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Pacific Environment Limited

Consulting • Technologies • Monitoring • Toxicology

Briefing Note: Monte Carlo and cumulative 24-hour average PM_{10} concentrations

1 INTRODUCTION

A detailed explanation was provided in Appendix 6 of the Drayton Coal South Project Justification[1] Report (February 2014), and this briefing note has drawn on that response substantially to provide this overview.

When considering the predicted contribution of the Project to ambient air quality concentrations, it is important to note that there are a number of inherent conservatisms in the emission calculations used in the dispersion modelling, resulting in a conservative assessment of the potential emissions and subsequently the predicted impacts.

The calculated emissions were based on years considered to be representative of worst-case operations, for example:

- Where coal and waste production were highest
- Where extraction or wind erosion areas were largest
- Where operations were located closest to receivers
- Inclusion in the emission inventories of emissions from the years where highwall mining in each mine area is at its most intensive.

In addition, the dispersion modelling completed assumes that all dust-generating activities occur equally over each hour of the year. In reality activities on a coal mine vary significantly on a day-to-day basis. When combined with the fact that the emission calculations were in themselves based on worst-case operations, the results of the dispersion modelling are considered to be conservative.

Finally, dispersion models are not 100% accurate, but are a tool which uses the best-available science to guide policy-making decisions. As noted in the US Environmental Protection Agency Guideline on Air Quality Models[2]:

- Models are more reliable for estimating longer time-averaged concentrations (e.g. annual averages) than for estimating short-term concentrations at specific locations (e.g. 24-hour averages).
- The models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area. In other words, estimates of concentrations that occur at a specific time and location, are poorly correlated with actually observed concentrations and are much less reliable than the longer-term averages.

[1] Available from https://majorprojects.affinitylive.com/public/d4f19a69d83c6a4c8c404526c3ff577a/02.%20Drayton%20South%20-%20Anglo%20American%20Response%20to%20PAC%20Review%20-%20Justification%20report.pdf

[2] 40 CFR Part 51 Revision to the Guideline on Air Quality Models: Adoption of Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule. Federal Register/ Vol. 70 , No. 216/ Wednesday, November 9, 2005 /Rules and Regulations. Available from http://www.epa.gov/ttn/scram/guidance/guide/appw_05.pdf (accessed 30 January 2014)

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It is considered that the predicted 24-hour average PM_{10} concentrations due to the Project-alone are very conservative and there is significant uncertainty in predicting the cumulative 24-hour average concentrations as they are compounded by the day-to-day variability in ambient dust levels and the spatial and temporal variation in any other anthropogenic activity (e.g. agricultural activity, bushfires etc), including mining in the future. Experience shows that the worst case 24-hour average PM_{10} concentrations are often strongly influenced by other sources, such as bushfires and dust storms, which are essentially unpredictable.

The Monte Carlo cumulative 24-hour average PM_{10} assessment is intended as a tool to identify potential risk areas and activities so that these can be appropriately managed by the operation on a day-to-day basis.

Identified risks from the Project would be managed by the proposed predictive/pro-active mitigation and management options.

2 MONTE CARLO EXPLANATION

2.1 Introduction

The Monte Carlo assessment uses a probabilistic approach to randomly combine the values from the background data set with the 365 values from the predicted concentrations data set repeated 250,000 times.

Probabilistic approaches enable the variation and uncertainty in data to be quantified, by using distributions instead of fixed values in the assessment.

From the results of the Monte Carlo calculations, the *probability* of the number of cumulative concentrations greater than 50 $\mu g/m^3$ can be determined. This probability was translated to a number of days for information purposes.

For all the reasons cited in **Section 1**, it is not considered feasible to determine precisely how many times an event will occur, when it will occur, or what the magnitude of the cumulative concentration will be.

2.2 Drayton South Monte Carlo Assessment

As presented in **Table 2-1**, the Monte Carlo method applied for Drayton South (the Project) initially used monitoring data from as early as 2000 through to late 2011, thus capturing all the variability in background concentrations from all data available, not just those that occurred in 2005. It was intended that this would give further reassurance that the Project would have minimal impact on the local air-shed.

