**0.001**	**0.030**
MONTH	DA	Y HOUR	WS		**Average g/s all**	**0.051**	**0.040**	**0.000**	**0.102**	**0.001**	**0.024**
			(m/s)	Negs corr to zero		C1	C2	C12	C13	C22	C23
			Layer 1	u*-ut*	F=c(u*-u*t)	E = F*M					
2	11	0	6.5	0.375	0.003075	0.071955	0.05658	0	0.142603	0.001076	0.033825
2	11	1	4.79	0.1869	0.00153258	0.035862	0.028199	0	0.071073	0.000536	0.016858
2	11	2	4.9	0.199	0.0016318	0.038184	0.030025	0	0.075675	0.000571	0.01795

Tracy Freeman:
Bypass conveyor, worst case is to assume not operating; ditto C37

Tracy Freeman:
50% utilisation factor x 50% of coal to each export conveyor.

Tracy Freeman:
50% utilisation factor x 50% of coal to each export conveyor.

Tracy Freeman:
worst case is to assume not operating

Prue Harwood:
8 x 16.5
4 on each side

Tracy Freeman:
Bypass conveyor, worst case is to assume not operating

Calculations continue for multiple rows and columns for all conveyors and all hours

Appendix D

Vehicle emission calculations

		Throughput	2008	2500000	tonnes/yr
AVERAGE EMISSION RATES			Expanded	5000000	tonnes/yr
Dozer and FELs operate up to 24 hours per day (based on Jan/Feb 09 operations spreadsheet and confirmed by LPC 10/3/09).					
Existing AND Expanded - FEL and Dozer use	*As described to TJF by LPC and SolidE on 10/3/09*				
Stacking	*Percentages modified by SolidE on 8/4/09*				
25% is stacked directly into position by the bucket wheel		**Existing emissions**			
- stacker touches all 100% of coal as it makes stockpiles for the FELs to take from		**Dozer**			
75% is touched by FEL and bulldozer		s - Stockton	10.4		
- FELs touch all 75%		s - Spring Creek	5.6		
- Bulldozer works all the time pushing and shaping		s - average	8.8		
Dozer works 50% of the time based on yard opn data 19 Jan - 15 Feb 09		M	10.5		
Reclaiming		ER	17.99551	kg/hr	
25% is loaded out by bucket wheel		Corrected ER	4.498878		
75% is touched by FELs		**FEL**			
Dozer works full time		EF	0.011202	kg/t	
Some coal bypasses stockpiles, approx 5% per year		avg tph moved	203.339	Annual throughput * 0.75 minus 5% bypasses stockpiles	
		avg ER	2.27783	kg/hr	
1 Bulldozer on site, used up to 24 hrs per day - same in the future just more hours on average					
Up to 3 FELs used at a time - likely to be same in the future but this isn't relevant to emissions as ER for FELs is based on tonnes moved		Total uncontrolled ER incl dozer @ 50% of time	4.527269		
			4.527269	kg/hr	
			1.257575	g/s	
		Expanded emissions			
		Dozer			
		s - Stockton	10.4		
		s - Spring Creek	5.6		
		s - average	8.8		
		M	10.5		
		EF	17.99551	kg/hr	
		Corrected ER	4.498878	kg/hr	
		FEL			
		EF	0.011202	kg/t	
		avg tph moved	385.274	Annual throughput * 0.75 minus 10% bypasses stockpiles	
		avg ER	4.315888	kg/hr	
		Total uncontrolled ER incl dozer @ 85% of time	8.139934		
			6.511947	kg/hr	
			1.808874	g/s	

PEAK EMISSION RATES - ALL VEHICLES IN USE

Dozer and FELs operate up to 24 hours per day (based on Jan/Feb 09 operations spreadsheet and confirmed by LPC 10/3/09).

