27 March 2017

Gwen Wilson
Broken Hill Operations Pty Ltd

Dear Gwen,

Re: Air Quality Assessment for the Rasp Mine Modification 4

1 INTRODUCTION

Pacific Environment has been commissioned by Broken Hill Operations Pty Ltd (BHOP), a wholly owned subsidiary of CBH Resources Ltd (CBH), to complete an air quality and greenhouse gas impact assessment for a proposed Modification to Rasp Mine, Broken Hill (Modification 4).

The Rasp Mine is an underground silver/zinc/lead operation located within the city limits of Broken Hill, NSW. The Mine also has the facilities to process the ore and dispatch concentrate products from the site by rail. There are a number of auxiliary facilities including maintenance workshops, inventory, chemical and explosives storage, backfill plant and rail siding.

BHOP seeks to modify the Rasp mine approval to:

- Install a Concrete Batching Plant (CBP) for the manufacture of fibrecrete and concrete for use at the Mine site; and
- Extend the life of the Blackwood Pit Tailings Storage Facility (TSF2) by installing embankments and a retaining wall at low points along its perimeter. TSF2 would comprise Embankments 1, 2 and 3.

The location of the proposed CBP and embankments that would comprise TSF2 are shown in **Figure 1-1**.

The following scope of work has been completed as part of the subject air quality assessment:

- Process site representative meteorology consistent with the methodology undertaken for previous air quality assessments to obtain a minimum one year of meteorological inputs suitable for use within an atmospheric dispersion model (AERMOD);
- Determine baseline local air quality based on 2016 operations;
- Undertake atmospheric dispersion modelling for the worst case emissions scenario; and
- Present the predicted air quality impacts (TSP, PM_{10}, $PM_{2.5}$, dust deposition and lead) within a letter report suitable for submission to the relevant authorities (NSW Department of Primary Industries (DPI) and Environment Protection Authority (EPA)).

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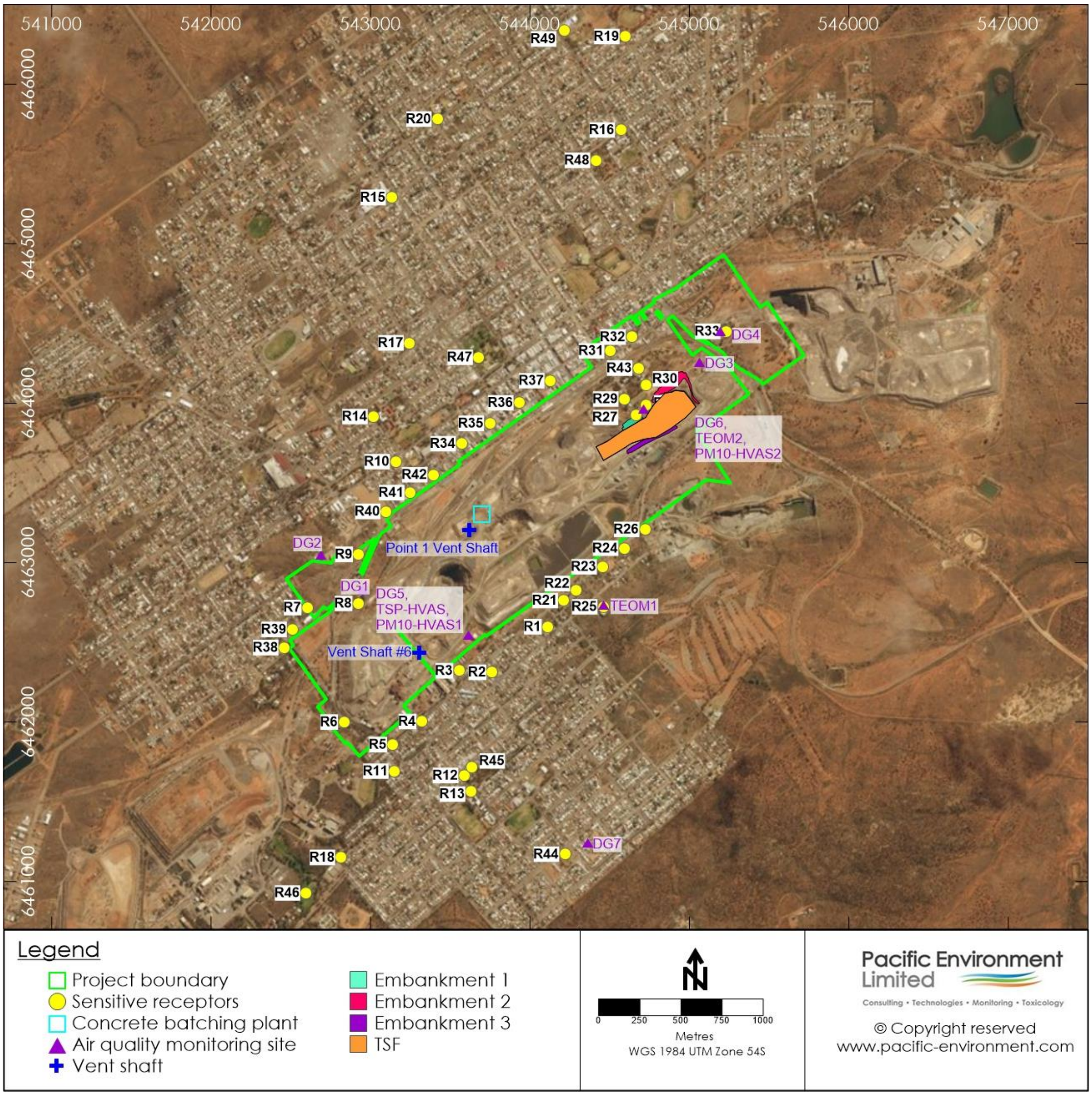

Figure 1-1: Location of proposed Concrete Batch Plant, Embankments 1,2 and 3, sensitive receptors and air quality monitoring network

2 AMBIENT AIR QUALITY CRITERIA

The *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (Approved Methods) (**EPA, 2016**) specifies air quality assessment criteria relevant for assessing impacts from air pollution. The air quality goals relate to the total particulate matter (PM) burden in the air and not just the PM from the Project. In other words, consideration of background PM needs to be made when using these goals to assess potential impacts. These criteria are health-based (i.e. they are set at levels to protect against health effects). These criteria are consistent with the *National Environment Protection Measure for Ambient Air Quality* (referred to as the Ambient Air-NEPM) (**NEPC, 1998a**).

Table 2-1 provides a summary of the air quality goals for pollutants that are relevant to this study. It is important to note that, with the exception of deposited dust, the criteria are applied to the cumulative impacts due to the proposed modification and other existing sources.

Table 2-1: NSW EPA Air Quality Criteria

Pollutant	Standard	Averaging Period
TSP	90 µg/m³	Annual
PM_{10}	50 µg/m³	24-Hour
	25 µg/m³	Annual
$PM_{2.5}$	25 µg/m³	24-Hour
	8 µg/m³	Annual
Pb (TSP fraction)	0.5 µg/m³	Annual
Deposited dust	2 g/m²/month (incremental) 4 g/m²/month (cumulative)	Annual

Notes: µg/m³ – micrograms per cubic metre.

In 2017 the EPA released an update to the Approved Methods **(EPA, 2016)** that includes an update to the annual PM_{10} criterion from 30 µg/m³ to 25 µg/m³. It is noted that the current Project Approval for Rasp Mine does not currently reflect this update. For the purposes of this assessment the criterion used is in line with current NSW policy **(EPA, 2016)**.

3 DISPERSION MODEL SET UP

3.1 Emissions inventory

Based on the project description, it is considered that the construction of Embankment 2 (E2) has the greatest short-term particulate emission potential, and has hence been used to predict the worst case 24-hour emissions. As Embankment 2 construction would take place over approximately 21 weeks it has been combined with Embankment 3 (16 weeks) for the consideration of annual averaging periods. Both the short-term and long-term emission calculations include emissions from the construction of a storm water collection pond, and for conservatism, the operations of the concrete batching plant.

The assumptions in the emissions estimates are generally based on those documented within **Environ (2010)**, with detailed information on mining operations having been provided by Rasp Mine.

PM emissions have been calculated for annualised and short-term scenarios in accordance with the relevant PM averaging periods:

- Annual average emissions - based on total material quantities to be handled for the construction of E2, E3 and CBP operating at 15,000 m³ per year.
- Worst case 24-hour emissions - based on maximum daily rate of 500 m³/day to be handled for the construction of E2 and CBP operating at 40 m³ per day.

The assumptions adopted in calculating PM emissions for this assessment have followed those used in **Environ (2010)**. A detailed list of assumptions are provided in **APPENDIX A**.

The calculation of potential lead (Pb) emissions was based on the percentage lead composition of different material substrates as established within **Environ (2010)**. In this manner, TSP emission estimates provided the basis for projecting suspended metal concentrations for comparison with NEPM criterion.

Compositional data on waste rock (used for embankment construction), unpaved roads and free areas, based on site-specific material sampling, has been made available for this assessment. These data are anticipated to provide a conservative estimate of lead percentage composition of waste rock. The adopted percentage lead composition used in this assessment are as follows:

- Waste rock = 0.5% Pb
- Unpaved roads = 2.4% Pb
- Free areas = 1.4% Pb.

Table 3-1 provides a summary of the PM and lead emissions inventory used in the dispersion modelling.

Table 3-1: Emissions estimates for Modification 4 (kg/y)

Activity	Annual emissions				Worst case 24-hour emissions*	
	TSP	PM_{10}	$PM_{2.5}$	Pb(TSP)	PM_{10}	$PM_{2.5}$
Waste rock - load in pit	59.3	28.0	4.2	0.3	176.4	26.7
Waste rock - haul to E2 (sealed)	1,170.1	125.6	30.4	28.1	1,413.5	342.0
Waste rock - haul to E2 (unsealed)	1,875.7	405.2	40.5	45.0	2,956.5	295.6
Waste rock - dump at E2	59.3	28.0	4.2	0.3	176.4	26.7
Prep E2 footprint - load at E2	4.1	0.7	0.3	0.1	-	-
Prep E2 footprint - haul within E2	50.7	11.0	1.1	1.2	-	-
Prep E2 footprint - dump at E2	4.1	1.9	0.3	0.1	-	-
Filter sand - load at external site	5.1	2.4	0.4	-	-	-
Filter sand - haul to E2 (sealed)	80.5	10.9	2.6	1.9	-	-
Filter sand - haul to E2 (unsealed)	-	-	-	-	-	-
Filter sand - dump at E2	5.1	2.4	0.4	-	-	-
Crushed rock rest layer - load in pit	4.1	1.9	0.3	0.0	-	-
Crushed rock rest layer - haul to E2 (sealed)	80.7	8.7	2.1	1.9	-	-
Crushed rock rest layer - haul to E2 (unsealed)	129.4	27.9	2.8	3.1	-	-
Crushed rock rest layer - dump at E2	4.1	1.9	0.3	0.0	-	-
Crushed rock rest layer - screening in pit	-	-	-	-	-	-
Crushed rock rest layer - primary crushing in pit	42.0	16.8	4.4	0.2	401.5	105.4
Anchorage of liner - haul to E2 (sealed)	8.4	1.6	0.4	0.2	14.7	3.6
Anchorage of liner - haul to E2 (unsealed)	-	-	-	-	-	-
Crest anchor trench - haul to E2 (sealed)	8.4	1.6	0.4	0.2	14.7	3.6
Crest anchor trench - haul to E2 (unsealed)	-	-	-	-	-	-
E2 - Dozer	1,318.7	239.2	138.5	6.6	610.5	353.4
Wind Erosion - E2 (during construction)	280.8	140.4	21.1	3.9	280.8	42.1
Wind Erosion - E2 (after construction)	14.0	7.0	1.1	0.2	14.0	2.1
Truck movement - cement	33.7	6.5	0.3	0.8	8.2	0.4
Truck movement - aggregate	82.7	15.9	0.8	2.0	20.2	1.0
Truck movement - sand	317.1	60.9	2.9	7.6	77.7	3.8
Truck movement - shotcrete	129.4	24.8	1.2	3.1	31.7	1.5
Loading cement at rail siding	12.8	6.1	0.9	-	7.1	1.1
Aggregate transfer	32.7	15.9	0.9	-	18.7	1.0
Sand transfer	16.5	7.6	0.4	-	9.0	0.5
Cement transfer	3.3	1.1	0.2	-	1.3	0.2
Weigh hopper loading	20.1	10.0	0.6	-	11.8	0.7
Truck loading	378.6	101.2	5.7	-	119.1	6.7
De-dusted air loading cement and fly-ash	-	52.5	2.9	-	61.8	3.5

Activity	Annual emissions				Worst case 24-hour emissions*	
	TSP	PM10	PM2.5	Pb(TSP)	PM10	PM2.5
Wind erosion (aggregate stock piles)	26.3	13.1	2.0	0.4	13.1	2.0
Wind erosion (whole CBP)	15.3	7.7	1.1	0.2	7.7	1.1
Waste rock - load in pit	41.9	19.8	3.0	0.2	-	-
Waste rock - haul to E3 (unsealed)	1,143.7	286.5	28.6	27.4	-	-
Waste rock - haul to E3 (sealed)	300.5	57.7	14.0	7.2	-	-
Waste rock - dump at E3	41.9	19.8	3.0	0.2	-	-
Filter sand - load at external site	4.9	2.3	0.4	-	-	-
Filter sand - haul to E3 (unsealed)	10.0	2.0	8.4	0.2	-	-
Filter sand - dump at E3	4.9	2.3	0.4	-	-	-
Crushed rock rest layer - load in pit	4.1	1.9	0.3	0.0	-	-
Crushed rock rest layer - haul to E3 (unsealed)	111.6	27.9	2.8	2.7	-	-
Waste rock - haul to E3 (sealed)	29.3	5.6	1.4	0.7	-	-
Crushed rock rest layer - dump at E3	4.1	1.9	0.3	0.0	-	-
Crushed rock rest layer - screening in pit	-	-	-	-	-	-
Crushed rock rest layer - primary crushing in pit	42.0	16.8	4.4	0.2	-	-
Toe and side anchorage of liner - haul to E3 (unsealed)	34.8	10.3	0.9	0.8	-	-
Crest anchor trench - haul to E3 (unsealed)	34.8	10.3	0.9	0.8	-	-
E3 - Dozer	1,098.9	199.3	115.4	5.5	-	-
Wind Erosion - E3 (during construction)	152.7	76.3	11.4	0.8	-	-
Wind Erosion - E3 (after construction)	7.6	3.8	0.6	0.0	-	-
Total	**9,341**	**2,131**	**472**	**154**	**6,447**	**1,225**

Note: **Annualised worst case 24-hour* emission estimates are reflective of the emission quantity applied in the model for the estimation of peak 24-hour impacts (i.e. assuming short-term peak operations occur on a continuous basis). These quantities are not reflective of annual emission estimates.

3.1.1 Control measures

Waste rock handling

A control efficiency of 50% has been applied to the handling of waste rock emplaced at the embankments. Water is integral to the construction process whereby the material to be constructed is wetted to aid in compaction and strengthen the integrity of the final structure of the embankment. This will be facilitated by a spray system curing capping material placement. Therefore, in reality the material handling activities by their very nature will be wet resulting in minimal PM emissions.

Tailings storage facility emissions

Field testing of dust lift-off from the tailings storage facility (TSF) was completed on 9 November 2016. The purpose of the study was to undertake a field survey of wind erosion potential from exposed surface areas at the Rasp Mine, Broken Hill. The full report is provided in **APPENDIX G.**

The results of the testing indicate that observed levels of moisture at the TSF (shown in **Figure 3-1**) are adequate for operational dust control. For moist surfaces within the TSF, confined air burst chamber (CABC) testing indicated a 100% control efficiency, whilst the USEPA sieving method classified the material as being non-conducive to wind erosion.

Where present, dry, crusted areas were also observed to provide a high level of control relative to disturbed surfaces, equivalent to the proposed final waste rock cover for the TSF.

The above conclusion assumes that crusted tailings remain undisturbed. On that basis, the use of waste rock cover is considered a more resilient, and less readily disturbed surface for the long-term containment of TSF material after the point at which the TSF is no longer active.

The field testing can be used to inform future operational dust control measures for the TSF, as follows:

- The threshold wind velocity for TSF material has been determined empirically and can be used for future alerts / alarms when combined with local wind speed observations.
- Selective use of dust suppressant in TSF spray system will aid control of the TSF when used in the proposed TSF spray system, particularly at the end of the TSF's operational life.
- Alerts / alarms can be set up on existing instrumentation to inform the use of TSF spray system
- As an additional safeguard, alerts can be set both for critical PM concentrations and wind velocities recorded in proximity to the TSF surface.

Figure 3-1: Tailings dam (TSF2) at Rasp Mine, 9 November 2016

Emissions from the TSF have been estimated assuming that under normal operations, 5% of the total area of the TSF (~9 ha) would be dry, and therefore susceptible to wind erosion. Of this 9 ha, 90% would comprise dry tailings and 10% dry fines. To consider a worst-case scenario, TSF 'upset conditions' were also assessed. This model scenario, designed to simulate a long-term breakdown of the proposed TSF spray system alongside limited cover supplied by fresh wet tailings across the TSF, assumes that 25% of the TSF is dry. The same apportionments of dry areas and dry fines were adopted as per the normal operations scenario.

It is noted that the control efficiency of the TSF crusting has not been explicitly accounted for in either scenario. Rather, the ability for PM generation is based on invoking the threshold friction velocity (the minimum wind speed required to liberate PM) established through the empirical testing detailed in

Appendix E. The estimated lead emissions have been based on data provided by BHOP; that tailings comprise 0.31% lead. The project terrain during the construction phase of Modification 4 has been referenced in the modelling.

The annual emissions from the TSF, under both normal and upset conditions, are summarised in **Table 3-2**.

Table 3-2: Summary of wind erosion emissions from the TSF for normal and upset conditions (kg/yr)

Scenario	TSP	PM_{10}	$PM_{2.5}$	Pb (TSP)
Normal conditions				
Dry area	1,562	781	117	4.8
Dry Fines	2,716	1,358	204	8.4
Upset conditions				
Dry area	7,812	3,906	586	24.2
Dry Fines	13,581	6,790	1,019	42.1

Note: *Annualised upset* emission estimates are reflective of the emission quantity applied in the model for the estimation of peak 24-hour impacts (i.e. assuming short-term peak operations occur on a continuous basis). The impact of upset conditions has not been calculated on an annual basis, as any upset scenario would be, by definition, only short-term in nature.

It is noted that the annual wind erosion emissions during upset conditions that are presented in **Table 3-2** would never actually occur for more than a 24-hour period. Annual, rather than 24-hour, emissions have been provided for comparative purposes only.

Wind erosion post-TSF closure

A very high level of control is demonstrated through the field testing for the proposed waste rock capping of the TSF (>99% compared to uncontrolled tailings; refer **APPENDIX G**). It is thus anticipated that an assumption that there would there would be no change in lead deposition from normal operations post-TSF closure is conservative (see **Section 5.6**).

Dust suppression on haul roads

Dust suppressants work by either agglomerating the fine particles, binding the surface particles together, or increasing the density of the road surface material. They reduce the ability of the surface particles to be lifted and suspended by vehicle tyres, vehicle-induced air turbulence, or the ambient wind.

A significant portion of the haul roads at Rasp Mine are paved, with the only unpaved sections understood to be down to Kintore Pit and a small section at the rail load out facility. It is noted that the working tracks to be used for the TSF embankment construction are also considered unpaved.

The estimated haul road PM emissions have adopted an 80% control efficiency associated with the application of a chemical suppressant to unpaved roads. Consistent with the Preferred Project Report (PPR) for the Rasp mine (**Environ (2010)**), it is understood that paved roads are regularly watered and swept, and therefore a 90% control efficiency has been applied.

Table 3-3 evaluates the performance of a range of chemical dust suppressants under a range of operational and environmental conditions. The choice of an effective dust suppressant at Rasp Mine should take into consideration these findings, but should be made taking into account site-specific conditions (and preferably verified empirically).

Table 3-3: Dust Suppressant Product Selection Chart

Dust Suppressant	Traffic Volumes (Average Daily Traffic)			Surface Material								Climate During Traffic		
				Plasticity Index			Fines (% Passing 75µm, No. 200 Sieve)							
	Light <100	Medium 100 to 250	Heavy >250[a]	<3	3-8	>8	<5	5-10	10-20	20-30	>30	Wet&/or Rainy	Damp to Dry	Dry[b]
Calcium Chloride	Good	Good	Fair	Poor	Fair	Good	Poor	Fair	Good	Fair	Poor[c]	Poor[c,d]	Good	Poor
Magnesium Chloride	Good	Good	Fair	Poor	Fair	Good	Poor	Fair	Good	Fair	Poor[c]	Poor[c,d]	Good	Fair
Petroleum	Fair	Fair	Fair	Good	Fair	Poor	Fair[e]	Fair	Fair[e]	Poor	Poor	Fair[c]	Good	Fair
Lignin	Good	Good	Fair	Poor	Fair	Good[e]	Poor	Fair	Good	Good	Fair[c,e]	Poor[d]	Good	Good
Tall Oil	Good	Fair	Poor	Good	Fair	Poor	Poor	Fair	Good[e]	Fair[c]	Poor	Fair	Good	Good
Vegetable Oils	Fair	Poor	Poor	Fair	Fair	Fair	Poor	Fair	Fair	Poor	Poor	Poor	Fair	Fair
Electro-chemical	Good	Fair	Fair	Poor	Fair	Good	Poor	Fair	Good	Good	Good	Fair[c,d]	Fair	Fair
Synthetic Polymers	Good	Fair	Poor	Good	Fair	Poor	Poor	Good	Good[e]	Poor	Poor	Fair	Good	Good
Clay additives[e]	Good	Fair	Poor	Good	Good	Fair	Good	Fair	Fair	Poor	Poor	Poor[c]	Fair	Good

Source: **Bolander & Yamada, 1999**

Notes:

a) May require higher or more frequent application rates, especially with high truck volumes;
b) Greater than 20 days with less than 20% humidity;
c) May become slippery in wet weather;
d) SS-1 or CSS-1 with only clean, open-graded aggregate;
e) Road mix for best results.