Table 2-1: Monitoring Data used to Determine Background

Monitoring Location	Monitoring Period	No. of daily 24-hour average concentrations	Data Source	Receiver ID
Mt Arthur Coal Edderton (DF04)	2002 – 2010	530	PAEHolmes (2009) BHP Billiton (2009) BHP Billiton (2010)	410 and 411
Anglo American (Lot 9)	2005 – 2009	288	Anglo American	
Mt Arthur Coal Windmill (DF03)	2002 – 2010	577	PAEHolmes (2009) BHP Billiton (2009) BHP Billiton (2010)	57, 58A, 145A, 226B, 226D, 227A, 227F, 240A and 250A
Anglo American (HV2a)	2000 – Nov. 2011	502	Anglo American	
Anglo American (HV5)	May 2001 – Nov. 2011	477	Anglo American	209 and 217

As presented in **Table 2-2**, there were a maximum of 19 exceedances recorded in any single year at HV2a and DF03. The vast majority of these exceedances were recorded at HV2a. It was noted in the original Air Quality and Greenhouse Gas Assessment (Appendix F[3] of the EA) that HV2a was originally located near a cultivated farming paddock and was moved to a more representative location at the end of 2006. It is apparent in the monitoring data that the measured exceedances have dropped dramatically at HV2a since that time, with a maximum of three exceedances occurring in 2009 which is considered to be more representative of the air shed in this region.

Table 2-2: Summary of monitoring data availability and exceedances of 24-hour criteria

	Llanillo (HV2a)		Mt Arthur Coal Windmill (DF03)	
Year	Total no. of 24-hour averages	No. >50 µg/m³	Total no. of 24-hour averages	No. >50 µg/m³
2001	14	0	-	-
2002	28	7	61	3
2003	27	5	60	4
2004	30	5	60	1
2005	55	**15**	61	1
2006	61	**19**	56	0
2007	56	2	57	0
2008	45	2	56	0
2009	57	3	58	1
2010	58	1	59	1
2011	56	0	49	2
Total	**502**	**59**	**577**	**13**

Bold red text shows the outliers in the dataset due to the monitor being located next to a cultivated paddock.

[3] Appendix F can be located here: https://majorprojects.affinitylive.com/public/a5c1ba076a89bf966953b76f0f51f870/46.%20Drayton%20South%20-%20EA%20Appendix%20F%20-%20Air%20Quality%20and%20Greenhouse%20Gas%20Impact%20Assessment.pdf (accessed 14 January 2014)

Monte Carlo is a statistical approach, therefore it uses the whole range of available data (in this case the 1079 data points form HV2a and DF03) and applies this to a single year (365 data points).

As **Figure 2-1** shows, when considering the entire dataset from HV2a and DF03, approximately 6.7% of the data were greater than 50 μg/m^3, which equals approximately 24 days (6.7% * 365 days). Based on the knowledge that data collected at HV2a pre-2006 were heavily influenced by the monitor being located near a cultivated farming paddock, and as such do not provide a true representation of the existing air quality, the Monte Carlo assessment has been repeated as part of this briefing note excluding these data. Excluding the pre-2006 data from the background dataset leaves approximately 2.5% of the data being greater than 50 μg/m^3, which equals approximately 9 days (2.5% * 365 days). This is considered to be more representative of the background air quality in the region.

