



Appendix B
Air Quality Review

Cristal Mining Australia Limited
Joe Bannister,
Development Manager

4 July 2014

Re: Snapper Mine Production Increase Modification Air Quality Review

1 INTRODUCTION

Cristal Mining Australia Limited (Cristal Mining) operates the Snapper and Ginkgo Mines, which are located approximately 85 kilometres (km) north-east of Wentworth and approximately 170 km to the south-east of Broken Hill in western New South Wales (NSW) (Figure 1.1). Cristal Mining's Ginkgo Mine is located approximately 10 km to the north-east of the Snapper Mine (Figure 1.1).

Cristal Mining is preparing an Environmental Assessment (EA) to support an application to modify the Snapper Mine Project Approval (06_0168) (the Snapper Mine Production Increase Modification [the Modification]). A review of the potential air quality impacts associated with the Modification is required to inform the EA. This document is an Air Quality Review for the proposed Modification.

Cristal Mining lodged a separate application to modify the Ginkgo Mine Development Consent (DA 251-09-01) under section 75W of the EP&A Act in November 2012 (the November 2012 Modification). This separate application is relevant to the development of the satellite Crayfish Deposit and is unrelated to this Modification.

2 OVERVIEW OF THE MODIFICATION

The Modification would include the following key components:

- variations to the Snapper Mine mining sequence (Mining Options 1 to 3);
- increase in the Snapper Mine maximum annual ore extraction rate from 9.1 million tonnes per annum (Mtpa) to 14 Mtpa;
- an option to use an overburden slurry pipeline system to transport overburden at the Snapper Mine; and
- increase in the combined mineral concentrate/heavy mineral concentrate (HMC) haulage rate from 735,000 tonnes per annum (tpa) to 975,000 tpa.

The variations to the Snapper Mine mining sequence would include either of the following mining options (Figures 2.1 to 2.3):

- **Mining Option 1** – initial single-pass mining followed by double-pass mining (in an anti-clockwise direction) using conventional dredge mining methods supplemented with dry mining (i.e. as per the currently approved) at an increased ore production rate of up to approximately 14 Mtpa.
- **Mining Option 2** – initial single-pass mining followed by double-pass mining (in a clockwise direction) using conventional dredge mining methods supplemented with dry mining at an increased ore production rate of up to approximately 14 Mtpa.
- **Mining Option 3** – single-pass mining using conventional dredge mining methods supplemented with an additional small dredge and dry mining at an increased ore production rate of up to approximately 14 Mtpa.