3.2 Characterising background air quality

As the Rasp Mine is operating, incremental PM contributions from the current operations are captured by the Rasp Mine air quality monitoring network.

Therefore to provide a more accurate understanding of the 'background' conditions (i.e. in the absence of mine activities), the current operations of Rasp Mine have been modelled using known quantities of materials handled and haul truck movements. The assumptions adopted in calculating PM emissions for this assessment have followed those used in **Environ (2010)**. A detailed list of assumptions are provided in **APPENDIX B**.

Background air quality has then been estimated referencing the ambient air quality monitoring data for 2016, minus Rasp Mine's contribution for during the same (modelled) year.

3.3 Model selection

For consistency with the original environmental assessment (EA), and historical modelling and assessment **(Pacific Environment 2011; 2013; 2014; 2015a; 2015b)**, the current assessment has used the US-EPA regulatory model, AERMOD. A detailed account of the model selection and modelling methodology is presented in the air assessment **(Environ, 2010)**.

3.4 Sensitive receptors

The NSW EPA definition of sensitive receptors **(EPA, 2016)** is:

> *"A location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area."*

In total, 49 sensitive receptors have been included in this study. There are 42 from the original study **(Environ, 2010)** and additional seven receptors of which include the bowling green and six playgrounds. Their location is shown in **Figure 1-1** and summary tables that describes each receptor in **APPENDIX D**.

Previous work completed as part of the most recent Health Risk Assessment (HRA) for the Rasp Mine *Health Risk Assessment Rasp Mine Broken Hill* **(Pacific Environment, 2015b)** specifically considered two sensitive receptors (R8 and R27). The evaluation of impacts at these two (effectively fenceline) receptor locations provides a conservatively high representation of impacts within the Broken Hill community. It may be reasonably assumed that potential mine-related impacts will be reduced at other locations, given that they will be further removed from the mine's operations.

4 EXISTING ENVIRONMENT

4.1 Dispersion Meteorology

Air pollutant concentrations are strongly influenced by meteorological conditions, primarily in the form of prevailing wind directions and interactions with diurnal flow regimes. Wind speed, wind direction, temperature and relative humidity all affect the dispersion and transport of pollution, and are basic input requirements for dispersion modelling. The local meteorology for Broken Hill has been described in detail in **Environ (2010)**.

The annual wind roses for 2008 and 2009 were reviewed as part of **Environ (2010)** and have been reproduced below in **Figure 4-1**.

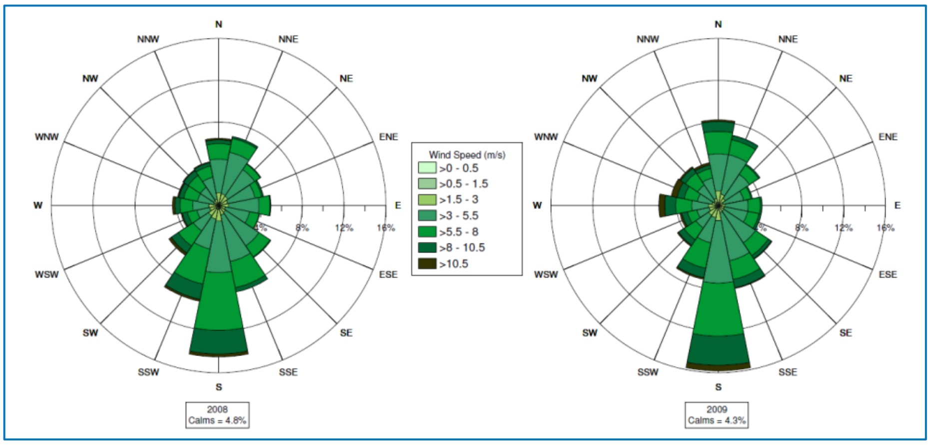

Figure 4-1: 2008 and 2009 annual wind roses for Broken Hill (source: Environ, 2010)

As some time has elapsed since the original EA a more recent meteorological dataset has been compiled for the year 2016 and has been used in the dispersion modelling. The annual and seasonal wind roses for 2016 are shown in **Figure 4-2**.

Across all three years, the annual wind roses display a very similar wind distribution pattern, with the highest frequency of winds originating from the south. In the 2016 dataset the frequency of winds is more evenly spread across the south, south-southeast and south-southwest.

Figure 4-2: Annual and seasonal wind roses for Broken Hill Airport (2016)

4.2 Local air quality

In 2015, *Health Risk Assessment Rasp Mine Broken Hill* (**Pacific Environment, 2015b**) provided an extensive review of the monitoring data collected on behalf of BHOP between 2008 and 2014.

The following provides a description of the ambient air quality monitoring that has been conducted at the site. All of these data were subsequently reviewed as part of **Pacific Environment (2015b)**:

- Three High volume Air Samplers (HVAS) measuring Total Suspended Particulate (TSP) / particulate matter less than 10µm in aerodynamic diameter (PM_{10}) and lead (Pb) concentrations at three locations on site;
- Two Tapered Element Oscillating Microbalances (TEOMs) measuring PM_{10} at two locations on site; and
- Seven Dust Deposition Gauges (DDGs) measuring dust deposition and % deposited Pb at seven locations on site.

These data have been assessed to examine temporal trends between 2008 and 2014 (subject to data availability). The mean, maximum, minimum, median, standard deviation, 25^{th} and 75^{th} percentile statistics were then determined for each financial year (FY) period.

The current assessment has drawn on the extensive database of air quality monitoring reviewed in **Pacific Environment (2015b**) and has incorporated more recent data up to and including December 2016 to establish background air quality associated with the currently operating Rasp Mine and the contributions from other sources in the Broken Hill area (for example, wood fire smoke and agriculture). Note that only six months of monitoring data is available for FY17 and therefore the results presented for FY17 are not representative of whole year of data. The data show an ongoing trend of improvement in the local air quality across all parameters measured (TSP, PM_{10}, lead and deposited dust).

Background data has been used that corresponds with the year of modelling, 2016. Given that there are several locations where PM_{10}, lead and deposited dust have been measured, a representative background dataset for each receptor has been based on the location of the sensitive receptor. Information on the allocated monitor are provided in **APPENDIX D**.

The following provides a summary of the adopted background values used for this assessment:

- PM_{10} annual average concentration = (TEOM 1 = 13.0 µg/m^3 ; TEOM 2 = 13.1 µg/m^3)
- PM_{10} 24-hour concentration = daily varying from either TEOM 1 or TEOM 2
- $PM_{2.5}$ annual average concentration = (TEOM 1 = 5.3 µg/m^3 ; TEOM 2 = 7.1 µg/m^3)[1]
- $PM_{2.5}$ 24-hour concentration = daily varying as ratio from either TEOM 1 or TEOM 2
- TSP annual average concentration = 35.8 µg/m^3
- Annual monthly average deposited dust = (0.4 g/m^2/month to 2.6 g/m^2/month)
- Annual average lead (TSP) concentration = (HVAS = 0.23 µg/m^3)
- Annual lead deposition (TSP fraction)= 0 µg/m^3

[1] There were no $PM_{2.5}$ monitoring data available to establish background concentrations. Therefore a $PM_{2.5}/PM_{10}$ ratio of 0.41 has been adopted. This value was based on the $PM_{2.5}/PM_{10}$ ratio for the OEH monitoring station at Wagga Wagga for 2016.

4.2.1 Background lead deposition

From the above, it is noted that the background annual lead deposition rates adopted for this assessment are 0 g/m^2/year. This is since the model predictions corresponding to 2016 operations indicated that mine-only activities more than accounted for the observed lead deposition rates (i.e. the model currently over-predicts Pb deposition with model results higher than monitored results at the majority of monitoring locations). A summary of the Pb (in TSP) emission estimates and adopted %Pb composition is provided in **APPENDIX B**.

The model predictions for the other air quality metrics were below their equivalent monitored concentrations. This is not to say that the model has under-predicted the remaining air quality metrics, but rather the model over-prediction for Pb deposition demonstrates that the emission inventory inputs regarding percentage lead within the site materials are considered to be conservatively high (see **APPENDIX B**).

Such a model over-prediction is not unexpected given the desire to adopt conservatively high assumptions within dispersion modelling exercises. To be explicit, this does not suggest that there are no other potential sources of fugitive lead in Broken Hill outside of the boundary of CML7, but rather that this assessment demonstrates a conservative approach in the evaluation of potential lead impacts. Other sources of lead deposition in the Broken Hill area include industrial processes within Broken Hill as well as natural / legacy dust sources from soils with elevated Pb levels that occur around the vicinity of the ore body.

On the basis of the above, to account for this model artefact no accounting of background Pb deposition is required when reconciling model predictions with observed levels of Pb deposition.

5 AIR QUALITY IMPACT ASSESSMENT

Incremental Project-related concentrations and deposition rates occurring due to operation of the CBP, combined with the construction of E2 and E3 embankments, were modelled (termed 'Incremental Mod 4 + CBP').

Model predictions for the TSF during upset operating conditions have only been provided for the short term averaging periods (i.e. maximum 24-hour PM_{10} and $PM_{2.5}$ concentrations). This is because the annual averaging periods are not relevant as the management of such upset conditions would be control emission within a short time frame.

It is both instructive and appropriate to model Modification 4 in isolation (i.e. without the inclusion of other emission sources on site). This is since any PM and Pb emissions associated with current operations at the Rasp Mine would be captured within the air quality monitoring data that currently takes place. A summary of the results for the current operations compared with those predicted for the PPR **(Environ, 2010)** are provided in **APPENDIX C**.

Model results are expressed as the maximum predicted concentration for each averaging period at the sensitive receptors over a twelve month period (calendar year 2016).

5.1 24-Hour and Annual Average PM_{10}

The maximum incremental 24-hour and annual average PM_{10} concentrations predicted to occur at nearby receptor locations due to Modification 4 for the modelled year 2016 are summarised in **Table 5-1**. The corresponding contour plots are included in **Appendix D**. It should be noted that these plots do not represent the dispersion pattern on any individual day. Rather, they illustrate an ensemble of the maximum concentrations simulated to be possible at each gridded receptor point across the modelling domain given the range of meteorological conditions occurring over the period modelled.

The contour plots for the maximum incremental 24-hour and annual average concentrations show that the PM_{10} concentrations are for the most part isolated to within the close vicinity to the CBP, E2, E3 and the associated haul roads.

The contribution of Modification 4 to the annual average impact assessment criterion (25 µg/m^3)[2] is approximately 1% (0.19 µg/m^3), and adds an additional 3% (0.66 µg/m^3) to the cumulative total when considered in conjunction with current operations. These are considered negligible contributions to the PM exposure in the Broken Hill area.

The receptor that is predicted to experience the maximum incremental 24-hour average contribution is R28, located to the immediate west of Embankment E2. This receptor is located at a heritage building located within CML7. The maximum 24-hour average increment at R28 is predicted to be 3.2 µg/m^3, approximately 6% of the EPA impact assessment criterion of 50 µg/m^3. It is noted that R28 is a mine owned building that has not been occupied in over 20 years.

Also included are the cumulative results, using on-site monitoring data for a Level 2 contemporaneous assessment in accordance with the Approved Methods **(EPA, 2016)**.

As Rasp Mine currently operate two TEOMs within the vicinity of the sensitive receptors assessed as part of this study, both TEOM data sets have been used where those receptors located to the north of the mine would most likely have a background (all sources) most similar to the PM_{10} measurements at TEOM 2 (see **Figure 1-1**). Similarly, for those receptors located to the south of Rasp Mine the TEOM 1 dataset have been referenced.

All cumulative results are predicted to be below the relevant impact assessment criterion. The exception to this is under the upset scenario, at receptor R27, which is shown in bold within **Table 5-1**. Receptor R27, located to the immediate southwest of R28 (see **Figure 1-1**), the predicted increment (52 µg/m^3) is just above the NSW impact assessment criterion of 50 µg/m^3. This exceedance is predicted to occur on one day during the modelling period (14 January 2016), under specific meteorological conditions coinciding with an upset event. Further, and for context in the evaluation of this predicted exceedance under upset scenario, it is noted that the Ambient Air-NEPM (**NEPC, 1998a**) allows for five exceedances per year.

On the day of this predicted 'upset scenario' exceedance, 11 of the 24 hours recorded wind speeds in excess of 10 m/s, resulting in elevated emissions from the TSF due to the threshold friction velocity required for TSF dust generation being exceeded. Source apportionment plots have been prepared for the 24-hour contributions during normal and upset TSF operating conditions for the day in question and are shown in **Figure 5-1**. During upset, the contribution of TSF emissions at Receptor R27 is almost triple that predicted for worst-case conditions under normal operations, and significantly greater than emission contributions from the rest of the mine and Modification 4 activities.

[2] The criterion in Rasp Mine's current Project Approval is 30 µg/m^3. See **Section 2** for further detail.

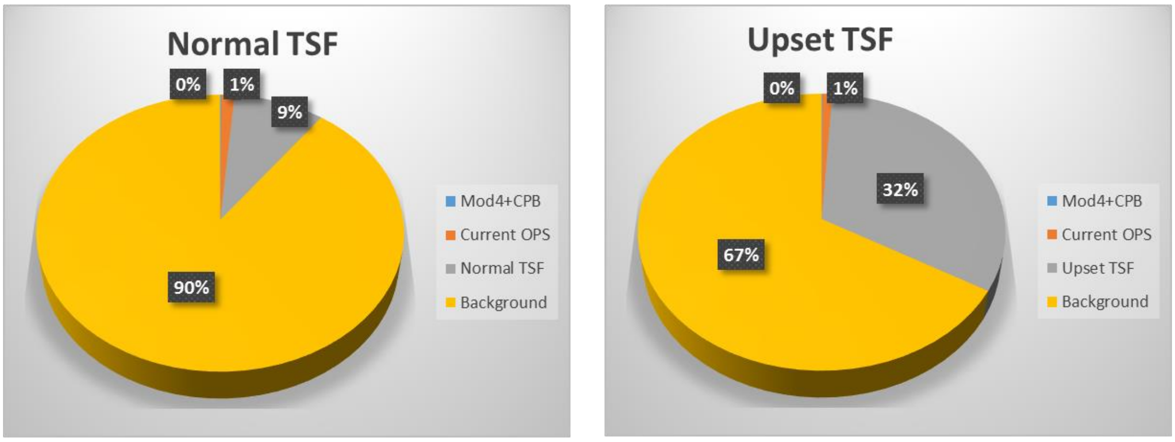

Figure 5-1: Source contributions at R27 for maximum 24-hour average PM_{10} predictions

It is considered that this exceedance event (upset conditions coinciding with elevated background PM_{10} concentrations) is unlikely to occur in reality, especially when the operational dust management activities documented in **Section 6** are implemented.

It is noted that the maximum 24-hour average results for almost all receptors is the same for normal and upset TSF operations. This has occurred because a contemporaneous assessment level 2 methodology was adopted, whereby the emissions, meteorology and background daily PM contributions align. Therefore at some receptors the maximum contribution from the TSF would not necessarily occur on the same day as the maximum contribution from Modification 4, the current operations and background. Generally speaking, the maximum 24-hour average prediction was either 36 µg/m³ or 46 µg/m³. Review of the time series data for the receptors indicates that these reported maxima were heavily influenced by the contribution of the background rather than Rasp Mine related sources.

A time series plot showing the 24-hour average PM_{10} contribution from Modification 4 (and operation of the CBP) in combination with the adopted background has been prepared R27 and is shown in **Figure** 5-2.

Table 5-1: Predicted annual average and maximum 24-hour PM_{10} concentrations (µg/m³)

Receptor ID	Annual average			Maximum 24-hour		
	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)	Cumulative (Increment + TSF upset + background)	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)	Cumulative (Increment + TSF upset + background)
Criterion	**n/a**	**25**	**25**	**n/a**	**50**	**50**
R1	0.03	13	13	1.4	36	36
R2	0.04	13	13	1.8	36	36
R3	0.05	13	13	1.9	36	36
R4	0.03	13	13	1.0	36	36
R5	0.02	13	13	0.8	36	36
R6	0.02	13	13	1.2	36	36
R7	0.01	13	13	0.5	46	46
R8	0.02	13	13	0.7	46	46
R9	0.02	13	13	1.2	46	46
R10	0.02	13	13	0.5	46	46
R11	0.01	13	13	0.6	36	36

Receptor ID	Annual average			Maximum 24-hour		
	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)	Cumulative (Increment + TSF upset + background)	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)	Cumulative (Increment + TSF upset + background)
Criterion	**n/a**	**25**	**25**	**n/a**	**50**	**50**
R12	0.01	13	13	0.6	36	36
R13	0.01	13	13	0.6	36	36
R14	0.01	13	13	0.3	46	46
R15	<0.01	13	13	0.3	46	46
R16	0.01	13	13	0.3	46	46
R17	0.01	13	13	0.4	46	46
R18	0.01	13	13	0.4	36	36
R19	<0.01	13	13	0.2	46	46
R20	<0.01	13	13	0.4	46	46
R21	0.03	13	13	1.8	36	36
R22	0.03	13	13	1.3	36	36
R23	0.02	13	13	1.0	36	36
R24	0.02	13	13	0.7	36	36
R25	0.02	13	13	0.8	36	36
R26	0.03	13	13	0.6	36	36
R27	0.14	13	14	3.1	46	**52**
R28	0.19	13	13	3.2	46	47
R29	0.06	13	13	1.4	46	46
R30	0.11	13	13	2.3	46	46
R31	0.03	13	13	1.7	46	46
R32	0.03	13	13	0.8	46	46
R33	0.04	13	13	1.9	46	46
R34	0.03	13	13	0.8	46	46
R35	0.02	13	13	1.0	46	46
R36	0.02	13	13	0.7	46	46
R37	0.02	13	13	0.6	46	46
R38	0.01	13	13	0.7	46	46
R39	0.01	13	13	0.7	46	46
R40	0.02	13	13	0.7	46	46
R41	0.02	13	13	0.7	46	46
R42	0.03	13	13	0.6	46	46
R43	0.06	13	13	3.2	46	46
R44	0.01	13	13	0.6	36	36
R45	0.01	13	13	0.6	36	36
R46	0.01	13	13	0.3	36	36
R47	0.01	13	13	0.5	46	46
R48	0.01	13	13	0.4	46	46
R49	<0.01	13	13	0.1	46	46

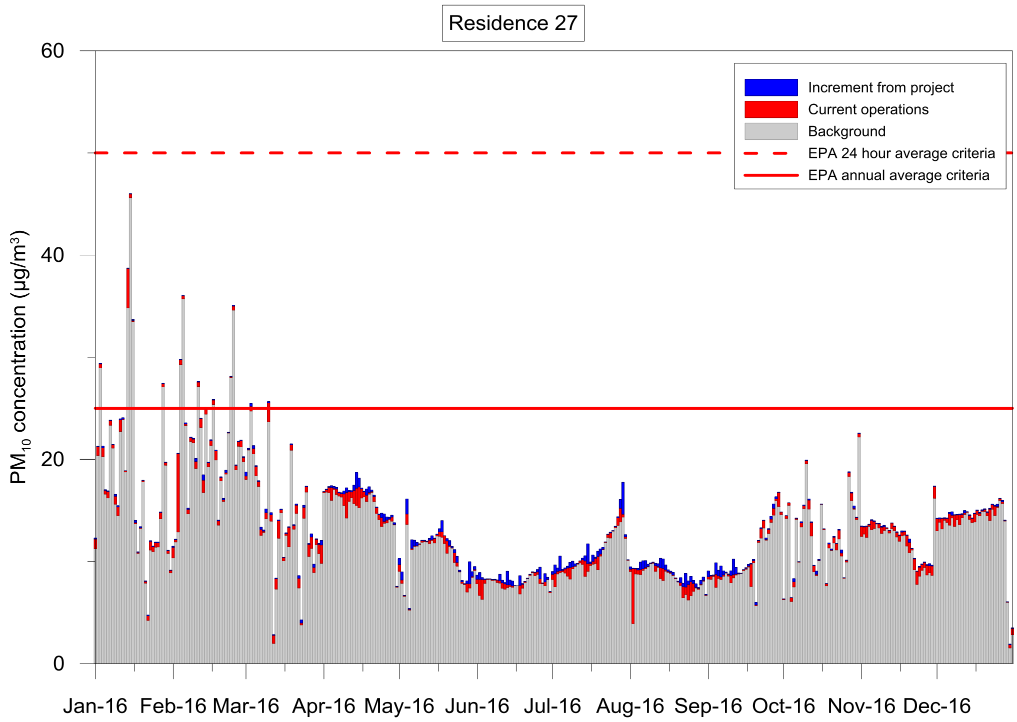

Figure 5-2: Time series for Level 2 PM_{10} assessment at R27 during normal TSF operations

The model predictions for PM_{10} during the 2016 operations are provided in **APPENDIX C**. These results have been compared to those that were originally predicted for the PPR **(Environ, 2010)**. For PM_{10}, the annual predictions are lower at all receptors. This result is expected as the 2016 operations did not operate at 100% capacity, while the PPR modelling assumes an emission inventory based on the mine operating at its approved capacity.