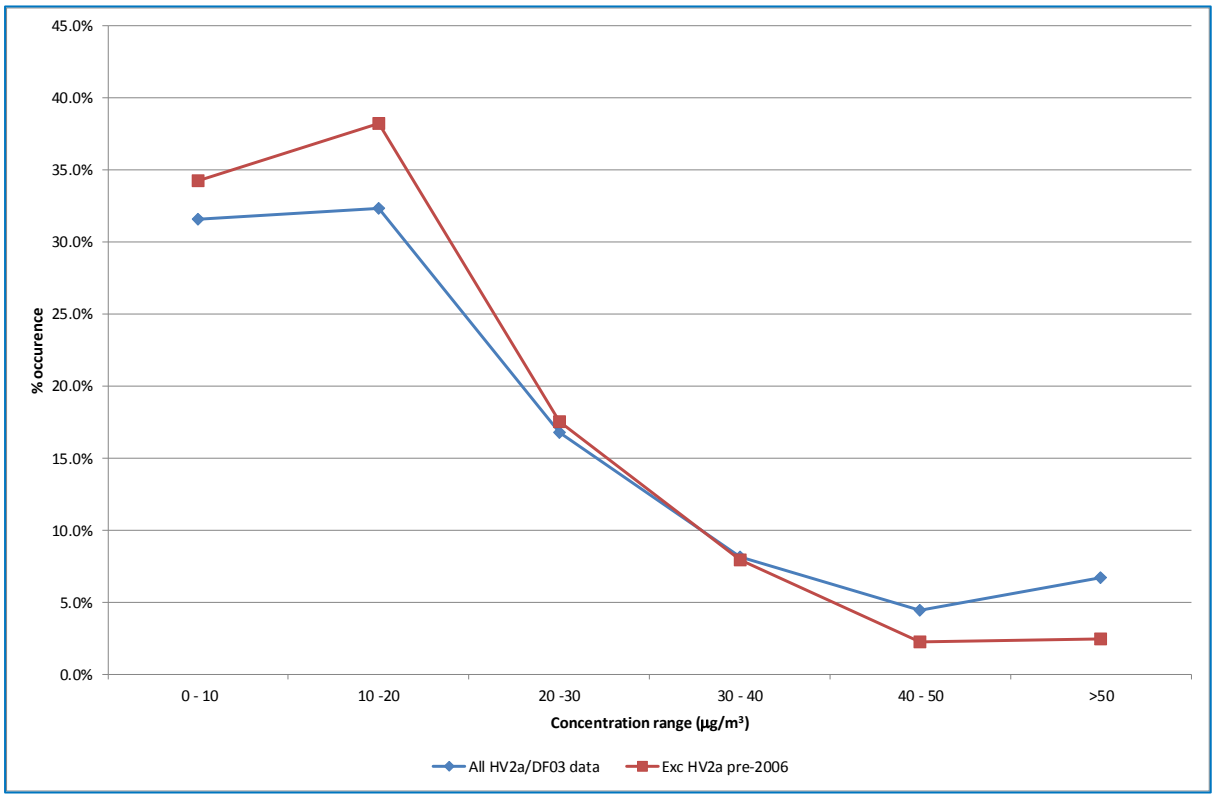

Figure 2-1: HVAS monitors DF03 and HV2a – percentage occurrence of 24-hour PM_{10} concentrations (μg/m^3)

Hence, as shown on **Figure 2-2**, running these data through Monte Carlo results in the conservative *probability* that 24 days (using all HV2a and DF03 data), and 9 days (excluding HV2a data pre-2006) would exceed the 50 μg/m^3 due to the *background alone*.