Existing AND Expanded - FEL and Dozer use	*As described to TJF by LPC and SolidE on 10/3/09*			
Stacking	*Percentages modified by SolidE on 8/4/09*			
25% is stacked directly into position by the bucket wheel		**Existing emissions**		
- stacker touches all 100% of coal as it makes stockpiles for the FELs to take from		**Dozer**		
75% is touched by FEL and bulldozer		s - Stockton	10.4	
- FELs touch all 75%		s - Spring Creek	5.6	
- Bulldozer works all the time pushing and shaping		s - average	8.8	
Dozer works 50% of the time based on yard opn data 19 Jan - 15 Feb 09		M	10.5	
Reclaiming		ER	17.99551	kg/hr
25% is loaded out by bucket wheel		Corrected ER	4.498878	
75% is touched by FELs		**FEL**		
Dozer works full time		EF	0.011202	kg/t
Some coal bypasses stockpiles, approx 5% per year		tph moved	2000	tph
		avg ER	22.40425	kg/hr
1 Bulldozer on site, used up to 24 hrs per day - same in the future just more hours on average				
Up to 3 FELs used at a time - likely to be same in the future but this isn't relevant to emissions as ER for FELs is based on tonnes moved		Total uncontrolled ER incl dozer	24.65369	
			24.65369	kg/hr
			6.848248	g/s
		Expanded emissions		
		Dozer		
		s - Stockton	10.4	
		s - Spring Creek	5.6	
		s - average	8.8	
		M	10.5	
		EF	17.99551	kg/hr
		Corrected ER	4.498878	
		FEL		
		EF	0.011202	kg/t
		avg tph moved	2000	tph
		avg ER	22.40425	kg/hr
		Total uncontrolled ER incl dozer	24.65369	
			19.72295	kg/hr
			5.478598	g/s

Tracy Freeman:
Katestone Environmental report notes these emissions are erroneous (see page 68 of KE report), and we should reduce er by factor of 4 to remove the "10 times higher" emission from the three samples used to derive the USEPA 1998 em factors

Tracy Freeman:
Table 1 ref 2: Bulldozers on coal EF = 35.6 x s^1.2 x M^(-1.4), here s =10.4% for stockton coal and 5.6% for spring creek and m = 10.5%.
Typical coal composition is 2:1 stockton vs spring creek in both base case and Stage 2 (SolidE 10/3/09)

Tracy Freeman:
FEL EF = 1.56 x 0.0596 x M^(-0.9) kg/t

Tracy Freeman:
Max hourly load in rate

Tracy Freeman:
Bulldozer working either on reclaiming or stacking but not both as only one bulldozer

Tracy Freeman:
No control factor, references (NPI and NSWMC) say no control here

Tracy Freeman:
Bulldozer working either on reclaiming or stacking but not both as only one bulldozer