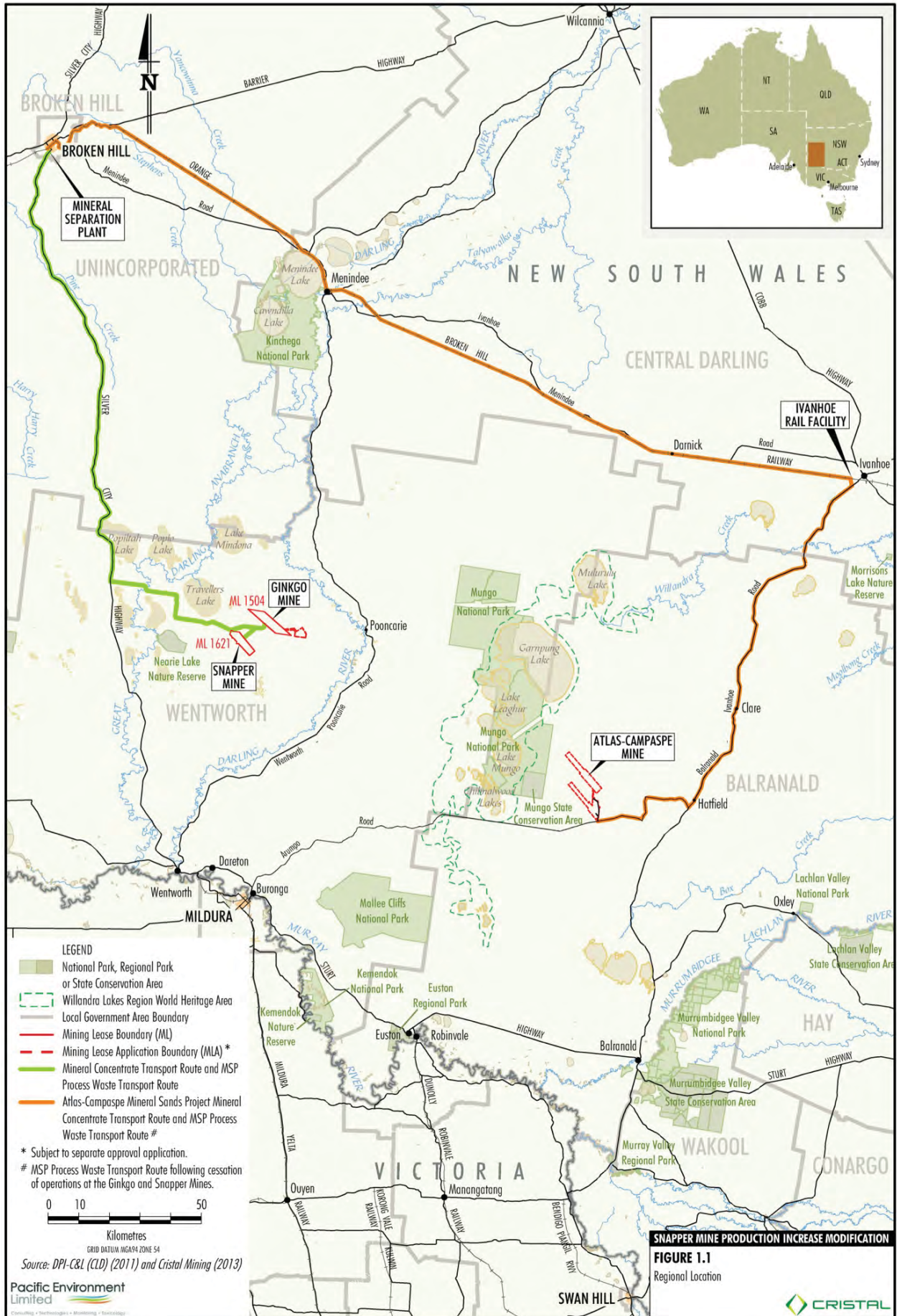






FIGURE 2.2
 Modified Snapper Mine
 General Arrangement
 (Mining Option 2)



No additional surface development area would be required for the Modification. The maximum annual overburden movement rate at the Snapper Mine would increase from approximately 27.2 Mtpa to approximately 36.8 Mtpa. The maximum annual topsoil movement would increase from approximately 145,540 cubic metres per year (m³/year) to approximately 225,590 m³/year. A detailed description of the Modification is provided in Section 3 of the EA.

3 EXISTING ENVIRONMENT

3.1 Sensitive Receptors

There are a number of sensitive receptors located in the vicinity of the Snapper and Ginkgo Mines as per **Figure 3.1**. The Manila and Trelega homesteads are the closest private receptors to the mines (located approximately 4 km to the north-east and 7 km south respectively), and are therefore the focus of this assessment.

3.2 Air Quality

Dust deposition is monitored by the proponent in the area surrounding the Snapper and Ginkgo Mines. There are no long-term measurements of total suspended particulate matter (TSP) or particulate matter less than 10 microns (PM₁₀) concentrations at the Snapper and Ginkgo Mines.

Figure 3.1 shows the location of the 16 dust deposition gauges surrounding the Snapper and Ginkgo Mines. Data collected from the gauges are summarised below in **Table 3.1**. These measurements include all background sources relevant to the location, including any contribution which may occur from the Ginkgo Mine (which commenced construction and operation in 2004 and 2005, respectively) and the Snapper Mine (which commenced construction and operation in 2008 and 2009, respectively).

Table 3.1: Annual Average Dust Deposition Levels (g/m²/month)

Gauge	2005 ^a	2006 ^b	2007	2008	2009	2010	2011	2012 ^c	2013 ^d	Average over site	Average over all sites and years
DG01	1.6	1.1	1.3	2.7	3.3	1.5	0.7	1.2	0.7	1.6	2.5
DG02	1.1	0.9	1.1	3.0	2.4	1.3	1.5	1.2	0.8	1.5	
DG03	1.6	0.9	1.2	2.8	3.3	1.4	0.9	0.7	1.0	1.5	
DG04	1.5	1.9	2.8	4.6	3.7	2.2	3.2	1.7	3.2	2.8	
DG05	0.8	1.4	2.6	4.6	4.0	2.0	1.8	4.3	1.3	2.5	
DG06	1.4	2.2	2.6	5.9	6.7	4.4	2.2	5.7	1.7	3.7	
DG07	0.9	2.2	3.6	5.6	5.6	2.4	5.6	6.7	2.7	3.9	
DG08	1.3	2.1	3.4	4.5	3.9	3.0	3.8	5.5	0.9	3.1	
DG09	0.6	1.7	2.1	3.5	2.7	7.1	7.4	4.1	1.0	3.4	
DG10	ND	1.9	1.3	2.5	1.8	1.2	1.3	5.0	2.3	2.2	
DG11	ND	1.3	1.8	2.9	3.1	1.9	4.3	5.8	2.1	2.9	
DG12	ND	1.7	1.3	2.4	3.6	1.6	0.9	0.7	0.8	1.6	
DG13	ND	1.2	0.9	3.6	2.8	1.3	0.8	1.3	1.1	1.6	
DG14	ND	1.5	1.1	2.4	3.7	1.3	1.0	1.7	0.7	1.7	
DG15	ND	ND	ND	ND	2.3	2.6	2.8	6.1	5.9	3.9	
DG16	ND	ND	ND	ND	ND	ND	ND	0.6	0.5	0.6	