In general, the maximum 24-hour average predictions are also below the PPR predicted increments. However there are several receptors where the predicted increment is greater than the PPR predictions (e.g. R27, R28 and R30). These changes are anticipated to be as a result of different meteorological files being used, where the 2016 current operations modelling adopted calendar year 2016 observations, while the PPR adopted 2008/2009 and therefore the 24-hour predictions will not always align with the annual results.

Various other factors should be taken into consideration including the change in source configuration, where the main vent shaft has been relocated and there has been the addition of Vent Shaft No. 6. The 2016 current operations modelling also references site-specific data (e.g. empirically derived control factors and materials samples) in derivation of the emission inventory.

5.2 24-Hour and Annual Average $PM_{2.5}$

The maximum incremental 24-hour and annual average $PM_{2.5}$ concentrations predicted to occur at nearby receptor locations due to Modification 4 for the modelled year 2016 are summarised in **Table 5-2**. The corresponding contour plots are included in **APPENDIX F**. As noted above, these plots do not represent the dispersion pattern on any individual day. Rather, they illustrate an ensemble of the maximum concentrations simulated to be possible at each gridded receptor point across the modelling domain given the range of meteorological conditions occurring over the period modelled.

The contour plots for the maximum incremental 24-hour and annual average concentrations show that the $PM_{2.5}$ concentrations are for the most part isolated to within close vicinity to the CBP, Embankment E2 and the associated haul roads.

The contribution of Modification 4 (combined with operation of the proposed CBP) to the annual average criterion (8 µg/m³) is approximately 1%. The receptor that is predicted to experience the maximum incremental 24-hour average contribution is R27, located to the immediate west of Embankment E2. The maximum 24-hour average increment at R27 is predicted to be 1.6 µg/m³, or 6% of the NSW impact assessment criterion of 25 µg/m³. These are considered negligible contributions to the PM exposure in the Broken Hill area.

No site-specific $PM_{2.5}$ monitoring data is available for the study area. Therefore, the assessment for this pollutant has adopted the approach described in **Section 4.2**, where a $PM_{2.5}/PM_{10}$ ratio has been applied to the available on-site data.

All results are below the relevant impact assessment criterion.

Table 5-2: Predicted incremental annual average and maximum 24-hour $PM_{2.5}$ concentrations (µg/m³)

Receptor ID	Annual average			Maximum 24-hour		
	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)	Cumulative (Increment + TSF upset + background)	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)	Cumulative (Increment + TSF upset + background)
Criterion	**n/a**	**8**	**8**	**n/a**	**25**	**25**
R1	0.005	5	5	0.2	15	15
R2	0.006	5	5	0.2	15	15
R3	0.006	5	5	0.2	15	15
R4	0.004	5	5	0.1	15	15
R5	0.003	5	5	0.1	15	15
R6	0.003	5	5	0.3	15	15
R7	0.001	7	7	0.1	19	19
R8	0.003	7	7	0.1	19	19
R9	0.003	7	7	0.2	19	19
R10	0.003	7	7	0.1	19	19
R11	0.002	5	5	0.1	15	15
R12	0.002	5	5	0.1	15	15
R13	0.002	5	5	0.1	15	15
R14	0.002	7	7	0.1	19	19
R15	0.001	7	7	0.2	19	19
R16	0.002	7	7	0.1	19	19
R17	0.002	7	7	0.2	19	19
R18	0.001	5	5	0.1	15	15
R19	0.001	7	7	0.1	19	19
R20	0.001	7	7	0.1	19	19
R21	0.006	5	5	0.2	15	15
R22	0.006	5	5	0.2	15	15
R23	0.007	5	5	0.2	15	15
R24	0.008	5	5	0.2	15	15

Receptor ID	Annual average			Maximum 24-hour		
	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)	Cumulative (Increment + TSF upset + background)	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)	Cumulative (Increment + TSF upset + background)
Criterion	n/a	8	8	n/a	25	25
R25	0.004	5	5	0.1	15	15
R26	0.009	5	5	0.2	15	15
R27	0.057	7	7	1.6	19	19
R28	0.082	7	7	1.5	19	19
R29	0.024	7	7	0.6	19	19
R30	0.048	7	7	1.1	19	19
R31	0.012	7	7	0.9	19	19
R32	0.013	7	7	0.4	19	19
R33	0.018	7	7	0.8	19	19
R34	0.004	7	7	0.2	19	19
R35	0.004	7	7	0.2	19	19
R36	0.005	7	7	0.2	19	19
R37	0.006	7	7	0.2	19	19
R38	0.001	7	7	0.1	19	19
R39	0.001	7	7	0.1	19	19
R40	0.003	7	7	0.2	19	19
R41	0.004	7	7	0.2	19	19
R42	0.004	7	7	0.1	19	19
R43	0.028	7	7	1.6	19	19
R44	0.001	5	5	0.1	15	15
R45	0.002	5	5	0.1	15	15
R46	0.001	5	5	0.1	15	15
R47	0.003	7	7	0.1	19	19
R48	0.002	7	7	0.1	19	19
R49	0.001	7	7	0.0	19	19

As with the PM_{10} predictions, it is noted that the maximum 24-hour average $PM_{2.5}$ results are the same for normal and upset TSF operations. This has occurred because a contemporaneous assessment level 2 methodology was adopted, whereby the emissions, meteorology and background daily PM contributions align. Therefore at some receptors the maximum contribution from the TSF would not necessarily occur on the same day as the maximum contribution from Modification 4, the current operations and background. Generally speaking, the maximum 24-hour average prediction was either 15 µg/m³ or 19 µg/m³. Review of the time series data for the receptors indicates that these reported maxima were heavily influenced by the contribution of the background rather than Rasp Mine related sources.

The model predictions for $PM_{2.5}$ during the 2016 operations are provided in **APPENDIX C**. These results have been compared to those that were originally predicted for the PPR (Environ, 2010). For $PM_{2.5}$, the annual predictions are lower at all receptors. In general, the maximum 24-hour average predictions are also below the PPR predicted increments. However there are several receptors where the predicted increment is above the PPR predictions (e.g. R34, R41 and R42). An explanation as to why this may occur is provided in Section **5.1**.

5.3 Annual average TSP

The incremental and cumulative annual average TSP concentrations predicted to occur at nearby receptor locations due to Modification 4 (and operation of the proposed CBP) for the modelled year 2016 are summarised in **Table 5-3**. The corresponding contour plots are included in **APPENDIX F**.

The contour plots for the incremental annual average concentrations show that, consistent with the smaller PM size fraction predictions, the TSP concentrations are for the most part isolated to within close vicinity to the CBP, Embankments E2, E3 and the associated haul roads.

At all receptors, the predicted annual average TSP concentrations are well below the NSW impact assessment criterion of 90 µg/m³.

The contribution of Modification 4 to the annual average EPA impact assessment criterion (90 µg/m³) is highest at R28 at 0.6% (increment 0.56 µg/m³) and 1.2% (when current operations are considered). These are considered negligible contributions to the PM exposure in the Broken Hill area.

The model predictions for TSP during the 2016 operations are provided in **APPENDIX C**. These results have been compared to those that were originally predicted for the PPR **(Environ, 2010)**. For TSP, the annual predictions are lower at all receptors. An explanation as to why this may occur is provided in **Section 5.1**.

Table 5-3: Predicted incremental and cumulative annual average TSP concentrations (µg/m³)

Receptor ID	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)	Receptor ID	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)
Criterion	n/a	90	Criterion	n/a	90
R1	0.06	36	**R26**	0.06	36
R2	0.08	36	**R27**	0.32	36
R3	0.12	36	**R28**	0.56	36
R4	0.07	36	**R29**	0.13	36
R5	0.04	36	**R30**	0.30	36
R6	0.03	36	**R31**	0.06	36
R7	0.01	36	**R32**	0.07	36
R8	0.03	36	**R33**	0.07	36
R9	0.03	36	**R34**	0.05	36
R10	0.03	36	**R35**	0.04	36
R11	0.02	36	**R36**	0.04	36
R12	0.02	36	**R37**	0.03	36
R13	0.02	36	**R38**	0.01	36
R14	0.02	36	**R39**	0.01	36
R15	0.01	36	**R40**	0.04	36
R16	0.01	36	**R41**	0.05	36
R17	0.01	36	**R42**	0.06	36
R18	0.01	36	**R43**	0.14	36
R19	0.01	36	**R44**	0.01	36
R20	0.01	36	**R45**	0.02	36
R21	0.06	36	**R46**	0.01	36

Receptor ID	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)	Receptor ID	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)
Criterion	n/a	90	Criterion	n/a	90
R22	0.05	36	**R47**	0.02	36
R23	0.05	36	**R48**	0.01	36
R24	0.05	36	**R49**	0.01	36
R25	0.04	36			

5.4 Monthly average deposited dust

The incremental and cumulative monthly average dust deposition levels predicted to occur at nearby receptor locations due to Modification 4 for the modelled year 2016 are summarised in **Table 5-4**. The corresponding contour plots are included in **APPENDIX F**.

The contour plots for the incremental average monthly dust deposition show that the deposited dust is anticipated to be for the most part isolated to within close vicinity to the CBP, E2, E3 and the associated haul roads.

At all receptors, the predicted dust deposition levels are well below both the incremental (2 g/m^2/month) and cumulative (4 g/m^2/month) impact assessment criteria.

The contribution of Modification 4 to the monthly average EPA impact assessment criterion (4 g/m^2/month) at the most impacted receptor (R28) is 8% (0.156 g/m^2/month), or 17% (0.33 g/m^2/month) when current mining operations are included. This is considered a negligible increased contribution to the particulate matter exposure in the Broken Hill area. When considered cumulatively (i.e. when existing dust deposition levels are considered) the predicted dust deposition levels would be a maximum of 2.8 g/m^2/month at R27, R28 and R30. This equates to 71% of the cumulative criterion of 4 g/m^2/month.

The model predictions for dust deposition during the 2016 operations are provided in APPENDIX C. These results have been compared to those that were originally predicted for the PPR (Environ, 2010). The predictions are lower at all receptors. An explanation as to why this may occur is provided in **Section 5.1**.

Table 5-4: Predicted incremental and cumulative monthly average deposited dust (g/m^2/month)

Receptor ID	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)	Receptor ID	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)
Criterion	2	4	Criterion	2	4
R1	0.019	1.6	**R26**	0.017	1.6
R2	0.023	1.6	**R27**	0.091	2.8
R3	0.036	1.6	**R28**	0.156	2.8
R4	0.021	1.6	**R29**	0.040	2.7
R5	0.009	1.6	**R30**	0.095	2.8
R6	0.007	1.6	**R31**	0.017	2.7

R7	0.004	0.8	**R32**	0.022	2.7
R8	0.009	0.8	**R33**	0.022	1.2
R9	0.009	0.4	**R34**	0.018	0.4
R10	0.010	0.4	**R35**	0.014	0.4
R11	0.006	1.6	**R36**	0.011	0.4
R12	0.005	1.0	**R37**	0.010	0.4
R13	0.004	1.0	**R38**	0.003	0.8
R14	0.005	0.4	**R39**	0.004	0.8
R15	0.002	0.4	**R40**	0.013	0.4
R16	0.003	0.4	**R41**	0.016	0.4
R17	0.004	0.4	**R42**	0.020	0.4
R18	0.003	1.0	**R43**	0.041	2.7
R19	0.002	0.4	**R44**	0.002	1.0
R20	0.002	0.4	**R45**	0.006	1.0
R21	0.017	1.6	**R46**	0.002	1.0
R22	0.016	1.6	**R47**	0.007	0.4
R23	0.015	1.6	**R48**	0.004	0.4
R24	0.015	1.6	**R49**	0.002	0.4
R25	0.011	1.6			

5.5 Annual average lead concentration

The incremental and cumulative annual average lead concentrations predicted to occur at nearby receptor locations due to Modification 4 for the modelled year 2016 are summarised in **Table 5-5.** The corresponding contour plots are included in **APPENDIX F**.

At all receptors, the predicted annual average lead concentrations are predicted to be well below the NSW impact assessment criterion of 0.5 µg/m^3.

The model predictions for lead concentration during the 2016 operations are provided in **APPENDIX C**. These results have been compared to those that were originally predicted for the PPR (Environ, 2010). The annual predictions are lower at all receptors. An explanation as to why this may occur is provided in **Section 5.1**.

Table 5-5: Predicted incremental and cumulative annual average lead concentrations (µg/m^3)

Receptor ID	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)	Receptor ID	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)
Criterion	**n/a**	**0.5**	**Criterion**	**n/a**	**0.5**
R1	0.0012	0.23	**R26**	0.0008	0.23
R2	0.0018	0.23	**R27**	0.0029	0.23
R3	0.0028	0.23	**R28**	0.0047	0.24
R4	0.0015	0.23	**R29**	0.0014	0.23

R5	0.0008	0.23	**R30**	0.0027	0.23
R6	0.0007	0.23	**R31**	0.0007	0.23
R7	0.0003	0.23	**R32**	0.0008	0.23
R8	0.0007	0.23	**R33**	0.0008	0.23
R9	0.0006	0.23	**R34**	0.0009	0.23
R10	0.0006	0.23	**R35**	0.0007	0.23
R11	0.0005	0.23	**R36**	0.0006	0.23
R12	0.0004	0.23	**R37**	0.0006	0.23
R13	0.0003	0.23	**R38**	0.0003	0.23
R14	0.0003	0.23	**R39**	0.0003	0.23
R15	0.0001	0.23	**R40**	0.0008	0.23
R16	0.0001	0.23	**R41**	0.0009	0.23
R17	0.0003	0.23	**R42**	0.0011	0.23
R18	0.0002	0.23	**R43**	0.0014	0.23
R19	0.0001	0.23	**R44**	0.0002	0.23
R20	0.0001	0.23	**R45**	0.0004	0.23
R21	0.0011	0.23	**R46**	0.0002	0.23
R22	0.0010	0.23	**R47**	0.0004	0.23
R23	0.0009	0.23	**R48**	0.0002	0.23
R24	0.0008	0.23	**R49**	0.0001	0.23
R25	0.0006	0.23			

5.6 Annual average lead deposition

The incremental and cumulative annual average lead deposition rates predicted to occur at nearby receptor locations due to Modification 4 for the modelled year 2016 are relevant to Human Health Risk Assessment, and are summarised in **Table 5-6.** The corresponding contour plots are included in **APPENDIX F**.

There is no lead deposition impact assessment criterion referenced by the NSW EPA.

The model predictions for lead deposition during the 2016 operations are provided in **APPENDIX C**. These results have been compared to those that were originally predicted for the PPR (Environ, 2010). The annual predictions are lower at all receptors. An explanation as to why this may occur is provided in Section **5.1**.

Table 5-6: Predicted incremental and cumulative annual average lead deposition (g/m²/year)

Receptor ID	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)	Cumulative (Increment + TSF upset + background)	Receptor ID	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)	Cumulative (Increment + TSF upset + background)
Criterion	n/a	n/a	n/a	Criterion	n/a	n/a	n/a
R1	0.005	0.019	0.019	**R26**	0.003	0.034	0.035
R2	0.006	0.023	0.023	**R27**	0.010	0.050	0.065

Receptor ID	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)	Cumulative (Increment + TSF upset + background)	Receptor ID	Incremental (Mod 4 + CBP)	Cumulative (Increment + TSF normal + background)	Cumulative (Increment + TSF upset + background)
Criterion	**n/a**	**n/a**	**n/a**	**Criterion**	**n/a**	**n/a**	**n/a**
R3	0.010	0.035	0.035	**R28**	0.016	0.047	0.057
R4	0.005	0.021	0.021	**R29**	0.005	0.032	0.036
R5	0.002	0.014	0.014	**R30**	0.010	0.031	0.037
R6	0.002	0.013	0.013	**R31**	0.002	0.014	0.015
R7	0.001	0.005	0.005	**R32**	0.003	0.014	0.015
R8	0.002	0.013	0.013	**R33**	0.003	0.014	0.016
R9	0.002	0.010	0.010	**R34**	0.004	0.015	0.015
R10	0.002	0.010	0.010	**R35**	0.003	0.013	0.013
R11	0.002	0.008	0.008	**R36**	0.002	0.012	0.012
R12	0.001	0.007	0.007	**R37**	0.002	0.012	0.012
R13	0.001	0.005	0.005	**R38**	0.001	0.004	0.004
R14	0.001	0.005	0.005	**R39**	0.001	0.004	0.004
R15	<0.001	0.002	0.002	**R40**	0.003	0.013	0.013
R16	0.001	0.003	0.003	**R41**	0.004	0.015	0.015
R17	0.001	0.005	0.005	**R42**	0.004	0.017	0.017
R18	0.001	0.004	0.004	**R43**	0.005	0.021	0.024
R19	<0.001	0.002	0.002	**R44**	0.001	0.003	0.003
R20	<0.001	0.002	0.002	**R45**	0.001	0.007	0.007
R21	0.004	0.019	0.019	**R46**	<0.001	0.003	0.003
R22	0.004	0.019	0.019	**R47**	0.002	0.008	0.008
R23	0.003	0.021	0.022	**R48**	0.001	0.003	0.003
R24	0.003	0.025	0.026	**R49**	<0.001	0.002	0.002
R25	0.002	0.013	0.013				

5.7 Cumulative impacts associated with the Broken Hill North Mine

In February 2017 the air quality assessment (**Pacific Environment, 2017**) for the Broken Hill North Mine Recommencement Project (Broken Hill North Mine) was released for public exhibition by the NSW Department of Planning. It is highlighted that to avoid any perceived conflicts of interest, the authors of this current report were deliberately not informed of details of the Broken Hill North Mine proposal. The Broken Hill North Mine is located to the north east of Rasp Mine and therefore PM emissions from this source would have the potential to result in cumulative impacts when combined with predictions associated with the Rasp Mine.

While the Broken Hill North Mine Recommencement Project has not yet been approved, it is important to acknowledge any potential changes in local air quality as a result of Broken Hill North Mine's potential future operations. **Pacific Environment (2017)** has provided tabulated results for the short term and long term air quality metrics, including PM_{10}, $PM_{2.5}$, TSP, dust deposition and lead concentration. No data were presented for lead deposition and therefore this cumulative assessment are limited to these metrics.

The receptor locations adopted within **Pacific Environment (2017)** have been compared with those that have been adopted for this assessment.

There are eight receptors that align with those used in Broken Hill North Mine air quality assessment such that impacts can be evaluated cumulatively. These receptors comprise R2, R11, R17, R18 R23, R24, R32 and R43 from the Rasp Mine receptor list and are shown in **Figure 5-3**.

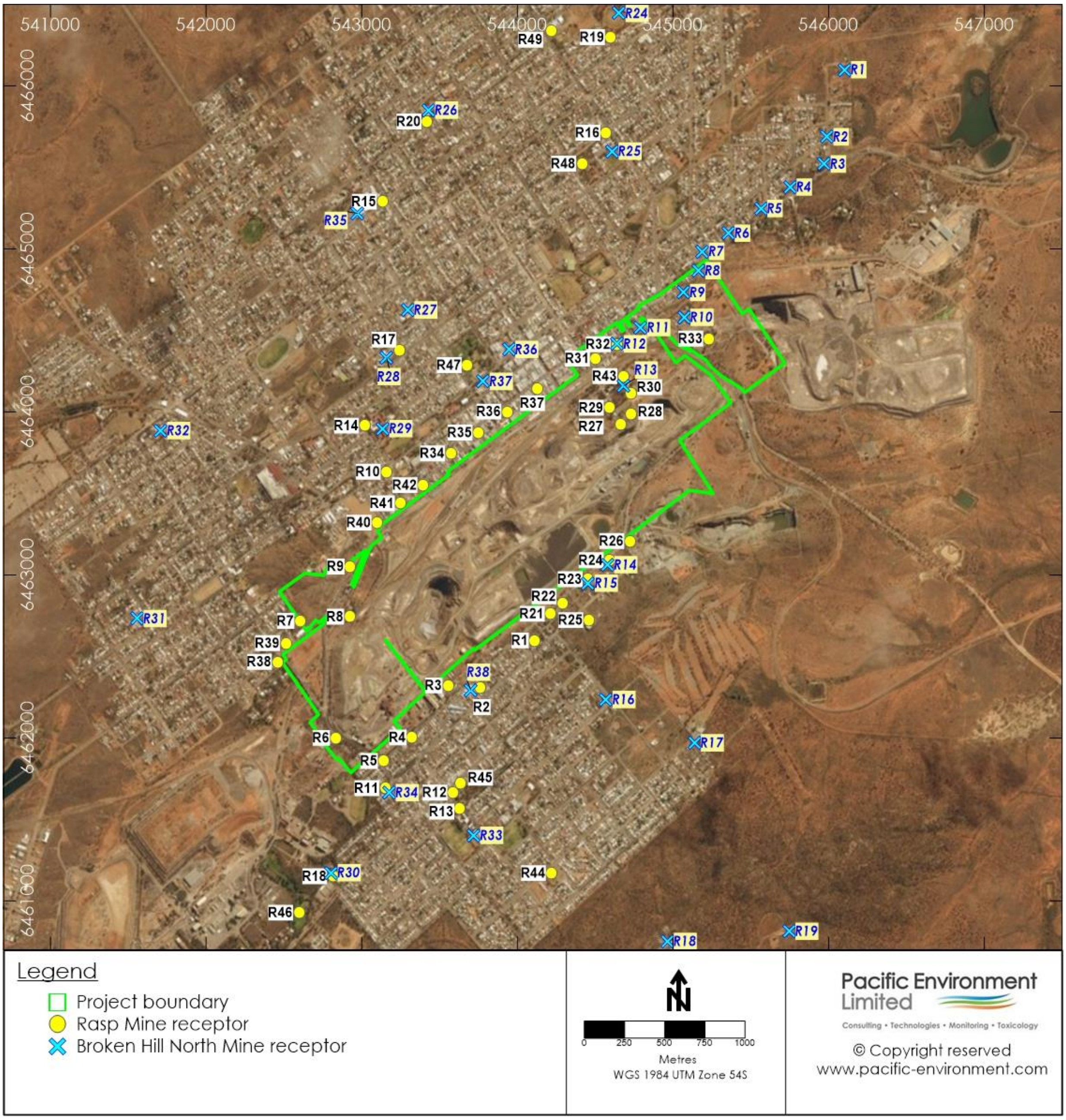

Figure 5-3: Rasp Mine receptors that align with those used in Broken Hill North Mine air quality assessment

At each of these receptors, the available maximum predictions for Broken Hill North Mine have been combined with the model results that have been compiled for this assessment. The annual average and maximum 24-hour predictions for PM_{10} and $PM_{2.5}$ are presented in **Table 5-7**. The annual results for TSP, dust deposition and lead concentration are presented in **Table 5-8**.