Tracy Freeman:
20% control factor for sheltering and wetting

Appendix E

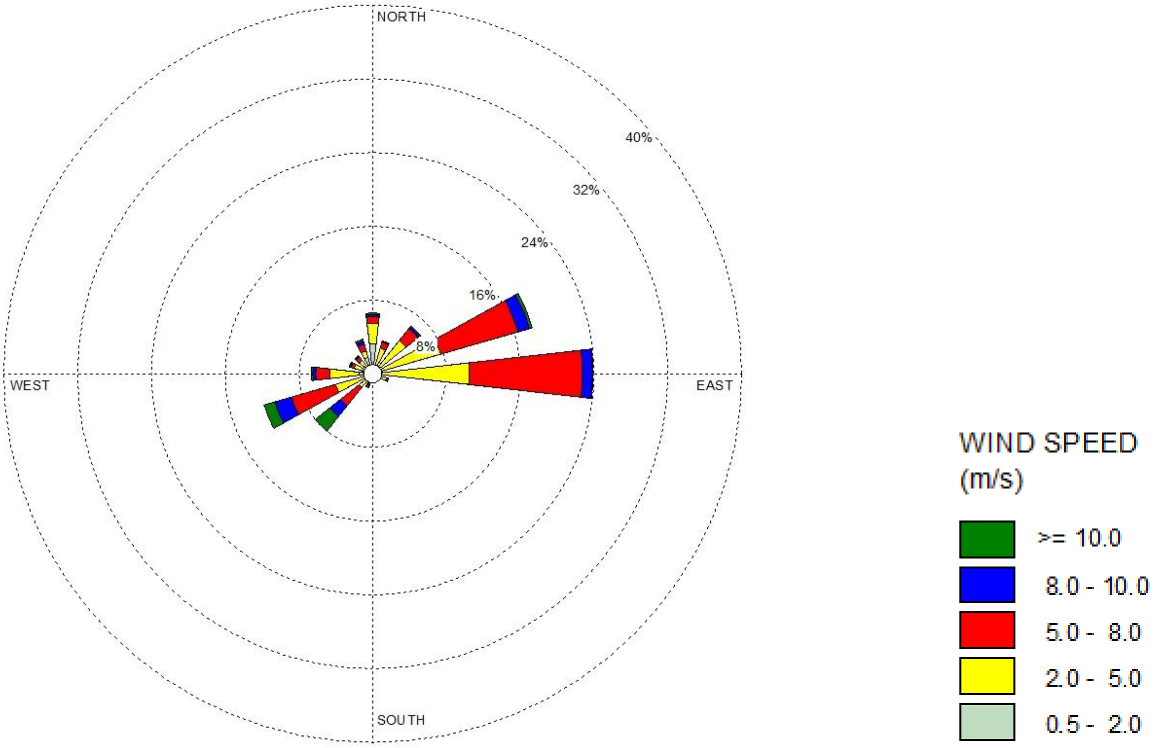
Summary of model source emissions input

Base Case				
AVERAGE EMISSIONS				
Source	**Type of source**	**Type of emission rate**	**Value of constant**	
Train unloading	1x area source	Constant	0.020	
Transfer points	1 area "yard west"	Constant	0.091	
Autostacking and reclaiming	1 area "yard central"	Constant	0.555	
Stacking & reclaiming vehicles	3 area "yard west", "yard central", "yard east"	Constant (distrib evenly per m2 across all yard areas)	2.52	
Stockpile liftoff	Various area sources, avg release ht 5m	Hourly varying (distrib evenly per m2 across all areas)		
Conveyors				
CV1	0.5xC13 + 0.5xC24 + 0.5xstacker + 0.5xreclaimer	Hourly varying		
CV2	0.5xC13 + 0.5xC24 + 0.5xstacker + 0.5xreclaimer	Hourly varying		
CV3	C22 + C23 + 0.5xC12	Hourly varying		
CV4	C10 + C9a + C9b + C9c	Hourly varying		
CV5	0.5xC8 + 0.5xC12	Hourly varying		
CV6	0.5xC8	Hourly varying		
CV7	C2 + 0.5xC1 + shiploader + constant (transfer points)	Hourly varying + a constant	0.017	
CV8	0.5xC1 + spur conveyor + constant (jetslinger + var transfer points)	Hourly varying + a constant	0.094	
Base Case				
PEAK EMISSIONS				
Source	**Type of source**	**Type of emission rate**		
Train unloading	1x area source	Constant	0.14	
Transfer points	1 area "yard west"	Constant	0.64	
Autostacking and reclaiming	1 area "yard central"	Constant	3.89	
Stacking & reclaiming vehicles	3 area "yard west", "yard central", "yard east"	Constant (distrib evenly per m2 across all yard areas)	13.7	
Stockpile liftoff	Various area sources, avg release ht 5m	Hourly varying (distrib evenly per m2 across all areas)		
Conveyors				
CV1	0.5xC13 + 0.5xC24 + 0.5xstacker + 0.5xreclaimer	Hourly varying		
CV2	0.5xC13 + 0.5xC24 + 0.5xstacker + 0.5xreclaimer	Hourly varying		
CV3	C22 + C23 + 0.5xC12	Hourly varying		
CV4	C10 + C9a + C9b + C9c	Hourly varying		
CV5	0.5xC8 + 0.5xC12	Hourly varying		
CV6	0.5xC8	Hourly varying		
CV7	C2 + 0.5xC1 + shiploader + constant (transfer points)	Hourly varying + a constant	0.12	
CV8	0.5xC1 + spur conveyor + constant (jetslinger + var transfer points)	Hourly varying + a constant	0.66	