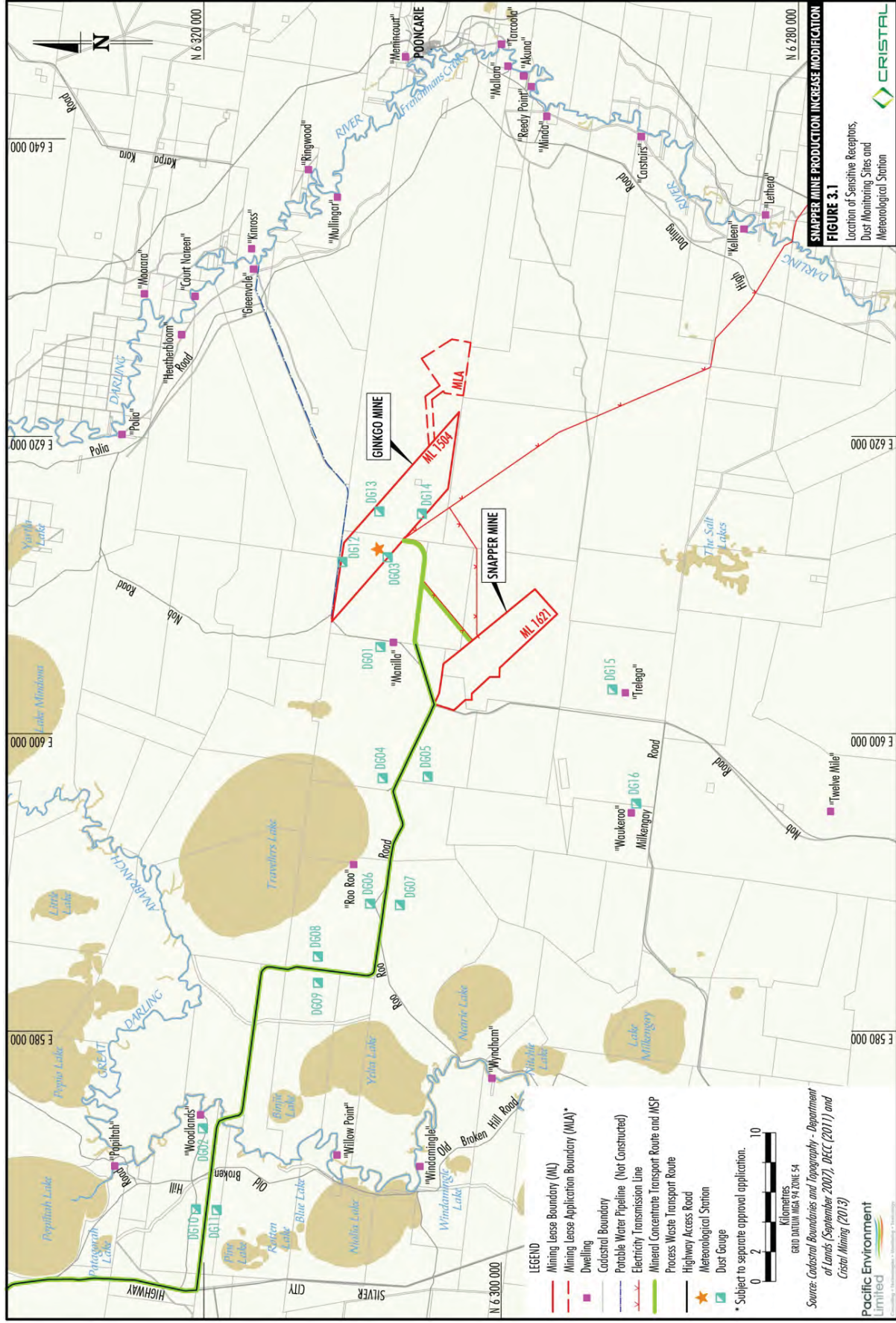
^a Data for DG03 available for December only, for DG05 from July to December only and for DG06, DG07, DG08 and DG09 from October to December only.