The tabulated results presented in **Pacific Environment (2017)** are limited to one decimal place consequently results for some residences have been reported as 0.0µg/m³. It has therefore been assumed that in these instances where the model prediction is 0.0µg/m³ that the contribution of Broken Hill North Mine is negligible.

In the case of lead concentration predictions the results have only been provided for the most impacted of the discrete receptors assessed (39 in total). In the absence of a full dataset, a highly conservative approach has therefore been adopted by assuming a uniform 0.006µg/m³ impact from the Broken Hill North Mine across all receptors.

Table 5-7: Predicted cumulative (in combination with Broken Hill North Mine) annual average and maximum 24-hour PM_{10} and $PM_{2.5}$ concentrations (µg/m³)

Receptor ID (Broken Hill North Mine receptor ID)	Annual average				Maximum 24-hour			
	Incremental (Mod 4 + CBP)	Broken Hill North Mine	Cumulative (Increment + TSF normal + background)	Cumulative (Increment + TSF upset + background)	Incremental (Mod 4 + CBP)	Broken Hill North Mine	Cumulative (Increment + TSF normal + background)	Cumulative (Increment + TSF upset + background)
PM_{10}								
Criterion	**n/a**	**n/a**	**25**	**25**	**n/a**	**n/a**	**50**	**50**
R2 (R38)	0.04	0.1	13	13	3.2	1.8	38	38
R11 (R34)	0.01	0.1	13	13	2.0	0.6	37	37
R17 (R28	0.01	0.0	13	13	1.1	0.4	46	46
R18 (R30)	0.01	0.1	13	13	1.4	0.4	37	37
R23 (R15)	0.02	0.1	13	13	4.5	1.0	37	37
R24 (R14)	0.02	0.1	13	13	5.1	0.7	37	37
R32 (R12)	0.03	0.1	13	13	1.5	0.8	47	47
R43 (R13)	0.06	0.1	13	13	2.9	3.2	49	49
$PM_{2.5}$								
Criterion	**n/a**	**n/a**	**8**	**8**	**n/a**	**n/a**	**25**	**25**
R2 (R38)	0.006	0.1	5	5	0.2	4.7	19	19
R11 (R34)	0.002	0.1	5	5	0.1	2.9	18	18
R17 (R28	0.002	0.0	5	5	0.2	0.9	20	20
R18 (R30)	0.001	0.1	5	5	0.1	2.1	17	17
R23 (R15)	0.007	0.1	5	5	0.2	6.1	21	21
R24 (R14)	0.008	0.2	5	5	0.2	6.9	22	22
R32 (R12)	0.013	0.1	5	5	0.4	2.1	21	21
R43 (R13)	0.028	0.1	5	5	1.6	3.4	22	22

Table 5-8: Predicted cumulative (in combination with Broken Hill North Mine) annual average TSP, dust deposition and lead concentrations

Receptor ID (Broken Hill North Mine receptor ID)	Incremental (Mod 4 + CBP)	Broken Hill North Mine	Cumulative (Increment + TSF normal + background)	Cumulative (Increment + TSF upset + background)
TSP (µg/m³)				
Criterion	**n/a**	**n/a**	**90**	**90**
R2 (R38)	0.08	0.0	36	36
R11 (R34)	0.02	0.0	36	36
R17 (R28	0.01	0.0	36	36
R18 (R30)	0.01	0.0	36	36
R23 (R15)	0.05	0.1	36	36
R24 (R14)	0.05	0.1	36	36
R32 (R12)	0.07	0.1	36	36
R43 (R13)	0.14	0.1	36	36
Dust deposition (g/m²/month)				
Criterion	**n/a**	**n/a**	**8**	**8**
R2 (R38)	0.023	0.0	1.6	1.6
R11 (R34)	0.006	0.0	1.6	1.6
R17 (R28	0.004	0.0	0.4	0.4
R18 (R30)	0.003	0.0	1.0	1.0
R23 (R15)	0.015	0.0	1.6	1.6
R24 (R14)	0.015	0.0	1.6	1.6
R32 (R12)	0.022	0.0	2.7	2.7
R43 (R13)	0.041	0.0	2.7	2.8
Lead concentration (µg/m³)				
Criterion	**n/a**	**n/a**	**0.5**	**0.5**
R2 (R38)	0.0018	0.006	0.24	0.24
R11 (R34)	0.0005	0.006	0.24	0.24
R17 (R28	0.0003	0.006	0.24	0.24
R18 (R30)	0.0002	0.006	0.24	0.24
R23 (R15)	0.0009	0.006	0.24	0.24
R24 (R14)	0.0008	0.006	0.24	0.24
R32 (R12)	0.0008	0.006	0.24	0.24
R43 (R13)	0.0014	0.006	0.24	0.24

For all of the air quality metrics assessed the cumulative results that combine emissions from Rasp Mine's existing operations, the proposed Modification 4 and CBP, the proposed Broken Hill North Mine Recommencement Project and contributions from other background sources are all below the NSW impact assessment criteria at the nominated co-located receptors.

Finally, it is highlighted that the Rasp Mine MOD4 construction is only scheduled to occur over a short period; the concrete batching plant construction is scheduled to occur over 5 weeks, and the TSF extension for 14 months.

Without additional knowledge as to the Broken Hill North Mine's proposed scheduling and development consent pathway, it should further be acknowledged that the two activities may or may not be undertaken at the same time, and as such the above discussion of cumulative impacts should be regarded as worst-case.

6 DUST MANAGEMENT

An additional aspect of the assessment process is to evaluate current and future operational dust management practices for Rasp Mine. The following aspects are discussed for consideration in future dust management for the site.

6.1 Real-time PM and Meteorological Monitoring

BHOP currently monitors PM_{10} concentrations and wind speed/direction continuously at two locations (north and south of current mining operations).

Monitoring is anticipated to continue at these locations, and could additionally be supplemented with additional monitoring locations representative of conditions at the TSF.

By combining these real-time observations with telemetry and readily available software, it is possible to introduce SMS or email alerts to relevant site personnel when critical PM concentrations or wind speeds occur.

A short-term average (e.g. 1-hour average) PM_{10} performance indicator can be set at a concentration that allows proactive dust management to be implemented in the event that PM concentrations are increasing, and may potentially approach the 24-hour PM_{10} impact assessment criterion in the near future.

The field investigations (**Appendix E**) indicate that a critical wind speed of 11 m/s (40km/hr; measured at 10m) should be used as an initial alert value to trigger further investigation and remedial action as this is the threshold friction velocity where dust entrainment may occur.

Winds that reach 14 m/s (50km/hr) should be used as the critical wind speed alarm value when immediate action is required (i.e. implementation of TSF water sprays or chemical dust suppressant). A review of the onsite meteorological data indicates that winds exceeding 11m/s may occur 1.3% of the time (or 112 hours per year) and exceeding 14m/s 0.02% of the time (or 2 hours per year).

In addition, a particulate matter concentration an alarm and alert system may also be implemented. Default values adopted at other extractive industry sites for the 1 hour average concentration are 80µg/m^3 as an alert / investigation level and 100µg/m^3 as an alarm requiring immediate rectification.

Alert/alarm values may be reviewed iteratively to ensure that they are sufficiently protective without generating excessive false alarms.

The monitoring network would be reviewed and augmented (if warranted) to provide additional data relevant to the future operation of the TSF.

It is suggested that an augmentation to the existing PM monitoring might include a mobile PM / wind speed monitoring unit that can be placed close to the TSF surface and progressively moved as the TSF is filled. Such a location is the ramp that is annotated in **Figure 3-1**.

An appropriate example unit is the TSI DRX PM_{10}/$PM_{2.5}$ monitor combined with Lufft sonic anemometer / weather station and solar power set-up.

6.2 Predictive / Forecast Meteorology and Real Time Management

An additional component of proactive dust management would be a meteorological forecasting system. This system is used to predict meteorological conditions for the coming day(s) to determine, at a minimum one day in advance, when an elevated risk of PM emissions may occur (e.g. based on wind speed, direction, rainfall and atmospheric stability).

The predictive meteorological forecasting system would provide simple indicators of the following day's dust risk, based on meteorological conditions that are known to have adverse impacts, and would allow mine personnel to put measures into place in advance. An example of such preparatory measures would include:

- scheduling additional water cart operations / chemical dust suppressant application;
- planning for modifying or relocating certain activities; and
- scheduling maintenance on equipment.

7 GREENHOUSE GAS EMISSIONS

The World Resources Institute / World Business Council for Sustainable Development Greenhouse Gas Protocol (the GHG Protocol) originally documented the different scopes for greenhouse gas (GHG) emission inventories. The GHG Protocol is the most widely used international accounting tool for government and business leaders to understand, quantify, and manage greenhouse gas emissions. This corporate accounting and reporting standard is endorsed by the Australian Department of Climate Change and Energy Efficiency.

The GHG Protocol defines three scopes for developing inventories leading to reporting of emissions. These scopes help to delineate direct and indirect emission sources, improve transparency, and provide a degree of flexibility for individual organisations to report based on their organisational structure, business activities and business goals.

Three scopes of emissions are defined in the GHG Protocol:

- 'Scope 1' emissions: direct GHG emissions occurring from sources owned or controlled by the company – for example vehicle fleet and direct fuel combustion. Any negative emissions (sequestration), for example from a plantation owned by the entity, would also be included in Scope 1.
- 'Scope 2' emissions: indirect GHG emissions from purchasing electricity or heat from other parties; and
- 'Scope 3' emissions: indirect emissions which occur due to the company's business activities, but from sources not owned or controlled by the company - for example emissions from employee business-related air travel.

Scope 1, 2 and 3 greenhouse gas emissions were quantified as part of the Rasp Mine Environment Assessment Report **(BHOP, 2010)**.

The proposed Modification 4 would be limited to Scope 1 emissions from diesel combustion. The diesel fuel consumption for Modification 4 is estimated to be approximately 350,000L of diesel fuel which equates to 0.9 ktCO_2-eq.[3]

[3] The **BHOP (2010)** annual Scope 1 fuel consumption was report as 1,604,400L resulting in an estimated 4.33 kt CO_2-eq. This is based on a 750,000 tpa ROM production rate. The total material to be moved for Modification 4 is approximately 79,000 m^3 or 165,000 tonnes.

For the project in its entirety annual emissions of GHG (Scope 1 and 2) are estimated at 40.21 ktCO2-e per year. Modification 4 would add an additional 2% loading.

8 CONCLUSION

This report has assessed particulate matter and lead impacts associated with the proposed Modification 4 activities at Rasp Mine. Local land use, terrain, air quality and meteorology have been considered in the assessment and dispersion modelling was completed using the AERMOD modelling system.

A comprehensive analysis of the baseline air quality was updated as part of this assessment, that now includes data up to and including December 2016. A comparison of the 2016 current operations modelling with the original modelling completed for the PPR **(Environ, 2010)** showed a decrease in impacts for all assessment criteria that are annually averaged. At some receptors, maximum predictions over short term averaging periods show an increase relative to PPR predictions. These changes are anticipated to be as a result of different meteorology, source locations and emissions inventory across the two modelling scenarios. The long term comparison demonstrates a continual improvement in the local air quality.

A worse case operating scenario for the modification activities was assessed with the construction of Embankment 2, Embankment 3 and the CBP in full operation. Emissions were calculated both in terms of annual average emissions and a 24-hour worst case scenario. The results demonstrate compliance with all the NSW EPA impact assessment criteria for all air quality parameters assessed.

The projected emissions from Modification 4 will only occur for up to 14 months during the construction period. On that basis, and the relatively minor contribution to predicted air quality at nearest sensitive receptors, the overall impact of Modification 4 is unlikely to have a discernible change in local air quality.

Cumulative impacts from the proposed Broken Hill North Mine Recommencement Project have been assessed for the short term and long term air quality metrics that include PM_{10}, $PM_{2.5}$, TSP, dust deposition and lead concentration. No data were presented for lead deposition and therefore limited to these metrics. The results demonstrate no exceedance of the NSW impact assessment criterion at any of the co-located receptors assessed.

A semi-quantitative approach was used to estimate greenhouse gas emissions. These emissions from the proposed Modification 4 would add an additional 2% loading to the annual emissions from Rasp Mine. In view of the above, it is anticipated that the proposed Modification 4 for Rasp Mine will result in negligible change to the local air quality.

As such, it is anticipated that the proposed embankment construction and CBP operation may be operated to ensure that there are no adverse air quality impacts associated with these activities in isolation, or in the context of the mine as a whole (i.e. cumulative air quality impacts).

I trust that the above provides sufficient detail and explanation for the required purpose. Please do not hesitate to contact the undersigned should you wish for clarification of any aspect of the above.

Yours sincerely,

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APPENDIX A. EMISSIONS INVENTORY AND ASSUMPTIONS FOR MODIFICATION 4

ACTIVITY	TSP	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units
Waste rock - load in pit	59	60,900	t/period	0.0019	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Waste rock - haul to E2 (sealed)	1,170	29,000	m3/period	0.0403	kg/m3	13	m3/load	64	mean vehicle mass (t)	4.4	km/return trip	0.1189	kg/VKT	0.5	silt loading (g/m	0	% control
Waste rock - haul to E2 (unsealed)	1,876	29,000	m3/period	0.3234	kg/m3	13	m3/load	50	Vehicle gross mass (t)	1.7	km/return trip	2.5356	kg/VKT	4.4	% silt content	80	% control
Waste rock - dump at E2	59	60,900	t/period	0.0019	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Prep E2 footprint - load at E2	4	4,200	t/period	0.0019	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Prep E2 footprint - haul within E2	51	2,000	m3/period	0.1268	kg/m3	8	m3/load	50	Vehicle gross mass (t)	0.4	km/return trip	2.5356	kg/VKT	4.4	% silt content	80	% control
Prep E2 footprint - dump at E2	4	4,200	t/period	0.0019	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Filter sand - load at external site	5	5,280	t/period	0.0019	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Filter sand - haul to E2 (sealed)	81	2,000	m3/period	0.0403	kg/m3	15	m3/load	51	mean vehicle mass (t)	6.4	km/return trip	0.0944	kg/VKT	0.5	silt loading (g/m	0	% control
Filter sand - haul to E2 (unsealed)	-	2,000	m3/period	0.0000	kg/m3	15	m3/load	35	Vehicle gross mass (t)	0.0	km/return trip	2.1596	kg/VKT	4.4	% silt content	80	% control
Filter sand - dump at E2	5	5,280	t/period	0.0019	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Crushed rock rest layer - load in pit	4	4,200	t/period	0.0019	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Crushed rock rest layer - haul to E2 (sealed)	81	2,000	m3/year	0.0403	kg/m3	13	m3/load	64	mean vehicle mass (t)	4.4	km/return trip	0.1189	kg/VKT	0.5	silt loading (g/m	0	% control
Crushed rock rest layer - haul to E2 (unsealed)	129	2,000	m3/year	0.3234	kg/m3	13	m3/load	50	Vehicle gross mass (t)	1.7	km/return trip	2.5356	kg/VKT	4.4	% silt content	80	% control
Crushed rock rest layer - dump at E2	4	4,200	t/period	0.0019	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Crushed rock rest layer - screening in pit	-	4,200	t/period	0.0000	kg/t												
Crushed rock rest layer - primary crushing in pit	42	4,200	t/period	0.0100	kg/t												
Toe and side anchorage of liner - haul to E2 (sealed	8	40	concrete mixer loads (return)					18	mean vehicle mass (t)	6.4	km/return trip	0.0328	kg/VKT	0.5	silt loading (g/m	0	% control
Toe and side anchorage of liner - haul to E2 (unsea	-	40	concrete mixer loads (return)					25	Vehicle gross mass (t)	0.0	km/return trip	1.8562	kg/VKT	4.4	% silt content	80	% control
Crest anchor trench - haul to E2 (sealed)	8	40	concrete mixer loads (return)					18	mean vehicle mass (t)	6.4	km/return trip	0.0328	kg/VKT	0.5	silt loading (g/m	0	% control
Crest anchor trench - haul to E2 (unsealed)	-	40	concrete mixer loads (return)					25	Vehicle gross mass (t)	0.0	km/return trip	1.8562	kg/VKT	4.4	% silt content	80	% control
E2 - Dozer	1,319	715	h/period	3.6886	kg/hr	4.4	Silt content	3	moisture content							50	% control
Wind Erosion - E2 (during construction)	281	0.6	ha	0.1000	kg/ha/h	4,380	h/y									0	% control
Wind Erosion - E2 (after cosntruction)	14	0.6	ha	0.1000	kg/ha/h	4,380	h/y									95	% control
Truck movement - cement	34	126	trucks/year	0.2673	kg/trip			29	Vehicle gross mass (t)	5.0	km/ return trip	0.0533	kg/VKT	0.5	silt loading (g/m	0	%control
Truck movement - aggregate	83	300	trucks/year	0.2755	kg/trip			55	Vehicle gross mass (t)	2.7	km/ return trip	0.1024	kg/VKT	0.5	silt loading (g/m	0	%control
Truck movement - sand	317	1,151	trucks/year	0.2755	kg/trip	13	payload (tonnes)	55	Vehicle gross mass (t)	2.7	km/ return trip	0.1024	kg/VKT	0.5	silt loading (g/m	0	%control
Truck movement - shotcrete	129	1,518	trucks/year	0.0852	kg/trip			18	Vehicle gross mass (t)	2.6	km/ return trip	0.0328	kg/VKT	0.5	silt loading (g/m	0	%control
Loading cement at rail siding	13	6,600	t/y	0.0019	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %								
Aggregate transfer	33	9,348	t/y	0.0035	kg/t												
Sand transfer	16	14,960	t/y	0.0011	kg/t												
Cement transfer	3	6,600	t/y	0.0005	kg/t												
Weigh hopper loading	20	30,908	t/y	0.0026	kg/t											75	
Truck loading	379	30,908	t/y	0.0490	kg/t											75	
Residual from de-dusted air loading cement and fly-	-	30,908	t/y	0.0000	g/Nm3	34	Nm3/minute	1	minutes/tonne								
Wind erosion (aggregate stock piles)	26	0.1	ha	0.1000	kg/ha/h	8,760	h/y									70	%control
Wind erosion (whole CBP)	15	0.4	ha	0.1000	kg/ha/h	8,760	h/y									95	%control
Waste rock - load in pit	42	43,050	t/period	0.0019	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Waste rock - haul to E3 (unsealed)	1,144	20,500	m3/period	0.2790	kg/m3	13	m3/load	36	mean vehicle mass (t)	1.7	km/return trip	2.1872	kg/VKT	4.4	% silt content	80	% control
Waste rock - haul to E3 (sealed)	300	20,500	m3/period	0.0147	kg/m3	13	m3/load	36	mean vehicle mass (t)	2.9	km/return trip	0.0665	kg/VKT	0.5	silt loading (g/m	0	
Waste rock - dump at E3	42	43,050	t/period	0.0019	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Filter sand - load at external site	5	5,040	t/period	0.0019	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Filter sand - haul to E3 (unsealed)	10	2,100	m3/period	0.0238	kg/m3	15	m3/load	35	Vehicle gross mass (t)	5.5	km/return trip	0.0646	kg/VKT	0.5	silt loading (g/m	80	% control
Filter sand - dump at E3	5	5,040	t/period	0.0019	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Crushed rock rest layer - load in pit	4	4,200	t/period	0.0019	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Crushed rock rest layer - haul to E3 (unsealed)	112	2,000	m3/year	0.2790	kg/m3	13	m3/load	36	mean vehicle mass (t)	1.7	km/return trip	2.1872	kg/VKT	4.4	% silt content	80	% control
Waste rock - haul to E3 (sealed)	29	2,000	m3/period	0.0147	kg/m3	13	m3/load	36	mean vehicle mass (t)	2.9	km/return trip	0.0665	kg/VKT	0.5	silt loading (g/m	0	
Crushed rock rest layer - dump at E3	4	4,200	t/period	0.0019	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Crushed rock rest layer - screening in pit	-	4,200	t/period	0.0000	kg/t												
Crushed rock rest layer - primary crushing in pit	42	4,200	t/period	0.0100	kg/t												
Toe and side anchorage of liner - haul to E3 (unsea	35	17	concrete mixer loads (return)					25	Vehicle gross mass (t)	5.5	km/return trip	1.8562	kg/VKT	4.4	% silt content	80	% control
Crest anchor trench - haul to E3 (unsealed)	35	17	concrete mixer loads (return)					25	Vehicle gross mass (t)	5.5	km/return trip	1.8562	kg/VKT	4.4	% silt content	80	% control
E3 - Dozer	1,099	596	h/period	3.6886	kg/hr	4.4	Silt content	3	moisture content							50	% control
Wind Erosion - E3 (during construction)	153	0.3	ha	0.1000	kg/ha/h	4,380	h/y									0	% control
Wind Erosion - E3 (after cosntruction)	8	0.3	ha	0.1000	kg/ha/h	4,380	h/y									95	% control
Total (kg/y)	**9,341**																