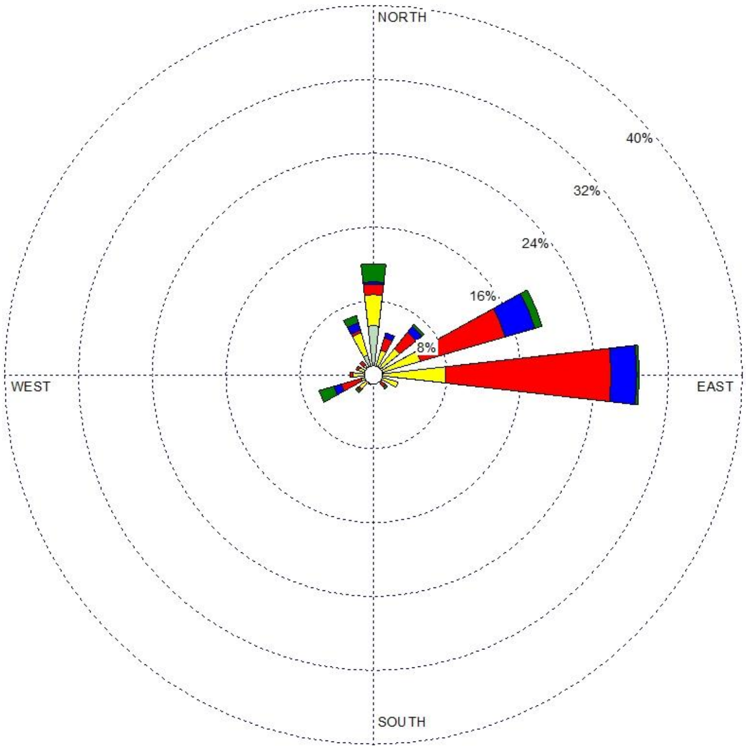
Extended case				
AVERAGE EMISSIONS				
Source	**Type of source**	**Type of emission rate**	**Value of constant**	
			5.4 Mtpa	
Train unloading	1x area source	Constant	0.043	
Transfer points	1 area "yard west"	Constant	0.079	
Autostacking and reclaiming	1 area "yard central"	Constant	0.72	
Stacking & reclaiming vehicles	3 area "yard west", "yard central", "yard east"	Constant (distrib evenly per m2 across all yard areas)	3.87	
Stockpile liftoff	Various area sources, avg release ht 5m	Hourly varying (distrib evenly per m2 across all areas)		
Conveyors				
CV21	0.5xC13 + 0.5xC24 + 0.5xstacker + 0.5xreclaimer	Hourly varying		
CV22	0.5xC13 + 0.5xC24 + 0.5xstacker + 0.5xreclaimer	Hourly varying		
CV23	C33 + C34 + C35	Hourly varying		
CV24	0.33xC32	Hourly varying		
CV25	0.33xC32 + C12 + 0.5xC36	Hourly varying		
CV26	0.33xC32	Hourly varying		
CV27	C23	Hourly varying		
CV28	C23a + 0.33xC31 + C22	Hourly varying		
CV29	0.33xC31 + C37 + 0.5xC36	Hourly varying		
CV30	0.33xC31	Hourly varying		
CV31	C2 + 0.5xC1 + shiploader + constant (transfer points)	Hourly varying + a constant	0.015	
CV32	0.5xC1 + spur conveyor + constant (jetslinger + var transfer points)	Hourly varying + a constant	0.15	
Extended case				
PEAK EMISSIONS				
Source	**Type of source**	**Type of emission rate**		
Train unloading	1x area source	Constant	0.140	
Transfer points	1 area "yard west"	Constant	0.26	
Autostacking and reclaiming	1 area "yard central"	Constant	2.33	
Stacking & reclaiming vehicles	3 area "yard west", "yard central", "yard east"	Constant (distrib evenly per m2 across all yard areas)	10.96	
Stockpile liftoff	Various area sources, avg release ht 5m	Hourly varying (distrib evenly per m2 across all areas)		
Conveyors				
CV21	0.5xC13 + 0.5xC24 + 0.5xstacker + 0.5xreclaimer	Hourly varying		
CV22	0.5xC13 + 0.5xC24 + 0.5xstacker + 0.5xreclaimer	Hourly varying		
CV23	C33 + C34 + C35	Hourly varying		
CV24	0.33xC32	Hourly varying		
CV25	0.33xC32 + C12 + 0.5xC36	Hourly varying		
CV26	0.33xC32	Hourly varying		
CV27	C23	Hourly varying		
CV28	C23a + 0.33xC31 + C22	Hourly varying		
CV29	0.33xC31 + C37 + 0.5xC36	Hourly varying		
CV30	0.33xC31	Hourly varying		
CV31	C2 + 0.5xC1 + shiploader + constant (transfer points)	Hourly varying + a constant	0.048	
CV32	0.5xC1 + spur conveyor + constant (jetslinger + var transfer points)	Hourly varying + a constant	0.493	