^b Data for DG10 and DG11 available from February to December only, for DG12, DG13 and DG14 from April to December only.

^c Data available for DG16 from February to December only.

^d Data available to August only.

ND = No Data



The data in **Table 3.1** shows that there are a number of sites from 2008 to 2013 where dust deposition levels have exceeded the relevant Environment Protection Authority's (EPA) impact assessment criterion of 4 g/m²/month. Of note, DG4 to DG8 recorded dust deposition levels above the EPA impact assessment criterion in 2008. These high annual averages are the result of unusually high readings in September which are most likely due to extensive dust storms experienced over NSW during this time (**Bureau of Meteorology, 2014**). DG6 and DG7 also recorded annual average levels above the EPA impact assessment criterion in 2009 which are also most likely the result of dust storms between September and December 2009 (**Bemax Resources, 2010**).

DG05 to DG11 and DG15 recorded levels above the EPA impact assessment criterion in 2012. Dust gauges DG05 to DG11 are located adjacent to the mineral concentrate transport route, along which the mineral concentrate/HMC is transported to the Broken Hill Mineral Separation Plant. However DG04 and DG02 are also located adjacent to the mineral concentrate transport route and have recorded levels significantly below the EPA impact assessment criterion for the same year. It is difficult to therefore conclude that the elevated dust levels result from wheel generated dust along the mineral concentrate transport route.

It is noted that the closest residence to the mineral concentrate transport route is approximately 1 km, whereas dust monitoring sites are generally less than 1 km from the mineral concentrate transport route.

The monitoring sites that represent dust levels at the Manilla and Trelega homesteads are DG01 and DG15. DG01 is consistently below the EPA impact assessment criterion. DG015 has recorded dust levels above the criterion in 2012 and 2013. These exceedances at DG015 in 2012 and 2013 were due to sample contamination (i.e. bird droppings) in January, March and June 2012 (**Bemax Resources, 2013**) and February 2013.

It should be noted that short term dust storm events can significantly increase the annual average dust deposition results. Readings taken for March 2011 at DG10 and for June 2012 at DG05 have been removed from the analysis as the values of 154.7 g/m²/month and 150.9 g/m²/month are considered outliers.

Figure 3.2 presents the monthly recorded dust deposition data. The plot also shows significant project milestones which are discussed further in **Section 6**.