ACTIVITY	PM10	Intensity	Units	Emission	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units
Waste rock - load in pit	28	60,900	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							50	% control
Waste rock - haul to E2 (sealed)	126	29,000	m3/period	0.0043	kg/m3	13	m3/load	36	mean vehicle mass (t)	4.4	km/return trip	0.0128	kg/VKT	0.5	silt loading (g/m	0	% control
Waste rock - haul to E2 (unsealed)	405	29,000	m3/period	0.0699	kg/m3	13	m3/load	36	mean vehicle mass (t)	1.7	km/return trip	0.5478	kg/VKT	4.4	% silt content	80	% control
Waste rock - dump at E2	28	60,900	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							50	% control
Prep E2 footprint - load at E2	1	4,200	t/period	0.0003	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							50	% control
Prep E2 footprint - haul within E2	11	2,000	m3/period	0.0274	kg/m3	8	m3/load	36	mean vehicle mass (t)	0.4	km/return trip	0.5478	kg/VKT	4.4	% silt content	80	% control
Prep E2 footprint - dump at E2	2	4,200	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							50	% control
Filter sand - load at external site	2	5,280	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							50	% control
Filter sand - haul to E2 (sealed)	11	2,000	m3/period	0.0054	kg/m3	15	m3/load	36	mean vehicle mass (t)	6.4	km/return trip	0.0128	kg/VKT	0.5	silt loading (g/m	0	% control
Filter sand - haul to E2 (unsealed)	-	2,000	m3/period	0.0000	kg/m3	15	m3/load	36	mean vehicle mass (t)	0.0	km/return trip	0.5478	kg/VKT	4.4	% silt content	80	% control
Filter sand - dump at E2	2	5,280	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							50	% control
Crushed rock rest layer - load in pit	2	4,200	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							50	% control
Crushed rock rest layer - haul to E2 (sealed)	9	2,000	m3/year	0.0043	kg/m3	13	m3/load	36	mean vehicle mass (t)	4.4	km/return trip	0.0128	kg/VKT	0.5	silt loading (g/m	0	% control
Crushed rock rest layer - haul to E2 (unsealed)	28	2,000	m3/year	0.0699	kg/m3	13	m3/load	36	mean vehicle mass (t)	1.7	km/return trip	0.5478	kg/VKT	4.4	% silt content	80	% control
Crushed rock rest layer - dump at E2	2	4,200	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							50	% control
Crushed rock rest layer - screening in pit	-	4,200	t/period	0.0000	kg/t												
Crushed rock rest layer - primary crushing in pit	17	4,200	t/period	0.0040	kg/t												
Toe and side anchorage of liner - haul to E2 (sealed)	2	40	concrete mixer loads (return)					18	mean vehicle mass (t)	6.4	km/return trip	0.0063	kg/VKT	0.5	silt loading (g/m	0	% control
Toe and side anchorage of liner - haul to E2 (unsealed)	-	40	concrete mixer loads (return)					25	Vehicle gross mass (t)	0.0	km/return trip	0.4649	kg/VKT	4.4	% silt content	80	% control
Crest anchor trench - haul to E2 (sealed)	2	40	concrete mixer loads (return)					18	mean vehicle mass (t)	6.4	km/return trip	0.0063	kg/VKT	0.5	silt loading (g/m	0	% control
Crest anchor trench - haul to E2 (unsealed)	-	40	concrete mixer loads (return)					25	Vehicle gross mass (t)	0.0	km/return trip	0.4649	kg/VKT	4.4	% silt content	80	% control
E2 - Dozer	239	715	h/period	0.6691	kg/hr	4.4	Silt content	3	moisture content							50	% control
Wind Erosion - E2 (during construction)	140	0.6	ha	0.0500	kg/ha/h	4,380	h/y									0	% control
Wind Erosion - E2 (after cosntruction)	7	0.6	ha	0.0500	kg/ha/h	4,380	h/y									95	% control
Truck movement - cement	6	126	trucks/year	0.0513	kg/trip			29	Vehicle gross mass (t)	5.0	km/ return trip	0.0102	kg/VKT	0.5	silt loading (g/m	0	%control
Truck movement - aggregate	16	300	trucks/year	0.0529	kg/trip			55	Vehicle gross mass (t)	2.7	km/ return trip	0.0197	kg/VKT	0.5	silt loading (g/m	0	%control
Truck movement - sand	61	1,150.77	trucks/year	0.0529	kg/trip	13	payload (tonnes)	55	Vehicle gross mass (t)	2.7	km/ return trip	0.0197	kg/VKT	0.5	silt loading (g/m	0	%control
Truck movement - shotcrete	25	1,518	trucks/year	0.0164	kg/trip			18	Vehicle gross mass (t)	2.6	km/ return trip	0.0063	kg/VKT	0.5	silt loading (g/m	0	%control
Loading cement at rail siding	6	6,600	t/y	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %								
Aggregate transfer	16	9,348	t/y	0.0017	kg/t												
Sand transfer	8	14,960	t/y	0.0005	kg/t												
Cement transfer	1	6,600	t/y	0.0002	kg/t												
Weigh hopper loading	10	30,908	t/y	0.0013	kg/t											75	
Truck loading	101	30,908	t/y	0.0131	kg/t											75	
Residual from de-dusted air loading cement and fly-ash	53	30,908	t/y	0.0500	g/Nm3	34	Nm3/minute	1	minutes/tonne								
Wind erosion (aggregate stock piles)	13	0.1	ha	0.0500	kg/ha/h	8,760	h/y									70	%control
Wind erosion (whole CBP)	8	0.4	ha	0.0500	kg/ha/h	8,760	h/y									95	%control
Waste rock - load in pit	20	43,050	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							50	% control
Waste rock - haul to E3 (unsealed)	286	20,500	m3/period	0.0699	kg/m3	13	m3/load	36	mean vehicle mass (t)	1.7	km/return trip	0.5478	kg/VKT	4.4	% silt content	80	% control
Waste rock - haul to E3 (sealed)	58	20,500	m3/period	0.0028	kg/m3	13	m3/load	36	mean vehicle mass (t)	2.9	km/return trip	0.0128	kg/VKT	0.5	silt loading (g/m	0	
Waste rock - dump at E3	20	43,050	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							50	% control
Filter sand - load at external site	2	5,040	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							50	% control
Filter sand - haul to E3 (unsealed)	2	2,100	m3/period	0.0047	kg/m3	15	m3/load	36	mean vehicle mass (t)	5.5	km/return trip	0.0128	kg/VKT	0.5	silt loading (g/m	80	% control
Filter sand - dump at E3	2	5,040	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							50	% control
Crushed rock rest layer - load in pit	2	4,200	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							50	% control
Crushed rock rest layer - haul to E3 (unsealed)	28	2,000	m3/year	0.0699	kg/m3	13	m3/load	36	mean vehicle mass (t)	1.7	km/return trip	0.5478	kg/VKT	4.4	% silt content	80	% control
Waste rock - haul to E3 (sealed)	6	2,000	m3/period	0.0028	kg/m3	13	m3/load	36	mean vehicle mass (t)	2.9	km/return trip	0.0128	kg/VKT	0.5	silt loading (g/m	0	
Crushed rock rest layer - dump at E3	2	4,200	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							50	% control
Crushed rock rest layer - screening in pit	-	4,200	t/period	0.0000	kg/t												
Crushed rock rest layer - primary crushing in pit	17	4,200	t/period	0.0040	kg/t												
Toe and side anchorage of liner - haul to E3 (unsealed)	10	17	concrete mixer loads (return)					36	mean vehicle mass (t)	5.5	km/return trip	0.5478	kg/VKT	4.4	% silt content	80	% control
Crest anchor trench - haul to E3 (unsealed)	10	17	concrete mixer loads (return)					36	mean vehicle mass (t)	5.5	km/return trip	0.5478	kg/VKT	4.4	% silt content	80	% control
E3 - Dozer	199	596	h/period	0.6691	kg/hr	4.4	Silt content	3	moisture content							50	% control
Wind Erosion - E3 (during construction)	76	0.3	ha	0.0500	kg/ha/h	4,380	h/y									0	% control
Wind Erosion - E3 (after cosntruction)	4	0.3	ha	0.0500	kg/ha/h	4,380	h/y									95	% control
Total (kg/y)	**2,131**																

ACTIVITY	PM10	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units
Waste rock - load in pit	176	383,250	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Waste rock - haul to E2 (sealed)	1,413	182,500	m3/period	0.0077	kg/m3	13	m3/load	64	mean vehicle mass (t)	4.4	km/return trip	0.0228	kg/VKT	0.5	silt loading (g/m	0	% control
Waste rock - haul to E2 (unsealed)	2,956	182,500	m3/period	0.0810	kg/m3	13	m3/load	50	Vehicle gross mass (t)	1.7	km/return trip	0.6351	kg/VKT	4.4	% silt content	80	% control
Waste rock - dump at E2	176	383,250	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Prep E2 footprint - load at E2	-	-	t/period	0.0003	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Prep E2 footprint - haul within E2	-	-	m3/period	0.0318	kg/m3	8	m3/load	50	Vehicle gross mass (t)	0.4	km/return trip	0.6351	kg/VKT	4.4	% silt content	80	% control
Prep E2 footprint - dump at E2	-	-	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Filter sand - load at external site	-	-	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Filter sand - haul to E2 (sealed)	-	-	m3/period	0.0077	kg/m3	15	m3/load	51	mean vehicle mass (t)	6.4	km/return trip	0.0181	kg/VKT	0.5	silt loading (g/m	0	% control
Filter sand - haul to E2 (unsealed)	-	-	m3/period	0.0000	kg/m3	15	m3/load	35	Vehicle gross mass (t)	0.0	km/return trip	0.5409	kg/VKT	4.4	% silt content	80	% control
Filter sand - dump at E2	-	-	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Crushed rock rest layer - load in pit	-	-	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Crushed rock rest layer - haul to E2 (sealed)	-	-	m3/year	0.0077	kg/m3	13	m3/load	64	mean vehicle mass (t)	4.4	km/return trip	0.0228	kg/VKT	0.5	silt loading (g/m	0	% control
Crushed rock rest layer - haul to E2 (unsealed)	-	-	m3/year	0.0810	kg/m3	13	m3/load	50	Vehicle gross mass (t)	1.7	km/return trip	0.6351	kg/VKT	4.4	% silt content	80	% control
Crushed rock rest layer - dump at E2	-	-	t/period	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Crushed rock rest layer - screening in pit	-	100,375	t/period	0.0000	kg/t												
Crushed rock rest layer - primary crushing in pit	402	100,375	t/period	0.0040	kg/t												
Toe and side anchorage of liner - haul to E2 (sealed)	15	365	concrete mixer loads (return)					18	mean vehicle mass (t)	6.4	km/return trip	0.0063	kg/VKT	0.5	silt loading (g/m	0	% control
Toe and side anchorage of liner - haul to E2 (unsealed	-	365	concrete mixer loads (return)					25	Vehicle gross mass (t)	0.0	km/return trip	0.4649	kg/VKT	4.4	% silt content	80	% control
Crest anchor trench - haul to E2 (sealed)	15	365	concrete mixer loads (return)					18	mean vehicle mass (t)	6.4	km/return trip	0.0063	kg/VKT	0.5	silt loading (g/m	0	% control
Crest anchor trench - haul to E2 (unsealed)	-	365	concrete mixer loads (return)					25	Vehicle gross mass (t)	0.0	km/return trip	0.4649	kg/VKT	4.4	% silt content	80	% control
E2 - Dozer	611	1,825	h/period	0.6691	kg/hr	4.4	Silt content	3	moisture content							50	% control
Wind Erosion - E2 (during construction)	281	0.6	ha	0.0500	kg/ha/h	8,760	h/y									0	% control
Wind Erosion - E2 (after cosntruction)	14	0.6	ha	0.0500	kg/ha/h	8,760	h/y									95	% control
Truck movement - cement	8	161	trucks/year	0.0513	kg/trip			29	Vehicle gross mass (t)	5.0	km/ return trip	0.0102	kg/VKT	0.5	silt loading (g/m	0	%control
Truck movement - aggregate	20	383	trucks/year	0.0529	kg/trip			55	Vehicle gross mass (t)	2.7	km/ return trip	0.0197	kg/VKT	0.5	silt loading (g/m	0	%control
Truck movement - sand	78	1,469	trucks/year	0.0529	kg/trip	13	payload (tonnes)	55	Vehicle gross mass (t)	2.7	km/ return trip	0.0197	kg/VKT	0.5	silt loading (g/m	0	%control
Truck movement - shotcrete	32	1,937	trucks/year	0.0164	kg/trip			18	Vehicle gross mass (t)	2.6	km/ return trip	0.0063	kg/VKT	0.5	silt loading (g/m	0	%control
Loading cement at rail siding	7	7,763	t/y	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %								
Aggregate transfer	19	10,995	t/y	0.0017	kg/t												
Sand transfer	9	17,596	t/y	0.0005	kg/t												
Cement transfer	1	7,763	t/y	0.0002	kg/t												
Weigh hopper loading	12	36,354	t/y	0.0013	kg/t											75	
Truck loading	119	36,354	t/y	0.0131	kg/t											75	
Residual from de-dusted air loading cement and fly-ash	62	36,354	t/y	0.0500	g/Nm3	34	Nm3/minute	1	minutes/tonne								
Wind erosion (aggregate stock piles)	13	0.1	ha	0.0500	kg/ha/h	8,760	h/day									70	%control
Wind erosion (whole CBP)	8	0.4	ha	0.0500	kg/ha/h	8,760	h/day									95	%control
Total (kg/y)	**6,447**																

ACTIVITY	PM2.5	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units
Waste rock - load in pit	4	60,900	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Waste rock - haul to E2 (sealed)	30	29,000	m3/period	0.0010	kg/m3	13	m3/load	36	mean vehicle mass (t)	4.4	km/return trip	0.0031	kg/VKT	0.5	silt loading (g/m	0	% control
Waste rock - haul to E2 (unsealed)	41	29,000	m3/period	0.0070	kg/m3	13	m3/load	36	mean vehicle mass (t)	1.7	km/return trip	0.0548	kg/VKT	4.4	% silt content	80	% control
Waste rock - dump at E2	4	60,900	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Prep E2 footprint - load at E2	0	4,200	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Prep E2 footprint - haul within E2	1	2,000	m3/period	0.0027	kg/m3	8	m3/load	36	mean vehicle mass (t)	0.4	km/return trip	0.0548	kg/VKT	4.4	% silt content	80	% control
Prep E2 footprint - dump at E2	0	4,200	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Filter sand - load at external site	0	5,280	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Filter sand - haul to E2 (sealed)	3	2,000	m3/period	0.0013	kg/m3	15	m3/load	36	mean vehicle mass (t)	6.4	km/return trip	0.0031	kg/VKT	0.5	silt loading (g/m	0	% control
Filter sand - haul to E2 (unsealed)	-	2,000	m3/period	0.0000	kg/m3	15	m3/load	36	mean vehicle mass (t)	0.0	km/return trip	0.0548	kg/VKT	4.4	% silt content	80	% control
Filter sand - dump at E2	0	5,280	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Crushed rock rest layer - load in pit	0	4,200	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Crushed rock rest layer - haul to E2 (sealed)	2	2,000	m3/year	0.0010	kg/m3	13	m3/load	36	mean vehicle mass (t)	4.4	km/return trip	0.0031	kg/VKT	0.5	silt loading (g/m	0	% control
Crushed rock rest layer - haul to E2 (unsealed)	3	2,000	m3/year	0.0070	kg/m3	13	m3/load	36	mean vehicle mass (t)	1.7	km/return trip	0.0548	kg/VKT	4.4	% silt content	80	% control
Crushed rock rest layer - dump at E2	0	4,200	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Crushed rock rest layer - screening in pit	-	4,200	t/period	0.0000	kg/t												
Crushed rock rest layer - primary crushing in pit	4	4,200	t/period	0.0011	kg/t												
Toe and side anchorage of liner - haul to E2 (sealed)	0	40	concrete mixer loads (return)					18	mean vehicle mass (t)	6.4	km/return trip	0.0015	kg/VKT	0.5	silt loading (g/m	0	% control
Toe and side anchorage of liner - haul to E2 (unsealed)	-	40	concrete mixer loads (return)					25	Vehicle gross mass (t)	0.0	km/return trip	0.0465	kg/VKT	4.4	% silt content	80	% control
Crest anchor trench - haul to E2 (sealed)	0	40	concrete mixer loads (return)					18	mean vehicle mass (t)	6.4	km/return trip	0.0015	kg/VKT	0.5	silt loading (g/m	0	% control
Crest anchor trench - haul to E2 (unsealed)	-	40	concrete mixer loads (return)					25	Vehicle gross mass (t)	0.0	km/return trip	0.0465	kg/VKT	4.4	% silt content	80	% control
E2 - Dozer	138	715	h/period	0.3873	kg/hr	4.4	Silt content	3	moisture content							50	% control
Wind Erosion - E2 (during construction)	21	0.6	ha	0.0075	kg/ha/h	4,380	h/y									0	% control
Wind Erosion - E2 (after cosntruction)	1	0.6	ha	0.0075	kg/ha/h	4,380	h/y									95	% control
Truck movement - cement	0	126	trucks/year	0.0124	kg/trip			29	Vehicle gross mass (t)	5.0	km/ return trip	0.0025	kg/VKT	0.5	silt loading (g/m	80	%control
Truck movement - aggregate	1	300	trucks/year	0.0128	kg/trip			55	Vehicle gross mass (t)	2.7	km/ return trip	0.0048	kg/VKT	0.5	silt loading (g/m	80	%control
Truck movement - sand	3	1,151	trucks/year	0.0128	kg/trip	13	payload (tonnes)	55	Vehicle gross mass (t)	2.7	km/ return trip	0.0048	kg/VKT	0.5	silt loading (g/m	80	%control
Truck movement - shotcrete	1	1,518	trucks/year	0.0040	kg/trip			18	Vehicle gross mass (t)	2.6	km/ return trip	0.0015	kg/VKT	0.5	silt loading (g/m	80	%control
Loading cement at rail siding	1	6,600	t/y	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %								
Aggregate transfer	1	9,348	t/y	0.0001	kg/t												
Sand transfer	0	14,960	t/y	0.0000	kg/t												
Cement transfer	0	6,600	t/y	0.0000	kg/t												
Weigh hopper loading	1	30,908	t/y	0.0001	kg/t											75	
Truck loading	6	30,908	t/y	0.0007	kg/t											75	
Residual from de-dusted air loading cement and fly-ash	3	30,908	t/y	0.0028	g/Nm3	34	Nm3/minute	1	minutes/tonne								
Wind erosion (aggregate stock piles)	2	0.1	ha	0.0075	kg/ha/h	8,760	h/y									70	%control
Wind erosion (whole CBP)	1	0.4	ha	0.0075	kg/ha/h	8,760	h/y									95	%control
Waste rock - load in pit	3	43,050	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Waste rock - haul to E3 (unsealed)	29	20,500	m3/period	0.0070	kg/m3	13	m3/load	36	mean vehicle mass (t)	1.7	km/return trip	0.0548	kg/VKT	4.4	% silt content	80	% control
Waste rock - haul to E3 (sealed)	14	20,500	m3/period	0.0007	kg/m3	13	m3/load	36	mean vehicle mass (t)	2.9	km/return trip	0.0031	kg/VKT	0.5	silt loading (g/m	0	
Waste rock - dump at E3	3	43,050	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Filter sand - load at external site	0	5,040	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Filter sand - haul to E3 (unsealed)	8	2,100	m3/period	0.0199	kg/m3	15	m3/load	35	Vehicle gross mass (t)	5.5	km/return trip	0.0541	kg/VKT	4.4	% silt content	80	% control
Filter sand - dump at E3	0	5,040	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Crushed rock rest layer - load in pit	0	4,200	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Crushed rock rest layer - haul to E3 (unsealed)	3	2,000	m3/year	0.0070	kg/m3	13	m3/load	36	mean vehicle mass (t)	1.7	km/return trip	0.0548	kg/VKT	4.4	% silt content	80	% control
Waste rock - haul to E3 (sealed)	1	2,000	m3/period	0.0007	kg/m3	13	m3/load	36	mean vehicle mass (t)	2.9	km/return trip	0.0031	kg/VKT	0.5	silt loading (g/m	0	
Crushed rock rest layer - dump at E3	0	4,200	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50	% control
Crushed rock rest layer - screening in pit	-	4,200	t/period	0.0000	kg/t												
Crushed rock rest layer - primary crushing in pit	4	4,200	t/period	0.0011	kg/t												
Toe and side anchorage of liner - haul to E3 (unsealed)	1	17	concrete mixer loads (return)					25	Vehicle gross mass (t)	5.5	km/return trip	0.0465	kg/VKT	4.4	% silt content	80	% control
Crest anchor trench - haul to E3 (unsealed)	1	17	concrete mixer loads (return)					25	Vehicle gross mass (t)	5.5	km/return trip	0.0465	kg/VKT	4.4	% silt content	80	% control
E3 - Dozer	115	596	h/period	0.3873	kg/hr	4.4	Silt content	3	moisture content							50	% control
Wind Erosion - E3 (during construction)	11	0.3	ha	0.0075	kg/ha/h	4,380	h/y									0	% control
Wind Erosion - E3 (after cosntruction)	1	0.3	ha	0.0075	kg/ha/h	4,380	h/y									95	% control
Total (kg/y)	**472**																