Appendix F

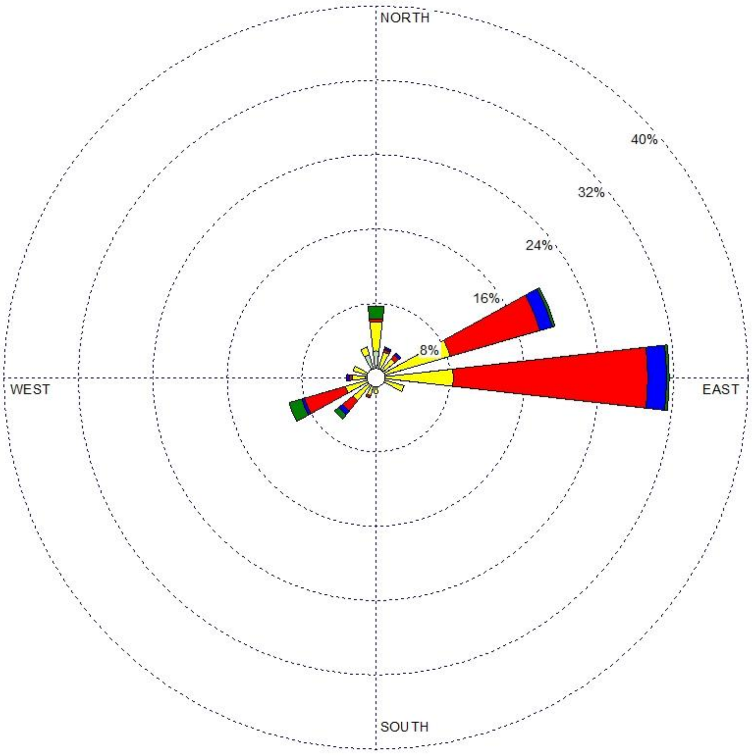
Officer's Point Windroses during Complaint Periods



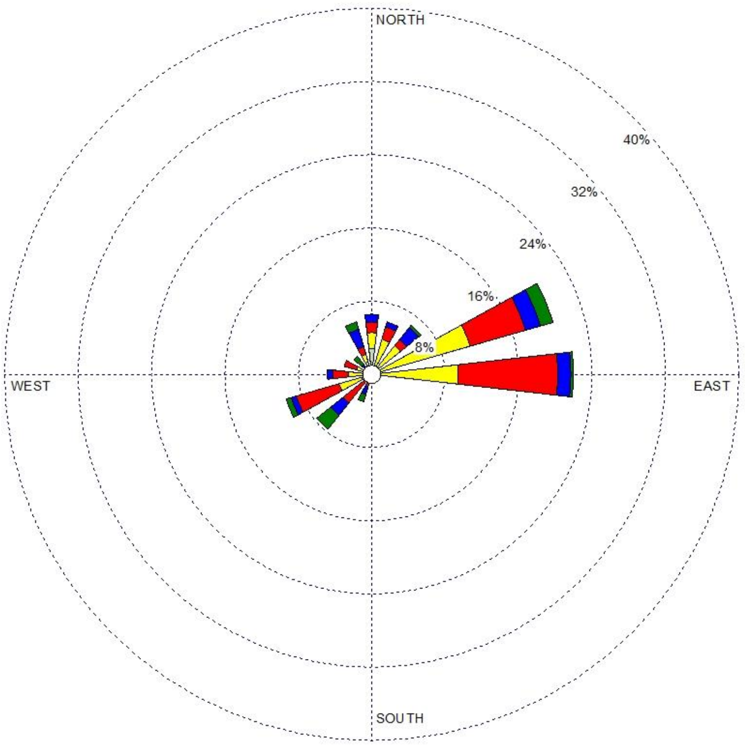
Officer's Point windrose all hours November – March months only, 2004 – 2008 (same data as Figure 4.3 of Beca Report).