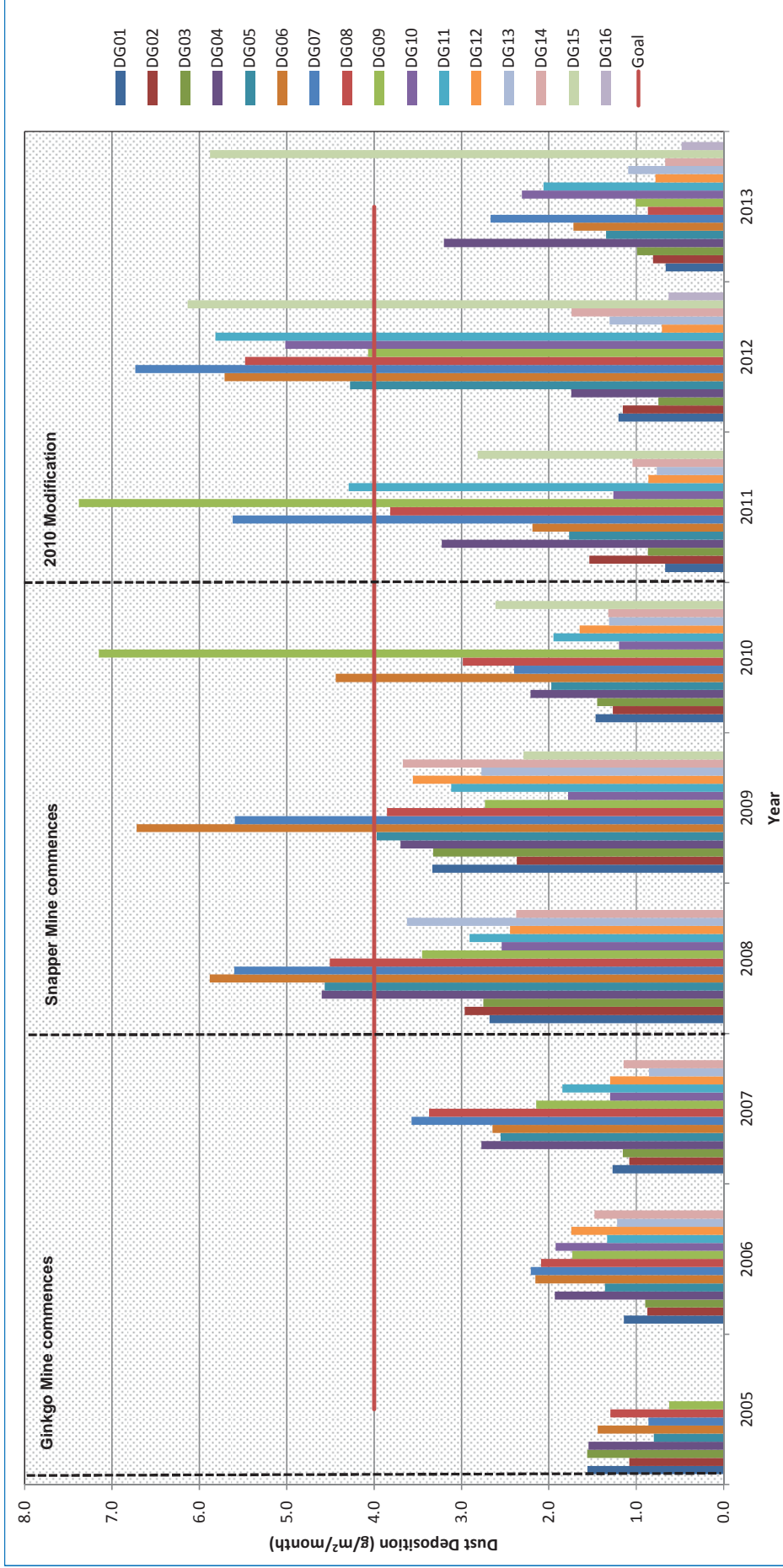


Figure 3.2: Annual Average Dust Deposition Levels (g/m²/month)

4 OVERVIEW OF PREVIOUS ASSESSMENTS

Pacific Environment (formally PAEHolmes and Holmes Air Sciences (HAS)) had previously completed air quality assessments for the Snapper and/or Ginkgo Mines in 2001, 2007 and 2010, as follows:

- Ginkgo Mineral Sands Mine Air Quality Assessment (the Ginkgo Mine AQA): for the construction and operation of the Ginkgo Mine (**HAS, 2001**).
- Snapper Mineral Sands Mine Air Quality Assessment (the Snapper Mine AQA): for the construction and operation of the Snapper Mine (**HAS, 2007**).
- 2010 Modification Air Quality Assessment (the 2010 Modification AQA): for a modification to both the Snapper and Ginkgo Mines, including changes to extraction rates and haulage of mineral concentrate/HMC (**PAEHolmes, 2010**).

In addition to these air quality assessments, Katestone prepared an air quality assessment for an application to modify the Ginkgo Mine Development Consent in 2012 to allow for the development of the Crayfish deposit (the Ginkgo Mine Modification AQA) (**Katestone, 2012**).

The 2010 Modification AQA and the Ginkgo Mine Modification AQA are the most relevant to the Modification and are discussed further in **Sections 4.1** and **4.2**.

4.1 2010 Modification AQA

The 2010 Modification AQA assessed the potential impacts of what is now the currently approved Snapper Mine (i.e. describes the currently approved Snapper Mine air quality impacts).

TSP emissions for the Snapper Mine were estimated for Years 2 and 9 (nominally 2011 and 2018). These estimated TSP emissions are shown in **Table 4.1**.

Table 4.1: Estimated Snapper Mine TSP emissions for the 2010 Modification

Activity	TSP emissions for Year 2 (kg/year)	TSP emissions for Year 9 (kg/year)
Bucket Scoop/Scraper loading, transporting and unloading topsoil	25,460	27,885
Dozers stripping overburden	101,250	101,250
Loading haul trucks	2,198	4,552
Haul trucks transporting overburden	458,913	1,629,016
Emplacement at overburden dumps	2,198	4,552
Dozers on overburden areas	134,999	134,999
Grading roads and open areas	21,566	21,566
Wind erosion from topsoil stockpiles	378,432	248,083
Wind erosion from overburden dumps	490,560	90,403
Wind erosion from disturbed area around mine	164,688	115,632
Wind erosion from product stockpiles	24,528	24,528
Total	1,804,792	2,402,466

Source: **PAEHolmes, 2010**.
(kg/year) kilograms per year

The 2010 Modification AQA also considered potential incremental TSP emissions from the proposed modifications to the Ginkgo Mine included in the 2010 Modification. The modifications to the Ginkgo Mine were considered to not add to previously predicted Ginkgo Mine TSP emissions (**PAEHolmes, 2010**) and therefore were not considered any further in the 2010 Modification AQA.