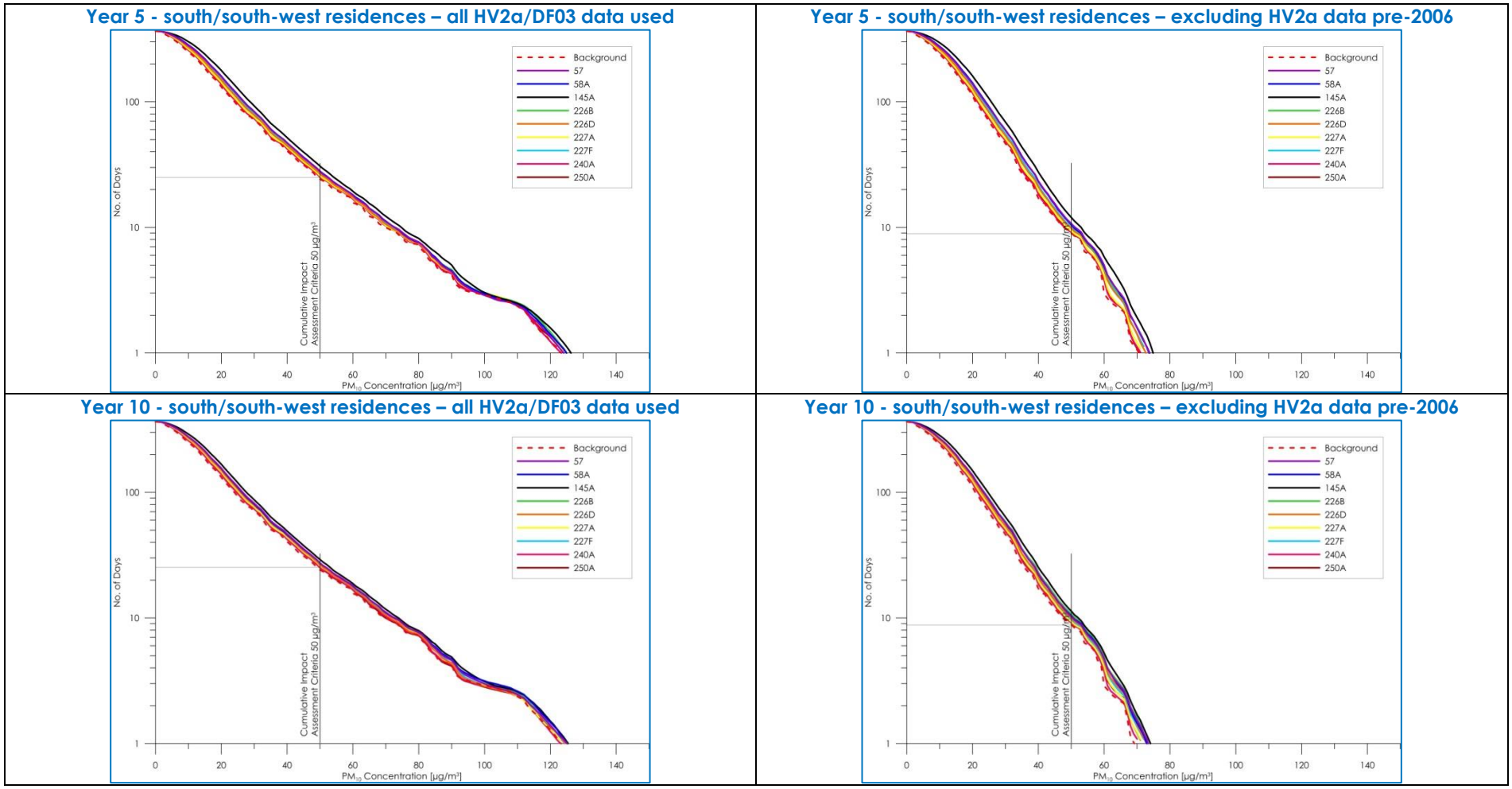

Figure 2-2: Number of days likely to exceed cumulative maximum 24-hr average PM_{10} concentration (50 µg/m³)

Table 2-3 and **Table 2-4** presents a comparison of the predicted number of additional days exceeding 50 µg/m³ using both background data sets with the predicted contribution for the Project in Year 5 and Year 10, respectively. Exclusion of the pre-2006 HV2a data shows a reduction in the number of predicted exceedances.

Table 2-3: Summary of days exceeding 50 µg/m³ – project alone and cumulative – Year 5

Receptor ID	Maximum predicted PM_{10} 24-hour concentrations	Predicted number of days exceeding 50 µg/m³ cumulative criteria							
	Project Alone		Background		Cumulative (Monte Carlo)		Days more than background due to Project	
	Year 5	Year 5	All HV2a/DF03 data	Exc. HV2a pre-2006	All HV2a/DF03 data	Exc. HV2a pre-2006	All HV2a/DF03 data	Exc. HV2a pre-2006
Units	µg/m³	Number of days						
Privately owned residences								
226B	16	0	24	9	28	10	4	1
226D	14	0	24	9	27	10	3	1
227A	8	0	24	9	26	9	2	0
227F	17	0	24	9	27	10	3	1
240A	6	0	24	9	25	9	1	0
250A	8	0	24	9	25	9	1	0
Mine owned residences								
57	17	0	24	9	28	11	3	2
58A	19	0	24	9	28	11	3	2
145A	14	0	24	9	31	12	5	3

Table 2-4: Summary of days exceeding 50 µg/m³ – project alone and cumulative – Year 10

Receptor ID	Maximum predicted PM_{10} 24-hour concentrations	Predicted number of days exceeding 50 µg/m³ cumulative criteria							
	Project Alone		Background		Cumulative (Monte Carlo)		Days more than background due to Project	
	Year 10	Year 10	All HV2a/DF03 data	Exc. HV2a pre-2006	All HV2a/DF03 data	Exc. HV2a pre-2006	All HV2a/DF03 data	Exc. HV2a pre-2006
Units	µg/m³	Number of days						
Privately owned residences								
226B	20	0	24	9	27	11	3	2
226D	17	0	24	9	26	10	2	1
227A	12	0	24	9	26	9	2	0
227F	13	0	24	9	26	10	2	1
240A	6	0	24	9	25	9	1	0
250A	9	0	24	9	25	9	1	0
Mine owned residences								
57	16	0	24	9	27	10	3	1
58A	18	0	24	9	27	10	3	1
145A	14	0	24	9	29	11	5	2

It is apparent from the above discussion that the elevated number of cumulative concentrations above the criteria has been influenced by the higher number of existing exceedances in the background data from 2006 (and earlier) than would typically occur in a single year (as seen in the data from 2007 onwards).

It is also important to consider that the predicted Project contribution at the worst-affected residence (226B) shows that:

- In Year 5 more than 50% of the predicted 24-hour average PM_{10} concentrations due to the Project are 1 µg/m³ or below (see **Figure 2-3**).
- In Year 10, 65% of the predicted 24-hour average PM_{10} concentrations due to the Project are 1 µg/m³ or below (see **Figure 2-4**).

This demonstrates that the predicted contributions from the retracted mine plan on private receivers are substantially lower than those predicted in the EA.