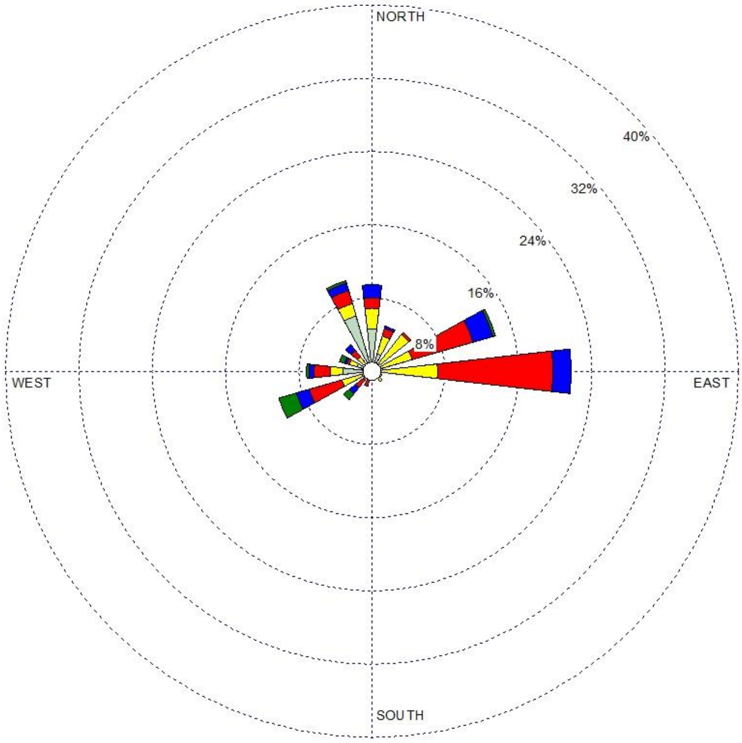
Two-week period leading up to 24 Jan 2006



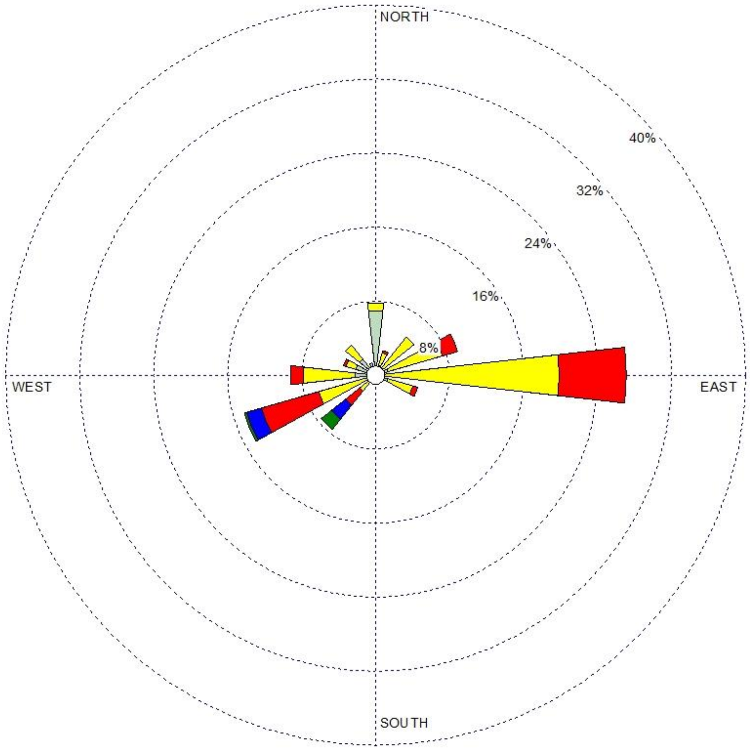
Two-week period leading up to 1 Feb 2006