Dispersion modelling of the Snapper Mine Year 9 operations was conducted to assess the potential air quality impacts associated with the 2010 Modification. Year 9 of the Snapper Mine operations was chosen for dispersion modelling as it represented the ‘worst-case’ scenario in terms of estimated emissions and proximity to the nearby Manilla homestead. **Table 4.2** presents the results of the dispersion modelling for the 2010 Modification. The following background levels used for the 2010 Modification AQA were also used in the Snapper Mine AQA cumulative assessment for consistency:

- Annual average background TSP – 54 micrograms per cubic metre ($\mu\text{g}/\text{m}^3$).
- Annual average background PM_{10} – 22 $\mu\text{g}/\text{m}^3$.
- Annual average background dust deposition – 2.4 $\text{g}/\text{m}^2/\text{month}$.

Table 4.2: Predicted ‘Worst-Case’ PM_{10} and TSP Concentrations and Dust Deposition Levels for the 2010 Modification

Sensitive Receptor	Year 9 Operations	Impact Assessment Criteria
Predicted Maximum 24-hour average PM_{10} concentrations ($\mu\text{g}/\text{m}^3$)		
Manilla	48	50
Trelega	12	
Predicted annual average PM_{10} concentrations ($\mu\text{g}/\text{m}^3$) (Predictions with background are shown in parentheses)		
Manilla	5 (27)	30
Trelega	1 (23)	
Predicted annual average TSP concentrations ($\mu\text{g}/\text{m}^3$) (Predictions with background are shown in parentheses)		
Manilla	6 (60)	90
Trelega	1 (55)	
Predicted annual average dust deposition ($\text{g}/\text{m}^2/\text{month}$) (Predictions with background are shown in parentheses)		
Manilla	0.13 (2.5)	2 (4 - cumulative)
Trelega	0.02 (2.4)	

Source: PAEHolmes, 2010.

The 2010 Modification AQA concluded that there would be no exceedances of EPA impact assessment criteria at the nearest sensitive receptors with the exception of cumulative 24-hour PM_{10} concentrations (see below for more details of this exceedance).

A cumulative assessment of 24-hour PM_{10} concentrations analysed the frequency (days) of 24-hour PM_{10} concentrations at the Manilla Homestead. The analysis concluded that adverse air quality impacts above the EPA impact assessment criterion (i.e. 50 $\mu\text{g}/\text{m}^3$) would be unlikely at nearest private receptors due to the Snapper and Ginkgo Mines but that there would, on occasion, be exceedances of the EPA impact assessment criterion at all residential properties in the area due to non-mine related sources of PM_{10} , such as dust storms and bushfires (PAEHolmes, 2010).

4.2 Ginkgo Mine Modification AQA

The Ginkgo Mine Modification AQA assessed the potential impacts of the currently approved Snapper and Ginkgo Mines plus the proposed Crayfish deposit (i.e. describes the currently approved and proposed Snapper and Ginkgo Mine cumulative air quality impacts).

The cumulative assessment concluded that the combined operations would comply with the relevant EPA impact assessment criteria for TSP, particulate matter less than 2.5 microns ($\text{PM}_{2.5}$) and dust deposition. There was one additional 24-hour PM_{10} concentration exceedance of the EPA impact assessment criterion, which occurred on a high background day (Katestone, 2012). The conclusions in the Ginkgo Mine Modification AQA are similar to those presented in the Snapper Mine AQA and the 2010 Modification AQA; that is, on occasion there may be exceedances of the EPA impact assessment criterion for 24-hour PM_{10} when background is high (e.g. during dust storms, bushfires).

Katestone (2012) predicted an exceedance for annual average PM₁₀ at the Manilla residence, attributed predominantly to background concentrations (including the Snapper Mine). The predicted contribution from the Snapper Mine at the Manilla residence is similar to that predicted in **PAEHolmes (2010)**, however, the assumed background was lower, and therefore no exceedance was predicted in **PAEHolmes (2010)**.

5 ESTIMATED EMISSIONS FOR THE MODIFICATION

5.1 Mining Operations

The following components of the Modification have the potential to change the TSP emissions at the Snapper Mine:

- increase in the maximum annual overburden movement from 27.2 Mtpa to 36.8 Mtpa; and
- increase in the maximum annual topsoil movement from 145,540 m³ to 225,590 m³.