ACTIVITY	PM2.5	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control
Waste rock - load in pit	27	383,250	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50
Waste rock - haul to E2 (sealed)	342	182,500	m3/period	0.0019	kg/m3	13	m3/load	64	mean vehicle mass (t)	4.4	km/return trip	0.0055	kg/VKT	0.5	silt loading (g/m	0
Waste rock - haul to E2 (unsealed)	296	182,500	m3/period	0.0081	kg/m3	13	m3/load	50	Vehicle gross mass (t)	1.7	km/return trip	0.0635	kg/VKT	4.4	% silt content	80
Waste rock - dump at E2	27	383,250	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50
Prep E2 footprint - load at E2	-	-	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50
Prep E2 footprint - haul within E2	-	-	m3/period	0.0032	kg/m3	8	m3/load	50	Vehicle gross mass (t)	0.4	km/return trip	0.0635	kg/VKT	4.4	% silt content	80
Prep E2 footprint - dump at E2	-	-	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50
Filter sand - load at external site	-	-	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50
Filter sand - haul to E2 (sealed)	-	-	m3/period	0.0019	kg/m3	15	m3/load	51	mean vehicle mass (t)	6.4	km/return trip	0.0044	kg/VKT	0.5	silt loading (g/m	0
Filter sand - haul to E2 (unsealed)	-	-	m3/period	0.0000	kg/m3	15	m3/load	35	Vehicle gross mass (t)	0.0	km/return trip	0.0541	kg/VKT	4.4	% silt content	80
Filter sand - dump at E2	-	-	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50
Crushed rock rest layer - load in pit	-	-	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50
Crushed rock rest layer - haul to E2 (sealed)	-	-	m3/year	0.0019	kg/m3	13	m3/load	64	mean vehicle mass (t)	4.4	km/return trip	0.0055	kg/VKT	0.5	silt loading (g/m	0
Crushed rock rest layer - haul to E2 (unsealed)	-	-	m3/year	0.0081	kg/m3	13	m3/load	50	Vehicle gross mass (t)	1.7	km/return trip	0.0635	kg/VKT	4.4	% silt content	80
Crushed rock rest layer - dump at E2	-	-	t/period	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							50
Crushed rock rest layer - screening in pit	-	100,375	t/period	0.0000	kg/t											
Crushed rock rest layer - primary crushing in pit	105	100,375	t/period	0.0011	kg/t											
Toe and side anchorage of liner - haul to E2 (sealed)	4	365	concrete mixer loads (return)					18	mean vehicle mass (t)	6.4	km/return trip	0.0015	kg/VKT	0.5	silt loading (g/m	0
Toe and side anchorage of liner - haul to E2 (unsealed)	-	365	concrete mixer loads (return)					25	Vehicle gross mass (t)	0.0	km/return trip	0.0465	kg/VKT	4.4	% silt content	80
Crest anchor trench - haul to E2 (sealed)	4	365	concrete mixer loads (return)					18	mean vehicle mass (t)	6.4	km/return trip	0.0015	kg/VKT	0.5	silt loading (g/m	0
Crest anchor trench - haul to E2 (unsealed)	-	365	concrete mixer loads (return)					25	Vehicle gross mass (t)	0.0	km/return trip	0.0465	kg/VKT	4.4	% silt content	80
E2 - Dozer	353	1,825	h/period	0.3873	kg/hr	4.4	Silt content	3	moisture content							50
Wind Erosion - E2 (during construction)	42	0.6	ha	0.0075	kg/ha/h	8,760	h/y									0
Wind Erosion - E2 (after cosntruction)	2	0.6	ha	0.0075	kg/ha/h	8,760	h/y									95
Truck movement - cement	0	161	trucks/year	0.0124	kg/trip			29	Vehicle gross mass (t)	5.0	km/ return trip	0.0025	kg/VKT	0.5	silt loading (g/m	80
Truck movement - aggregate	1	383	trucks/year	0.0128	kg/trip			55	Vehicle gross mass (t)	2.7	km/ return trip	0.0048	kg/VKT	0.5	silt loading (g/m	80
Truck movement - sand	4	1,469	trucks/year	0.0128	kg/trip	13	payload (tonnes)	55	Vehicle gross mass (t)	2.7	km/ return trip	0.0048	kg/VKT	0.5	silt loading (g/m	80
Truck movement - shotcrete	2	1,937	trucks/year	0.0040	kg/trip			18	Vehicle gross mass (t)	2.6	km/ return trip	0.0015	kg/VKT	0.5	silt loading (g/m	80
Loading cement at rail siding	1	7,763	t/y	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in m/s	3	moisture content in %							
Aggregate transfer	1	10,995	t/y	0.0001	kg/t											
Sand transfer	1	17,596	t/y	0.0000	kg/t											
Cement transfer	0	7,763	t/y	0.0000	kg/t											
Weigh hopper loading	1	36,354	t/y	0.0001	kg/t											75
Truck loading	7	36,354	t/y	0.0007	kg/t											75
Residual from de-dusted air loading cement and fly-ash	3	36,354	t/y	0.0028	g/Nm3	34	Nm3/minute	1	minutes/tonne							
Wind erosion (aggregate stock piles)	2	0.1	ha	0.0075	kg/ha/h	8,760	h/y									70
Wind erosion (whole CBP)	1	0.4	ha	0.0075	kg/ha/h	8,760	h/y									95
Total (kg/y)	**1,225**															

ACTIVITY	Assumptions
Waste rock - load in pit	Assumed that waste rock will be loaded in Kintore Pit. Moisture content based on Environ (2010).
Waste rock - haul to E2 (sealed)	Haul roads to lengths to be estimated from maps. Silt content based on Environ (2010). 90% control per Environ (2010)
Waste rock - haul to E2 (unsealed)	Haul roads to lengths to be estimated from maps. Silt content based on Environ (2010). 80% control with water and chemical suppressant
Waste rock - dump at E2	Moisture content based on Environ (2010)
Prep E2 footprint - load at E2	Moisture content based on Environ (2010)
Prep E2 footprint - haul within E2	Haul roads to lengths to be estimated from maps. Silt content based on Environ (2010). 80% control with water and chemical suppressant
Prep E2 footprint - dump at E2	Average wind speed and moisture content based on Environ (2010)
Filter sand - load at external site	Assumed to happen offsite
Filter sand - haul to E2 (sealed)	Haul roads to lengths to be estimated from maps. Silt content based on Environ (2010). 90% control per Environ (2010)
Filter sand - haul to E2 (unsealed)	Haul roads to lengths to be estimated from maps. Silt content based on Environ (2010). 80% control with water and chemical suppressant
Filter sand - dump at E2	Moisture content based on Environ (2010)
Crushed rock rest layer - load in pit	Assumed that crushed rock will be loaded in Kintore Pit.
Crushed rock rest layer - haul to E2 (sealed)	Haul roads to lengths to be estimated from maps. Silt content based on Environ (2010). 90% control per Environ (2010)
Crushed rock rest layer - haul to E2 (unsealed)	Haul roads to lengths to be estimated from maps. Silt content based on Environ (2010). 80% control with water and chemical suppressant
Crushed rock rest layer - dump at E2	Average wind speed and moisture content based on Environ (2010)
Crushed rock rest layer - screening in pit	Water sprays will be used as a control measure. Assumes high moisture content ore per Environ (2010), therefore no emissions from screening
Crushed rock rest layer - primary crushing in pit	Water sprays will be used as a control measure. Assumes high moisture content ore per Environ (2010).
Toe and side anchorage of liner - haul to E2 (sealed)	Haul roads to lengths to be estimated from maps. Silt content based on Environ (2010). 90% control per Environ (2010)
Toe and side anchorage of liner - haul to E2 (unsealed)	Haul roads to lengths to be estimated from maps. Silt content based on Environ (2010). 80% control with water and chemical suppressant
Crest anchor trench - haul to E2 (sealed)	Haul roads to lengths to be estimated from maps. Silt content based on Environ (2010). 90% control per Environ (2010)
Crest anchor trench - haul to E2 (unsealed)	Haul roads to lengths to be estimated from maps. Silt content based on Environ (2010). 80% control with water and chemical suppressant
E2 - Dozer	Operating hours are 7am to 6pm M to F and 7am to 1pm Sat. Assumes a 6 month construction period. Assumes that during this period some of the time will be spent constructing decant pond. Assumes dust generating activities only 50% of the time.
Wind Erosion - E2 (during construction)	Assumed no control during construction. Assumes only held of area exposed at any one time.
Wind Erosion - E2 (after construction)	Chemical suppressant will be applied and achieve 95% dust control. Per Environ (2010)
Truck movement - cement	For truck GVM and MVM see email from client on 20.09.2016. 90% control per Environ (2010)
Truck movement - aggregate	For truck GVM and MVM see email from client on 20.09.2016. 90% control per Environ (2010)
Truck movement - sand	For truck GVM and MVM see email from client on 20.09.2016. 90% control per Environ (2010)
Truck movement - shotcrete	For truck GVM and MVM see email from client on 20.09.2016. 90% control per Environ (2010)

Loading cement at rail siding	Assumes 3% moisture content
Aggregate transfer	Uncontrolled
Sand transfer	Uncontrolled
Cement transfer	Controlled through use of water spray
Weigh hopper loading	70& control applied as it will be in a building (per Environ 2010)
Truck loading	Controlled through use of water spray
Residual from de-dusted air loading cement and fly-ash	
Wind erosion (aggregate stock piles)	Assumes area of stockpiles to be 0.1 ha. Control applied for enclosure
Wind erosion (whole CBP)	Chemical suppressant will be applied and achieve 95% dust control. Per Environ (2010)
Waste rock - load in pit	Assumed that waste rock will be loaded in Kintore Pit. Average wind speed and moisture content based on Environ (2010).
Waste rock - haul to E3 (unsealed)	Haul roads to lengths to be estimated from maps. Silt content based on Environ (2010). 80% control with water and chemical suppressant
Waste rock - haul to E3 (sealed)	
Waste rock - dump at E3	Average wind speed and moisture content based on Environ (2010)
Filter sand - load at external site	Assumed to happen offsite
Filter sand - haul to E3 (unsealed)	Haul roads to lengths to be estimated from maps. Silt content based on Environ (2010). 80% control with water and chemical suppressant
Filter sand - dump at E3	Average wind speed and moisture content based on Environ (2010)
Crushed rock rest layer - load in pit	Assumed that crushed rock will be loaded in Kintore Pit.
Crushed rock rest layer - haul to E3 (unsealed)	Haul roads to lengths to be estimated from maps. Silt content based on Environ (2010). 80% control with water and chemical suppressant
Waste rock - haul to E3 (sealed)	
Crushed rock rest layer - dump at E3	Average wind speed and moisture content based on Environ (2010)
Crushed rock rest layer - screening in pit	Water sprays will be used as a control measure. Assumes high moisture content ore per Environ (2010), therefore no emissions from screening
Crushed rock rest layer - primary crushing in pit	Water sprays will be used as a control measure. Assumes high moisture content ore per Environ (2010).
Toe and side anchorage of liner - haul to E3 (unsealed)	Haul roads to lengths to be estimated from maps. Silt content based on Environ (2010). 80% control with water and chemical suppressant
Crest anchor trench - haul to E3 (unsealed)	Haul roads to lengths to be estimated from maps. Silt content based on Environ (2010). 80% control with water and chemical suppressant
E3 - Dozer	Operating hours are 7am to 6pm M to F and 7am to 1pm Sat. Assumes a 5 month construction period. Assumes that during this period some of the time will be spent constructing decant pond. Assumes dust generating activities only 50% of the time.
Wind Erosion - E3 (during construction)	Assumed no control during construction. Assumes only held of area exposed at any one time.
Wind Erosion - E3 (after construction)	Chemical suppressant will be applied and achieve 95% dust control. Per Environ (2010)

APPENDIX B. EMISSIONS INVENTORY AND ASSUMPTIONS FOR OPERATIONS IN 2016

ACTIVITY	TSP emission (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units
Haul - from Kintore Pit to ROM pad (unsealed	5,650	12,915	km/year	2.1872	kg/VKT	17016	no. trips	36	mean vehicle mass (t)	0.8	km	2.1872	kg/VKT	4.4	% silt content	80	% control
Haul - from Kintore Pit to ROM pad (sealed)	1,381	20,777	km/year	0.0665	kg/VKT	17016	no. trips	36	mean vehicle mass (t)	1.2	km	0.0665	kg/VKT	0.5	silt loading (g/m	0	% control
Haul - Concentrate to rail (sealed)	408	6,134	km/year	0.0665	kg/VKT	3205	no. trips	36	mean vehicle mass (t)	1.9	km	0.0665	kg/VKT	0.5	silt loading (g/m	0	% control
Haul -Waste to Kintore Pit (unsealed)	1,434	3,279	km/year	2.1872	kg/VKT	4320	no. trips	36	mean vehicle mass (t)	0.8	km	2.1872	kg/VKT	4.4	% silt content	80	% control
Haul -Waste to Kintore Pit (sealed)	431	6,476	km/year	0.0665	kg/VKT	4320	no. trips	36	mean vehicle mass (t)	1.5	km	0.0665	kg/VKT	0.5	silt loading (g/m	0	% control
Haul - to workshop (sealed)	204	3,066	km/year	0.0665	kg/VKT	10220	no. trips	36	mean vehicle mass (t)	0.3	km	0.0665	kg/VKT	0.5	silt loading (g/m	0	% control
Dump - Ore at ROM pad	25	12,915	t/year	0.0019	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							0	% control
FEL at ROM pad	4,869	2,640	h/year	3.6886	kg/hr	4.4	Silt content	3	moisture content							50	% control
Crushed ore storage bin trasnfer	25	12,915	t/year	0.0019	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							0	% control
Concentrate handling	1	6,134	t/year	0.0004	kg/t	2.90	average of (wind speed/2.2)^1.3 in	9	moisture content in %							70	% control
Wind Erosion - ROM pad	77	0.25	ha	0.1000	kg/ha/h	8,760	h/y									65	% control
Wind Erosion - Free areas	726	24.4	ha	0.1000	kg/ha/h	8,760	h/y									96.6	% control
Wind Erosion - Disturbed areas	5,937	67.8	ha	0.1000	kg/ha/h	8,760	h/y									90	% control
Total (kg/y)	**21,167**																

ACTIVITY	PM10 emission (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units
Haul - from Kintore Pit to ROM pad (unseale	239	12,915	km/year	0.0923	kg/VKT	17016	no. trips	36	mean vehicle mass (t)	0.8	km	0.0923	kg/VKT	4.4	% silt content	80	% control
Haul - from Kintore Pit to ROM pad (sealed)	1,608	20,777	km/year	0.0774	kg/VKT	17016	no. trips	36	mean vehicle mass (t)	1.2	km	0.0774	kg/VKT	0.5	silt loading (g/m	0	
Haul - Concentrate to rail (sealed)	475	6,134	km/year	0.0774	kg/VKT	3205	no. trips	36	mean vehicle mass (t)	1.9	km	0.0774	kg/VKT	0.5	silt loading (g/m	0	% control
Haul -Waste to Kintore Pit (unsealed)	61	3,279	km/year	0.0923	kg/VKT	4320	no. trips	36	mean vehicle mass (t)	0.8	km	0.0923	kg/VKT	4.4	% silt content	80	% control
Haul -Waste to Kintore Pit (sealed)	501	6,476	km/year	0.0774	kg/VKT	4320	no. trips	36	mean vehicle mass (t)	1.5	km	0.0774	kg/VKT	0.5	silt loading (g/m	0	% control
Haul - to workshop (sealed)	237	3,066	km/year	0.0774	kg/VKT	10220	no. trips	36	mean vehicle mass (t)	0.3	km	0.0774	kg/VKT	0.5	silt loading (g/m	0	
Dump - Ore at ROM pad	12	12,915	t/year	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							0	% control
FEL at ROM pad	883	2,640	h/year	0.6691	kg/hr	4.4	Silt content	3	moisture content							50	% control
Crushed ore storage bin trasnfer	12	12,915	t/year	0.0009	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							0	% control
Concentrate handling	0	6,134	t/year	0.0002	kg/t	2.90	average of (wind speed/2.2)^1.3 in	9	moisture content in %							70	% control
Wind Erosion - ROM pad	38	0.25	ha	0.0500	kg/ha/h	8,760	h/y									65	% control
Wind Erosion - Free areas	363	24.4	ha	0.0500	kg/ha/h	8,760	h/y									96.6	% control
Wind Erosion - Disturbed areas	2,968	67.8	ha	0.0500	kg/ha/h	8,760	h/y									90	% control
Total (kg/y)	**7,397**																

ACTIVITY	PM2.5 emission (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units
Haul - from Kintore Pit to ROM pad (unseal	58	12,915	km/year	0.0223	kg/VKT	17016	no. trips	36	mean vehicle mass (t)	0.8	km	0.0223	kg/VKT	4.4	% silt content	80	% control
Haul - from Kintore Pit to ROM pad (sealec	161	20,777	km/year	0.0077	kg/VKT	17016	no. trips	36	mean vehicle mass (t)	1.2	km	0.0077	kg/VKT	0.5	silt loading (g/m	0	
Haul - Concentrate to rail (sealed)	47	6,134	km/year	0.0077	kg/VKT	3205	no. trips	36	mean vehicle mass (t)	1.9	km	0.0077	kg/VKT	0.5	silt loading (g/m	0	% control
Haul -Waste to Kintore Pit (unsealed)	15	3,279	km/year	0.0223	kg/VKT	4320	no. trips	36	mean vehicle mass (t)	0.8	km	0.0223	kg/VKT	4.4	% silt content	80	% control
Haul -Waste to Kintore Pit (sealed)	50	6,476	km/year	0.0077	kg/VKT	4320	no. trips	36	mean vehicle mass (t)	1.5	km	0.0077	kg/VKT	0.5	silt loading (g/m	0	% control
Haul - to workshop (sealed)	24	3,066	km/year	0.0077	kg/VKT	10220	no. trips	36	mean vehicle mass (t)	0.3	km	0.0077	kg/VKT	0.5	silt loading (g/m	0	
Dump - Ore at ROM pad	2	12,915	t/year	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							0	% control
FEL at ROM pad	511	2,640	h/year	0.3873	kg/hr	4.4	Silt content	3	moisture content							50	% control
Crushed ore storage bin trasnfer	2	12,915	t/year	0.0001	kg/t	2.90	average of (wind speed/2.2)^1.3 in	3	moisture content in %							0	% control
Concentrate handling	0.1	6,134	t/year	0.0000	kg/t	2.90	average of (wind speed/2.2)^1.3 in	9	moisture content in %							70	% control
Wind Erosion - ROM pad	6	0.25	ha	0.0075	kg/ha/h	8,760	h/y									65	% control
Wind Erosion - Free areas	54	24.4	ha	0.0075	kg/ha/h	8,760	h/y									96.6	% control
Wind Erosion - Disturbed areas	445	67.8	ha	0.0075	kg/ha/h	8,760	h/y									90	% control
Total (kg/y)	**1,375**																

Parameter	Vent shaft	Baghouse stack	Vent shaft 6
Stack height (m)	3.00	5.00	8.0
Stack diameter (m)	4.7	0.7	4.0000
Exit Velocity (m/s)	10.4	19.7	4.9
Temperature (K)	295	Ambient	295
Easting (m)	543,616	544,736	543,304
Northing (m)	6,463,201	6,463,699	6,462,437
TSP emission rate (g/s)	0.12	0.005	0.12
PM_{10} emission rate (g/s)	0.09	0.005	0.09
$PM_{2.5}$ emission rate (g/s)	0.03	0.001	0.03
Lead (TSP) emission rate (g/s)	0.004	0.0001	0.0036

ACTIVITY	TSP Emission kg/year	Adopted Pb source measurement	Adopted Pb composition (%)
Haul - from Kintore Pit to ROM pad (unsealed)	133.9	Unpaved Road	2.4%
Haul - from Kintore Pit to ROM pad (sealed)	32.7	Unpaved Road	2.4%
Haul - Concentrate to rail (sealed)	9.7	Unpaved Road	2.4%
Haul -Waste to Kintore Pit (unsealed)	34.0	Unpaved Road	2.4%
Haul -Waste to Kintore Pit (sealed)	10.2	Unpaved Road	2.4%
Haul - to workshop (sealed)	4.8	Unpaved Road	2.4%
Dump - Ore at ROM pad	0.8	ROM ore	3.0%
FEL at ROM pad	146.1	ROM ore	3.0%
Crushed ore storage bin transfer	0.8	ROM ore	3.0%
Concentrate handling	0.6	Concentrate	73.3%
Wind Erosion - ROM pad	2.3	ROM ore	3.0%
Wind Erosion - Free areas	10.1	Free areas	1.4%
Wind Erosion - Disturbed areas	140.7	Unpaved Road	2.4%
Vent shaft	126.0	ROM ore	3.0%
Baghouse stack	3.0	ROM ore	3.0%
Vent shaft 6	114.0	ROM ore	3.0%