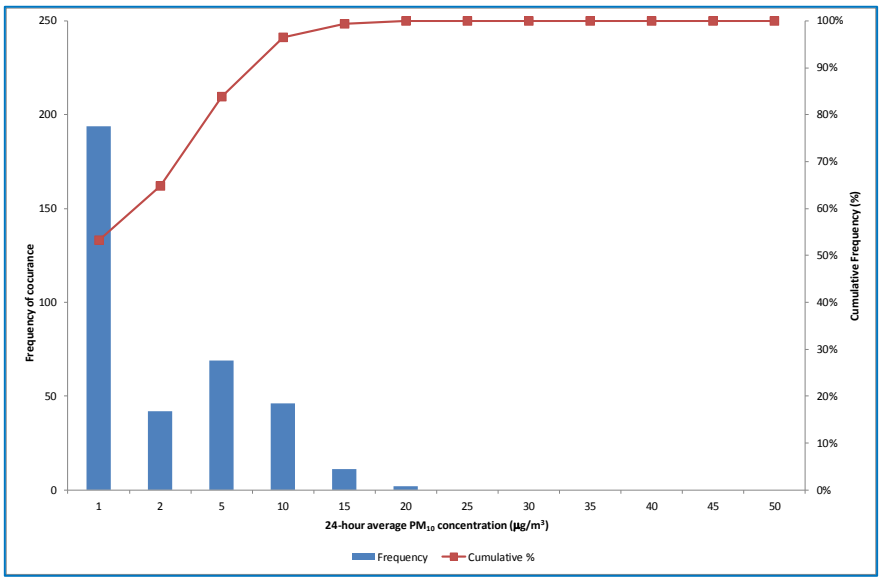

Figure 2-3: Frequency distribution of predicted 24-hour average PM_{10} concentrations at 226B Year 5

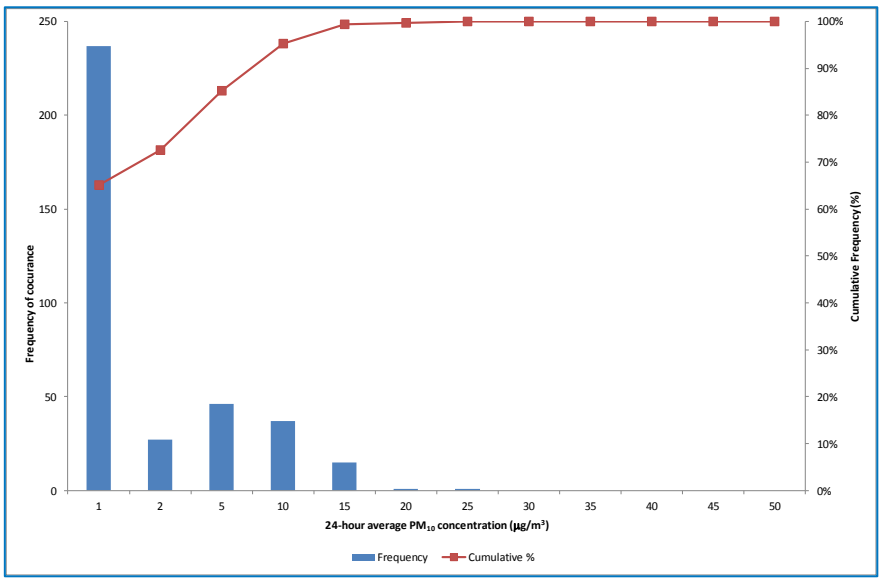

Figure 2-4: Frequency distribution of predicted 24-hour average PM_{10} concentrations at 226B Year 10

2.2.1 Summary

Due to the assessment being based on worst-case operations, it is considered that the predictions of Project-only contribution to ambient air quality are very conservative, particularly when considering the 24-hour average concentrations. It is apparent from the above discussion that the number of cumulative concentrations predicted above the 24-hour average PM_{10} criteria has been heavily influenced by the high number of exceedances in the background data for 2006 (and earlier) than would typically occur in a single year, resulting in an conservative assessment of potential impacts. As such the revised assessment presented in this briefing note is considered to provide a more representative assessment of the potential 24-hour average PM_{10} impacts for the region.

More than 50% of the predicted concentrations due to the Project-alone at the closest residence (226B) are below 1 $\mu g/m^3$ (see **Figure 2-4**), as such it is considered that the cumulative assessment presented was very conservative.

Anglo American has implemented a best practice predictive and real-time dust management system at their Drayton site, which includes a daily risk forecast tool for planning and managing day-to-day operations and a real-time dust monitoring system to act and respond to short-term elevated dust. Also, as part of the "dust stop' PRP process, Drayton has identified adverse meteorological conditions for managing visible dust from overburden handling, also used for managing day-to-day operations. These systems would be extended to Drayton South if approved.