The proposed variations to the Snapper Mine mining sequence (i.e. Mining Options 1 to 3) and the increase in the maximum annual ore production rate are not expected to significantly change TSP emissions as mining would continue to be primarily undertaken using dredge mining (i.e. a wet process).

If an overburden slurry pipeline system is used in combination with the existing/approved truck and shovel methods it would result in a reduction in TSP emissions and the overburden material would be slurried for transport rather than transported 'dry' via haul truck.

The TSP emissions for the Modification have been estimated using the latest emission factors/equations to comply with the most recent and appropriate US EPA AP-42 emission estimation techniques. In particular, since the 2010 Modification, the contemporary standard emission factors for haul roads and wind erosion have been revised consistent with the most recent and appropriate US EPA AP-42 emission estimate techniques. The contemporary techniques require material parameters specific to the site (e.g. the silt content and moisture content of haul roads) to be considered when determining the emission factor. By comparison, for the 2010 Modification, default emission factors (i.e. used consistently for all mining operations in the state) were used, which did not require the consideration of material parameters relevant to the site.

The estimated TSP emissions for the Modification and the 2010 Modification (**Section 4**) are presented in **Table 5.1**.

Table 5.1: Estimated Snapper Mine TSP Emissions for the Modification and the 2010 Modification

ACTIVITY	Modification - TSP emissions in kg/y	2010 Modification - TSP emissions in kg/y
Bucket Scoop/Scraper loading, transporting and unload topsoil	39,463	27,885
Dozers stripping overburden	101,250	101,250
Loading haul trucks	6,175	4,552
Haul trucks transporting overburden	1,556,548	1,629,016
Emplacement at overburden dumps	6,175	4,552
Dozers on overburden areas	134,999	134,999
Grading roads and open areas	21,566	21,566
Wind erosion from topsoil stockpiles	62,021	248,083
Wind erosion from overburden dumps	22,601	90,403
Wind erosion from disturbed area around mine	28,908	115,632
Wind erosion from product stockpiles	6,132	24,528
Total Estimated Emissions	1,985,839	2,402,467

Note: The TSP emission estimate for the Modification has been calculated using a different methodology to that used for the 2010 Modification – see below for explanation.

The total estimated annual TSP emissions for the Modification are 1,985,839 kg/year, compared with 2,402,467 kg/year as estimated in the 2010 Modification AQA (PAEHolmes, 2010). This represents a decrease of 416,628 kg/year or 17% of the estimated TSP emissions in the 2010 Modification AQA.

The reduction in the estimated TSP emissions for the Modification in comparison to the 2010 Modification, despite the proposed increase in the rate of overburden and topsoil movement, is due to the use of the updated emission factors/equations to comply with the most recent and appropriate US EPA AP-42 emission estimation techniques. The contemporary emissions factors/equations for hauling and wind erosion relevant to the Snapper Mine are lower than the default emissions factors used in the 2010 Modification AQA.

5.2 Road Transport

The maximum mineral concentrate/HMC transport rate would increase from approximately 735,000 tpa to approximately 975,000 tpa for the Modification.

The increased mineral concentrate/HMC transport rate is required as the transport of ilmenite-rich mineral concentrate that has been stockpiled at the Ginkgo Mine would occur in parallel with the transport of mineral concentrates produced from ongoing production at the Snapper and Ginkgo Mines.

It is expected that there would be no increase in the approved mineral concentrate/HMC transport vehicle movements (i.e. 37 loads per day [or 74 movements per day]) despite the proposed increase in the mineral concentrate/HMC transport rate as larger AB-triple vehicles (capacity of 77 t) are now predominately used rather than double road trains (capacity of 54 t).

Although there would no change to the number of mineral concentrate/HMC transport movements, there would be an increase of approximately 3% in TSP emissions due to the increased vehicle gross mass of the mineral concentrate/HMC vehicles.

6 ASSESSMENT OF POTENTIAL IMPACTS

6.1 Mining Operations

The TSP emissions for the Modification have been estimated using the latest emission factors/equations to comply with the most recent and appropriate US EPA AP-42 emission estimation techniques (Section 5). The estimated TSP emissions for the Modification are lower than estimated in the 2010 Modification AQA. The reduction in the estimated TSP emissions despite the proposed increase in the rate of overburden and topsoil movement is due to the use of the updated emission factors/equations to comply with the most recent and appropriate US EPA AP-42 emission estimation techniques. The contemporary emissions factors/equations relevant to the Snapper Mine for hauling and wind erosion are lower than the default emissions factors used in the 2010 Modification AQA.

There would be no change to the currently approved Snapper Mine surface development area for the Modification, and therefore, there would be no change to the proximity of emission sources to the closest sensitive receivers.