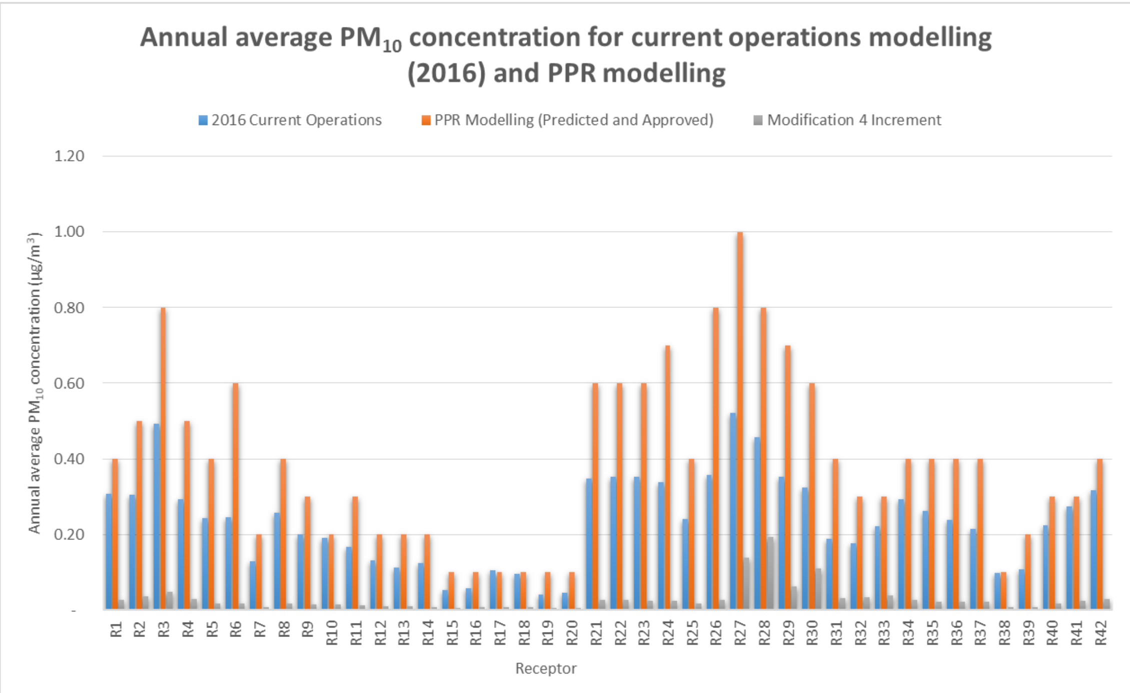
APPENDIX C. PREDICTED IMPACTS FOR RASP MINE FOR 2016 OPERATIONS COMAPRED WITH PPR RESULTS

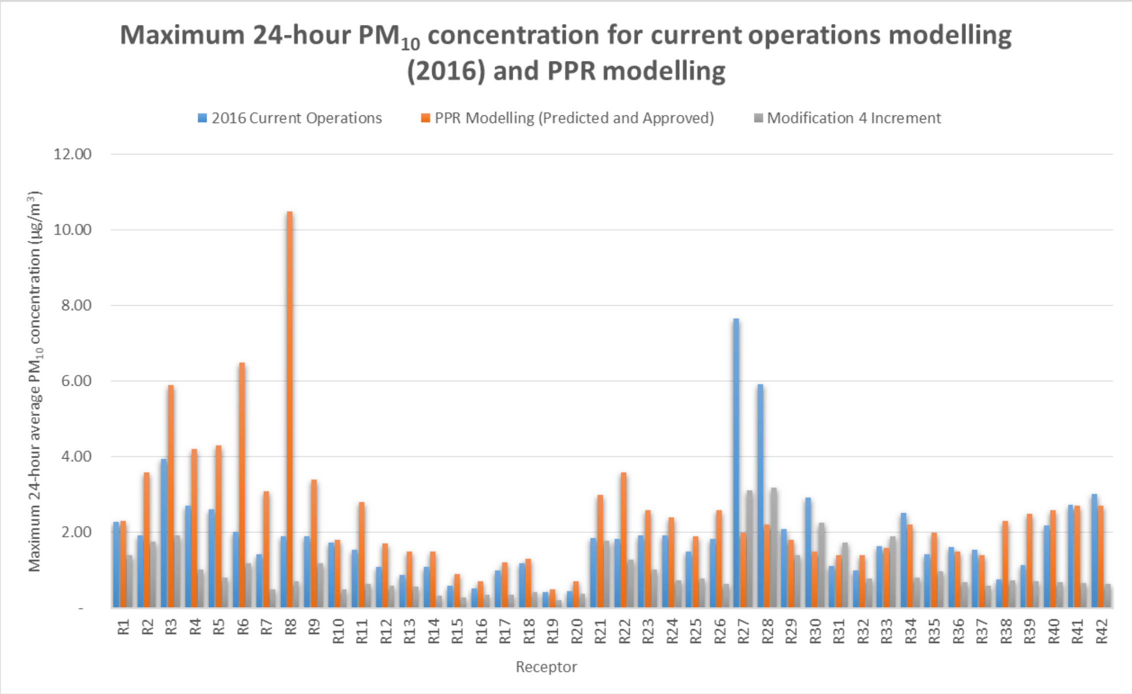
REVIEW OF CURRENT OPERATIONS DISPERSION MODELLING

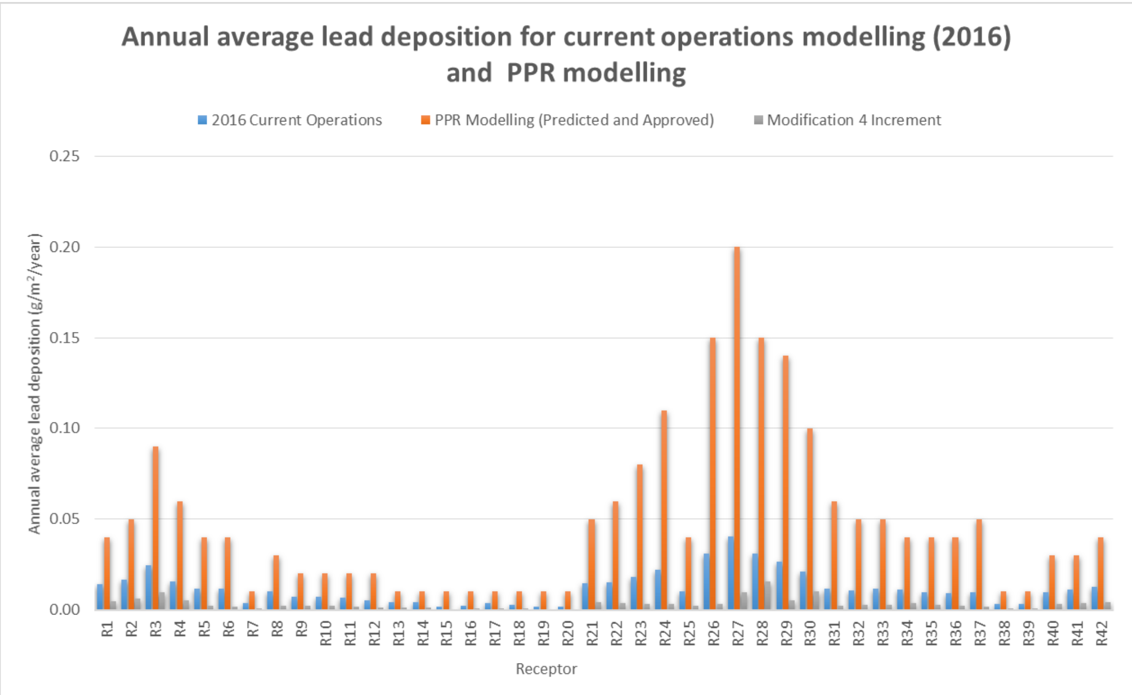
The following provides an overview of the air dispersion modelling that was configured for the current operations of Rasp Mine. The modelled year was 2016 and combined detailed information on the site operations with site representative meteorological data. These data can be directly compared with the air dispersion modelling that was completed for Rasp Mine's Preferred Project Report (PPR) **(Environ, 2010)**.

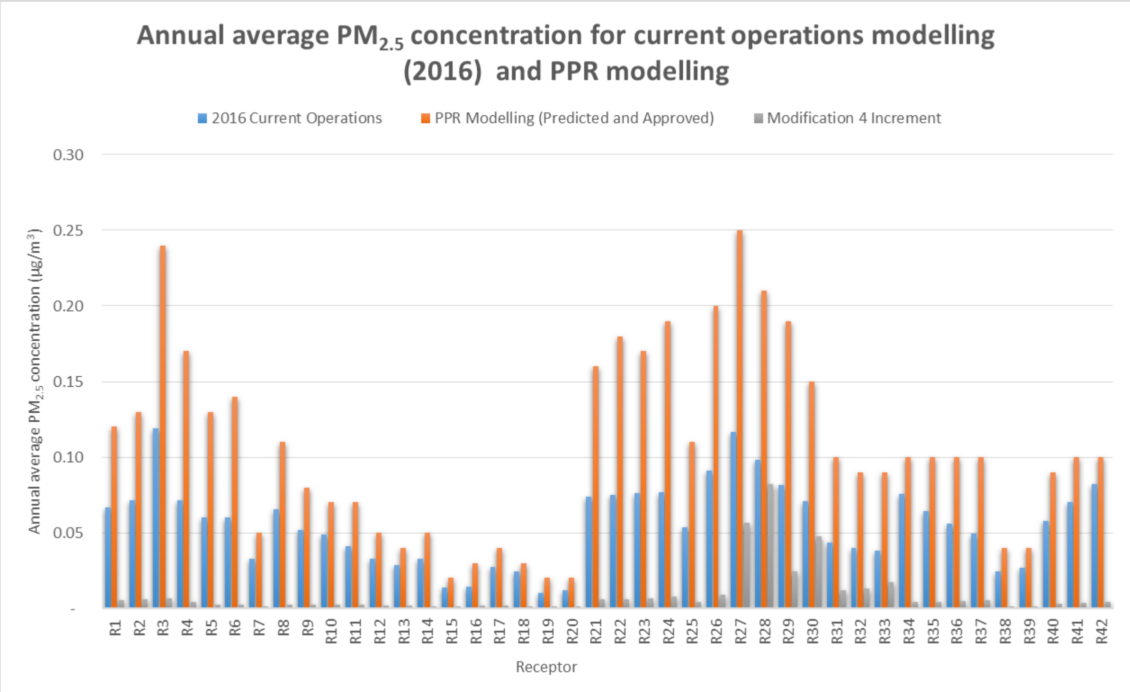
The following considerations should be made in comparing these two sets of results:

- The 2016 operations did not operation at 100% capacity, while the PPR calculation all emissions based on the respective assumption.
- Different meteorological files were used. The 2016 current operations adopted 2016, while the PPR adopted 2008/2009. Therefore the 24-hour predictions will not always align with the annual results.
- The source configuration has changed, where the main vent shaft has been relocated and there has been the addition of Vent Shaft No. 6.
- Updates to emission factors that have taken place since the PPR modelling.

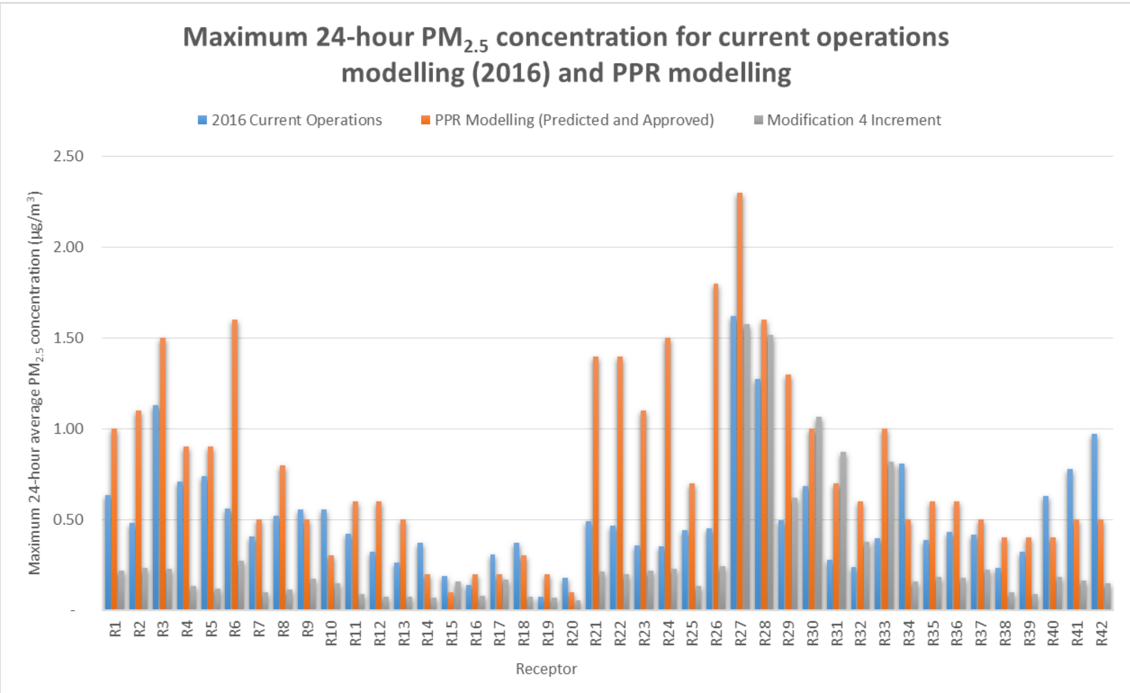



Maximum 24-hour PM_{10} concentration for current operations modelling (2016) and PPR modelling
2016 Current Operations
PPR Modelling (Predicted and Approved)
Modification 4 Increment
Maximum 24-hour average PM_{10} concentration (µg/m^3)
12.00
10.00
8.00
6.00
4.00
2.00
-
R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13 R14 R15 R16 R17 R18 R19 R20 R21 R22 R23 R24 R25 R26 R27 R28 R29 R30 R31 R32 R33 R34 R35 R36 R37 R38 R39 R40 R41 R42
Receptor

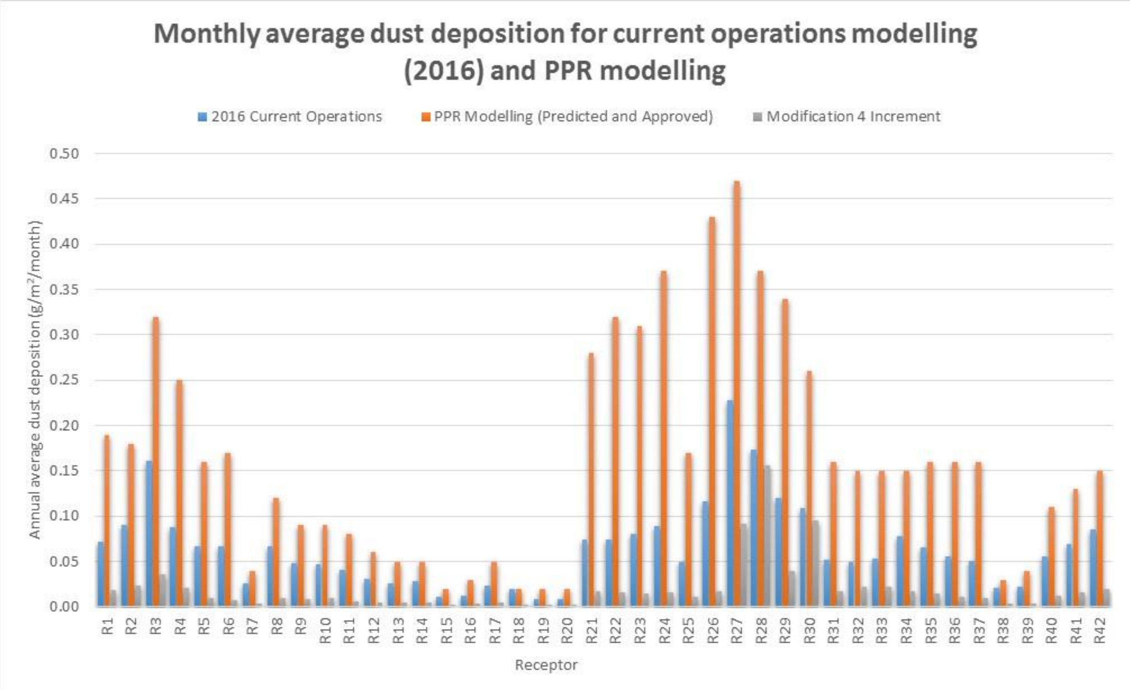

Annual average lead deposition for current operations modelling (2016) and PPR modelling
2016 Current Operations
PPR Modelling (Predicted and Approved)
Modification 4 Increment
Annual average lead deposition (g/m^2/year)
0.25
0.20
0.15
0.10
0.05
0.00
R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13 R14 R15 R16 R17 R18 R19 R20 R21 R22 R23 R24 R25 R26 R27 R28 R29 R30 R31 R32 R33 R34 R35 R36 R37 R38 R39 R40 R41 R42
Receptor

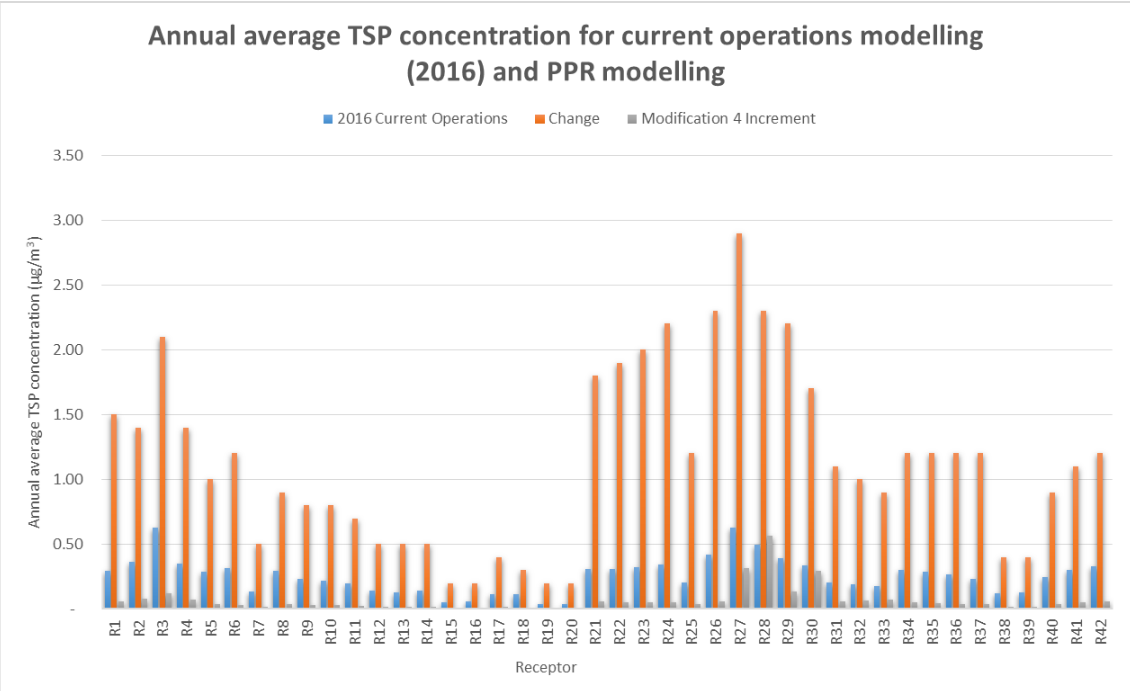


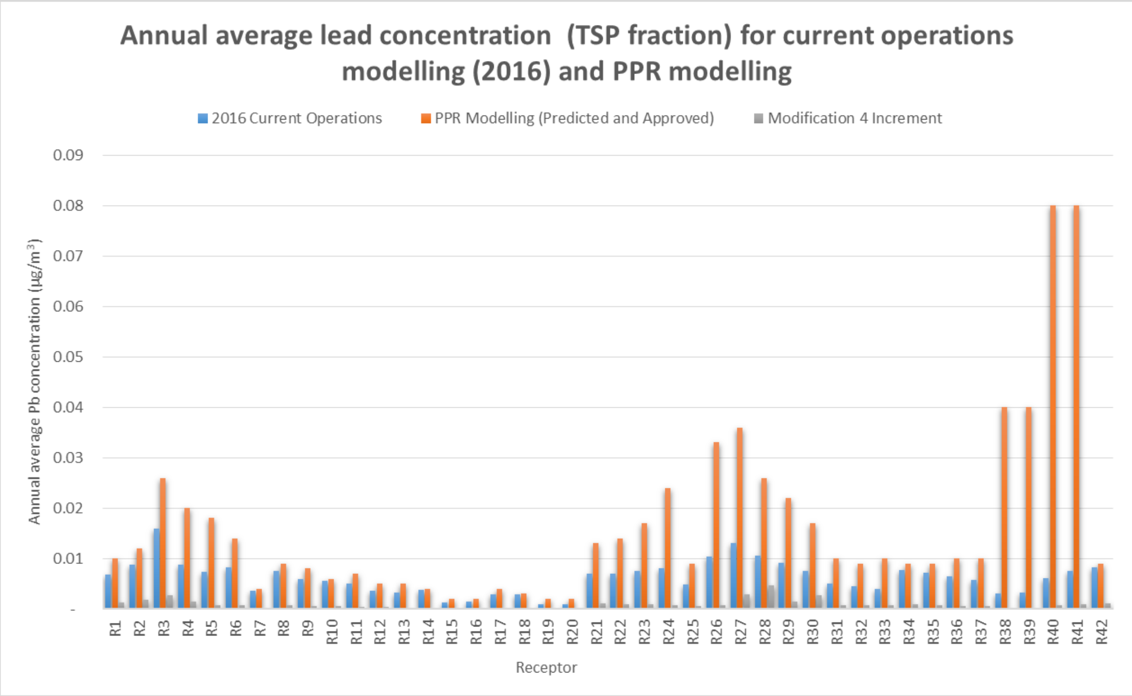
Annual average PM2.5 concentration for current operations modelling (2016) and PPR modelling
2016 Current Operations
PPR Modelling (Predicted and Approved)
Modification 4 Increment
Annual average PM2.5 concentration (µg/m3)
0.30
0.25
0.20
0.15
0.10
0.05
-
R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13 R14 R15 R16 R17 R18 R19 R20 R21 R22 R23 R24 R25 R26 R27 R28 R29 R30 R31 R32 R33 R34 R35 R36 R37 R38 R39 R40 R41 R42
Receptor