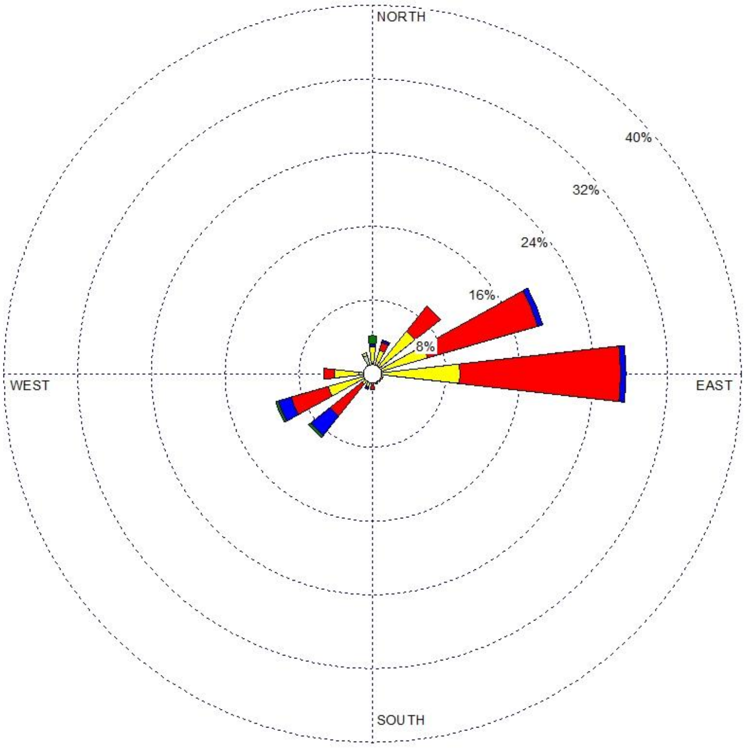
Two-week period leading up to 2 Nov 2006



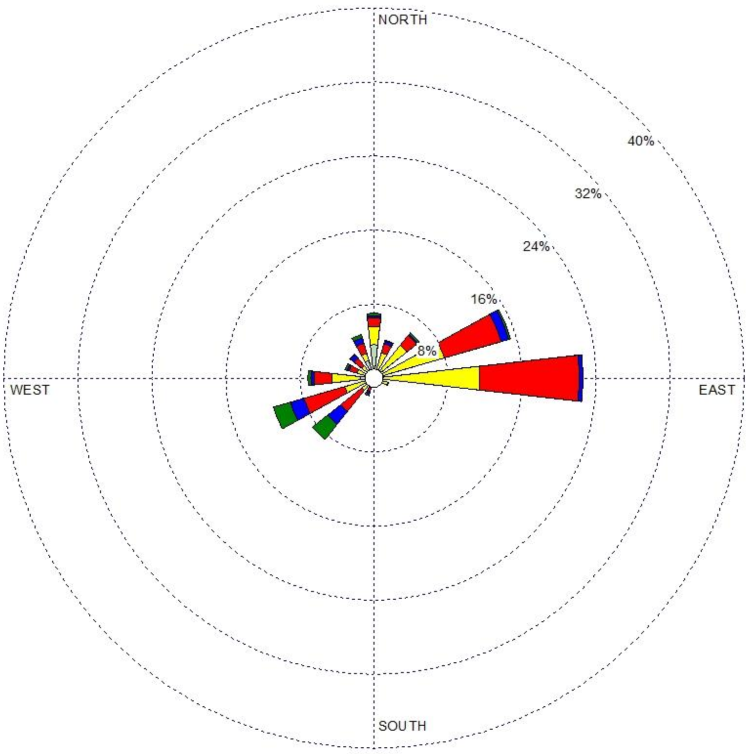
Two-week period leading up to 16 Nov 2006