As the predicted TSP emissions for the Modification are lower than the 2010 Modification and the proximity of emission sources to the closest sensitive receivers would remain unchanged, the dispersion modelling results in the 2010 Modification AQA would overstate the potential air quality impacts for the Modification. Therefore, revised dispersion modelling is not considered to be required for the Modification, as predicted impacts would be lower than those presented in the 2010 Modification AQA.

As discussed in **Section 4**, no exceedances of the EPA's impact assessment criteria as a result of the 2010 Modification were predicted but that there would, on occasion, be exceedances of the 50 µg/m³ criterion at all residential properties in the area due to non-mine related sources of PM₁₀, such as dust storms and bushfires. It is considered that the Modification would not change this conclusion as the estimated TSP emissions for the Modification are less than for the 2010 Modification.

6.2 Cumulative impacts

The Ginkgo Mine Modification AQA assessed the potential impacts of the currently approved Snapper and Ginkgo Mines plus the proposed Crayfish deposit (i.e. describes the currently approved and proposed Snapper and Ginkgo Mine cumulative air quality impacts).

The cumulative assessment concluded that the combined operations would comply with the relevant EPA impact assessment criteria for TSP, PM_{2.5} and dust deposition. There was one additional 24-hour PM₁₀ concentration exceedance of the EPA impact assessment criterion, which occurred on a high background day (**Katestone, 2012**). The conclusions in the Ginkgo Mine Modification AQA are similar to those presented in the Snapper Mine AQA and the 2010 Modification AQA; that is, on occasion there may be exceedances of the EPA impact assessment criterion for 24-hour PM₁₀ when background is high (e.g. during dust storms, bushfires).

Katestone (2012) predicted an exceedance for annual average PM₁₀ at the Manilla residence, attributed predominantly to background concentrations (including the Snapper Mine). The predicted contribution from the Snapper Mine at the Manilla residence is similar to that predicted in **PAEHolmes (2010)**, however, the assumed background was lower, and therefore no exceedance was predicted in **PAEHolmes (2010)**.

It is considered that the Modification would not change the conclusions in the Ginkgo Mine Modification AQA as the estimated TSP emissions for the Modification are less than for the 2010 Modification.

6.3 Road transport

Although there would no change to the number of mineral concentrate/HMC transport movements, there would be an increase of approximately 3% in TSP emissions due to the increased vehicle gross mass of the mineral concentrate/HMC vehicles. Given the closest sensitive receiver to the mineral concentrate transport route is approximately 1 km away, an increase in TSP emissions of 3% is unlikely to result in measureable increases in dust at residences located along the mineral concentrate transport route.

7 CONCLUSIONS

This review of the potential air quality impacts associated with the Modification is based on:

- A review of the existing dust monitoring in the vicinity of the Snapper and Ginkgo Mines; and
- A comparison of dust emissions for the Modification with the information presented in existing air quality assessments (i.e. the Snapper AQA, 2010 Modification AQA and the Ginkgo Mine Modification AQA).

The review found that no exceedances of the EPA's impact assessment criteria as a result of the Modification were predicted but that there would, on occasion, be exceedances of the 24-hour PM₁₀ criterion (50 µg/m³) at all residential properties in the area due to non-mine related sources of PM₁₀, such as dust storms and bushfires.

In addition, the study found that the Modification is unlikely to result in measureable increases in dust at residences located along the mineral concentrate transport route.

8 REFERENCES

Bureau of Meteorology website (2014)

http://www.bom.gov.au/inside/services_policy/public/sigwxsum/sigwmenu.shtml

Bemax Resources (2010) Ginkgo Mineral Sands Mine Annual Environmental Management Report.

Bemax Resources (2013) Snapper Mineral Sands Mine Annual Environmental Management Report 2012.

Holmes Air Sciences (2001) "Air Quality Assessment: Ginkgo Mineral Sands Project, NSW" Prepared for BeMax Resources NL by Holmes Air Sciences, August 2001.

Holmes Air Sciences (2007) "Air Quality Assessment: Snapper Mineral Sands Project" Prepared for BEMAX Resources Limited by Holmes Air Sciences, January 2007.

Katestone Environmental Pty Ltd (2012) "Air Quality Impact and Greenhouse Gas Assessment – Ginkgo Mineral Sands Mine, Crayfish Modification" Prepared for BEMAX Resources Limited, November 2012.

PAEHolmes (2010) "Snapper & Ginkgo Mines Modification – Air Quality Impact Assessment" Prepared for BEMAX Resources Limited by PAEHolmes, April 2010.