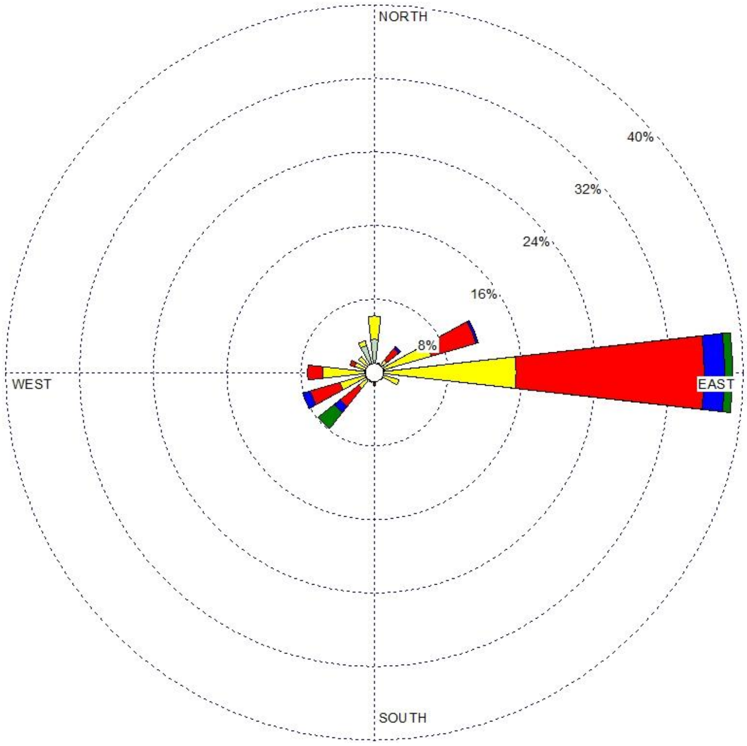
Two-week period leading up to 22 Feb 2007



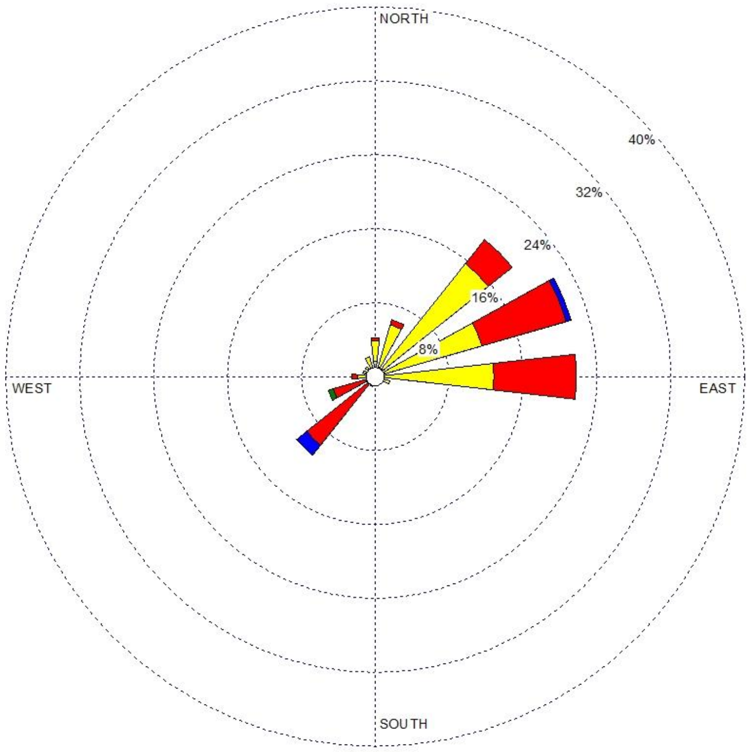
Two-week period leading up to 11 Dec 2007



Three-month period leading up to 11 Dec 2007



Two-week period leading up to 29 Jan 2009



Two-week period leading up to 12 Feb 2010