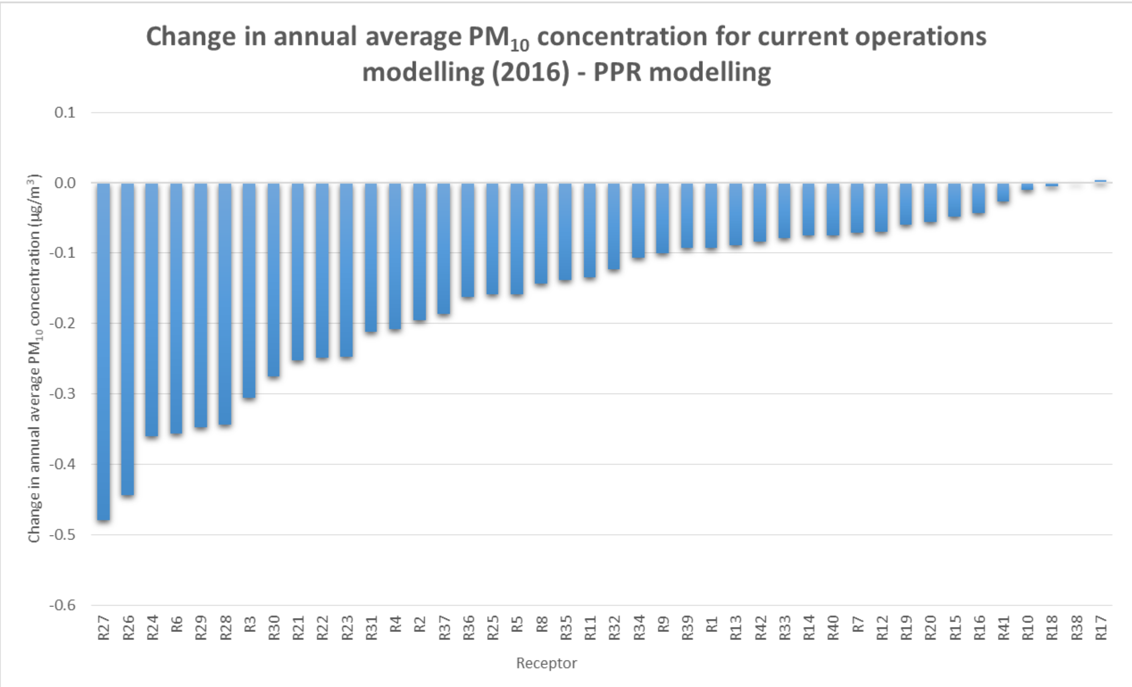


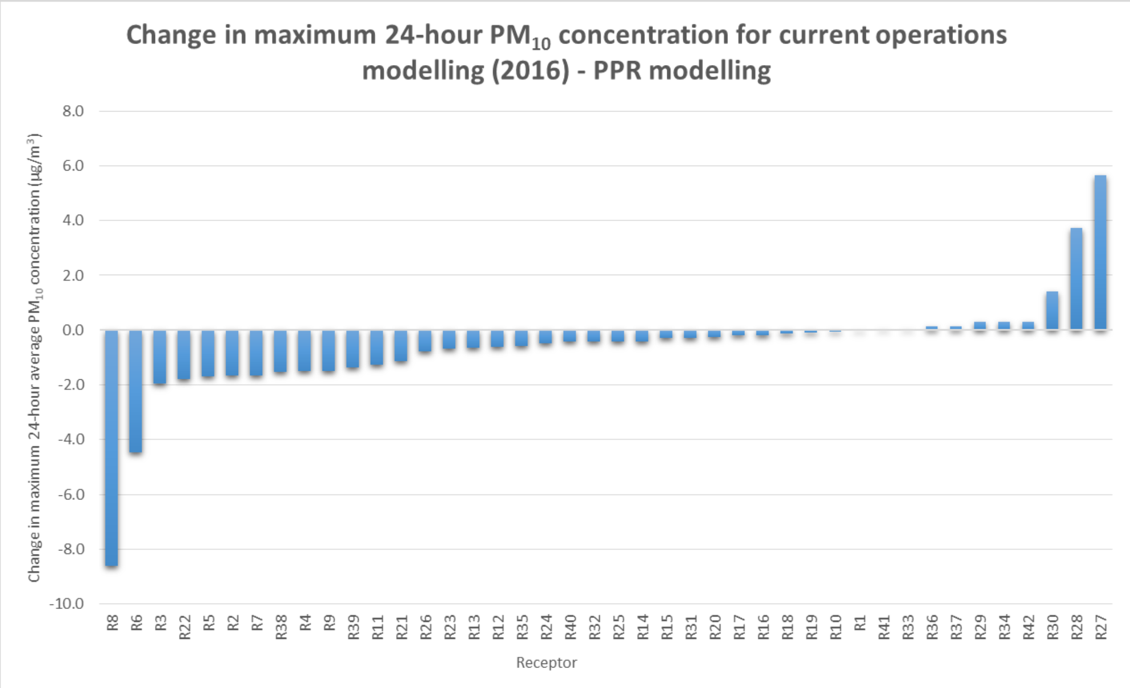
Maximum 24-hour PM2.5 concentration for current operations modelling (2016) and PPR modelling
2016 Current Operations
PPR Modelling (Predicted and Approved)
Modification 4 Increment
Maximum 24-hour average PM2.5 concentration (µg/m3)
2.50
2.00
1.50
1.00
0.50
-
R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13 R14 R15 R16 R17 R18 R19 R20 R21 R22 R23 R24 R25 R26 R27 R28 R29 R30 R31 R32 R33 R34 R35 R36 R37 R38 R39 R40 R41 R42
Receptor


Monthly average dust deposition for current operations modelling (2016) and PPR modelling
2016 Current Operations
PPR Modelling (Predicted and Approved)
Modification 4 Increment
Annual average dust deposition (g/m²/month)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
R19
R20
R21
R22
R23
R24
R25
R26
R27
R28
R29
R30
R31
R32
R33
R34
R35
R36
R37
R38
R39
R40
R41
R42
Receptor

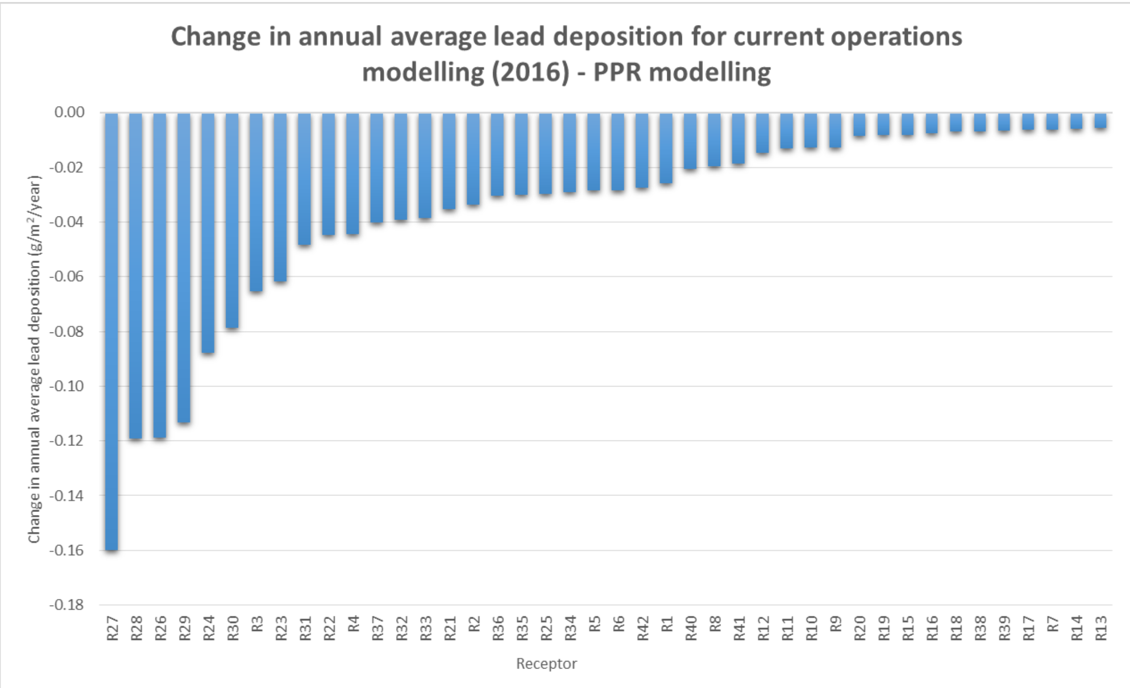

Annual average TSP concentration for current operations modelling (2016) and PPR modelling
2016 Current Operations
Change
Modification 4 Increment
Annual average TSP concentration (µg/m³)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
-
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
R19
R20
R21
R22
R23
R24
R25
R26
R27
R28
R29
R30
R31
R32
R33
R34
R35
R36
R37
R38
R39
R40
R41
R42
Receptor


Annual average lead concentration (TSP fraction) for current operations modelling (2016) and PPR modelling
2016 Current Operations
PPR Modelling (Predicted and Approved)
Modification 4 Increment
Annual average Pb concentration (µg/m³)
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
-
R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13 R14 R15 R16 R17 R18 R19 R20 R21 R22 R23 R24 R25 R26 R27 R28 R29 R30 R31 R32 R33 R34 R35 R36 R37 R38 R39 R40 R41 R42
Receptor

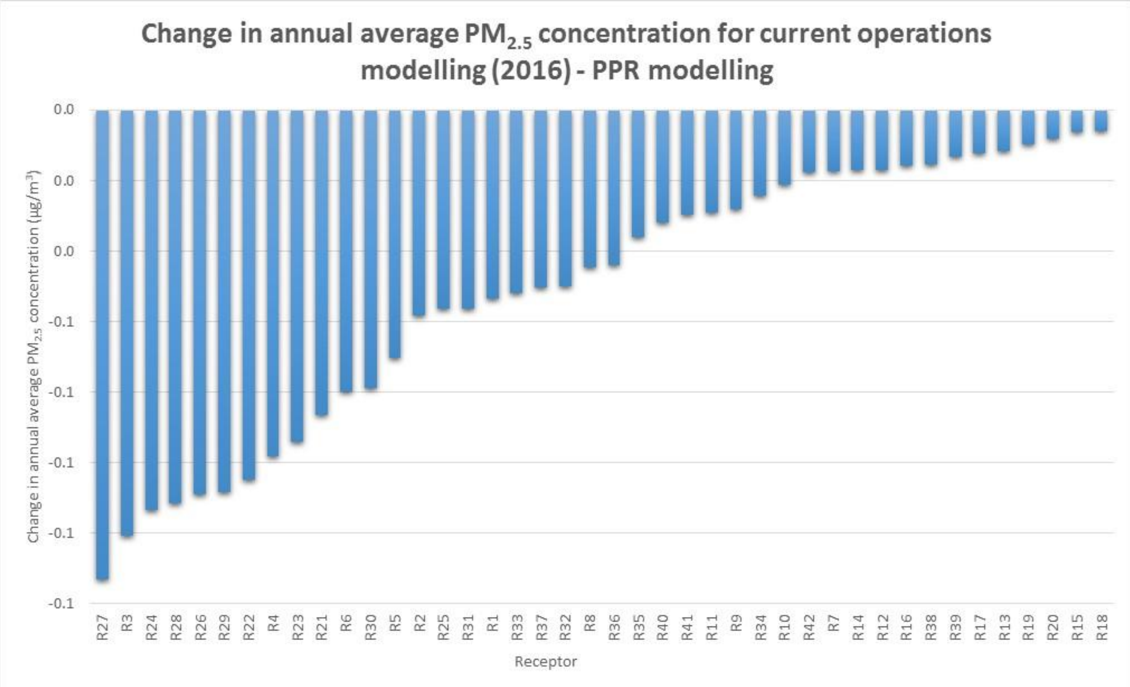

Change in annual average PM10 concentration for current operations modelling (2016) - PPR modelling
Change in annual average PM10 concentration (µg/m³)
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
R27 R26 R24 R6 R29 R28 R3 R30 R21 R22 R23 R31 R4 R2 R37 R36 R25 R5 R8 R35 R11 R32 R34 R9 R39 R1 R13 R42 R33 R14 R40 R7 R12 R19 R20 R15 R16 R41 R10 R18 R38 R17
Receptor

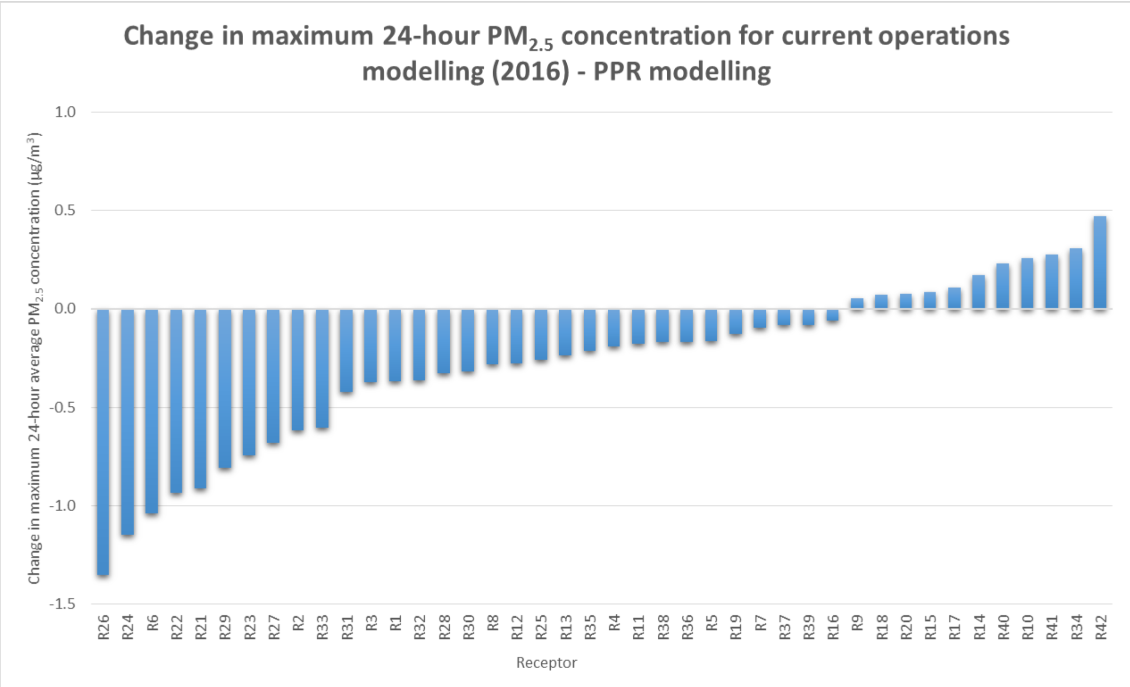


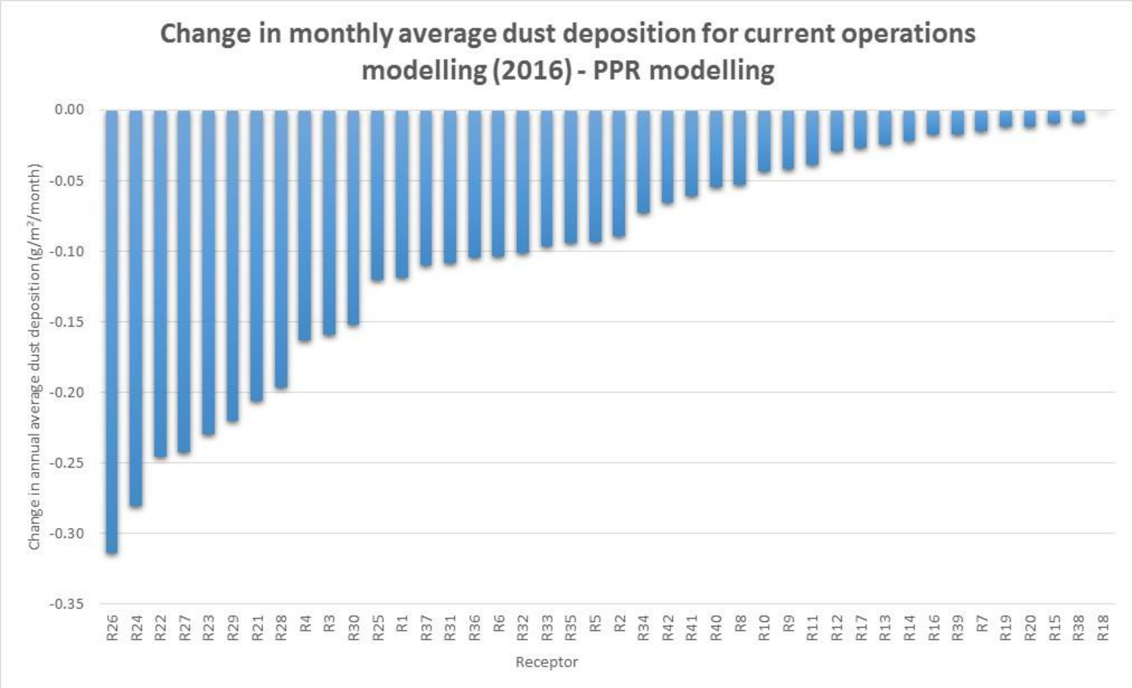
Change in maximum 24-hour PM_{10} concentration for current operations modelling (2016) - PPR modelling
Change in maximum 24-hour average PM_{10} concentration (µg/m³)
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
R8 R6 R3 R22 R5 R2 R7 R38 R4 R9 R39 R11 R21 R26 R23 R13 R12 R35 R24 R40 R32 R25 R14 R15 R31 R20 R17 R16 R18 R19 R10 R1 R41 R33 R36 R37 R29 R34 R42 R30 R28 R27
Receptor

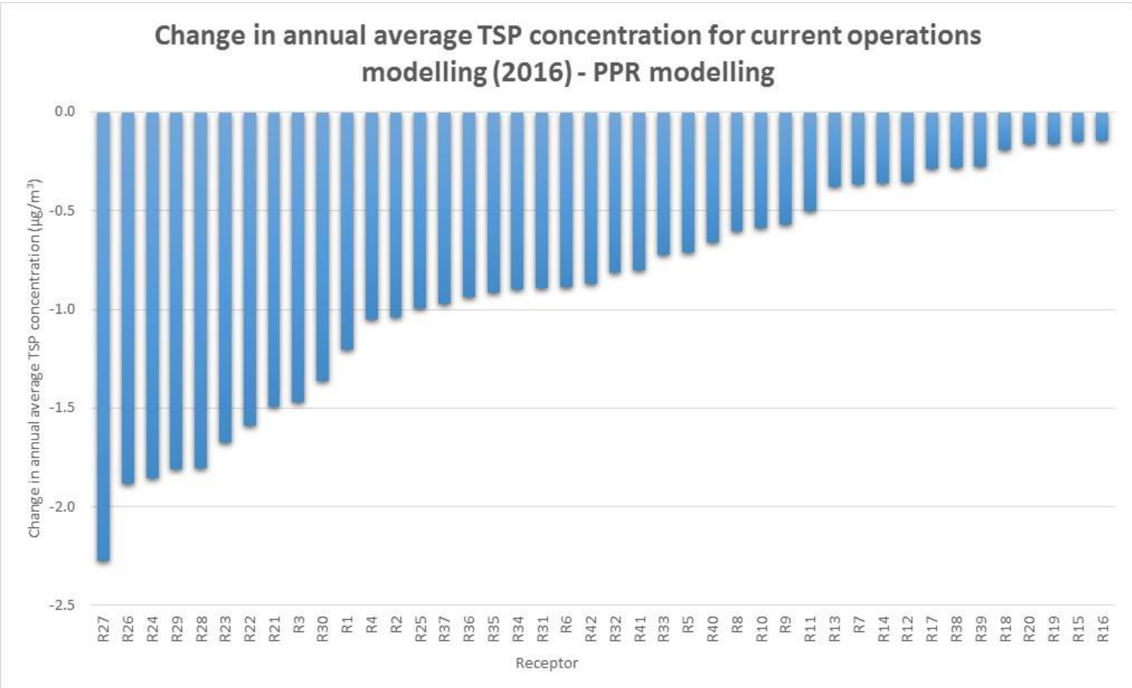


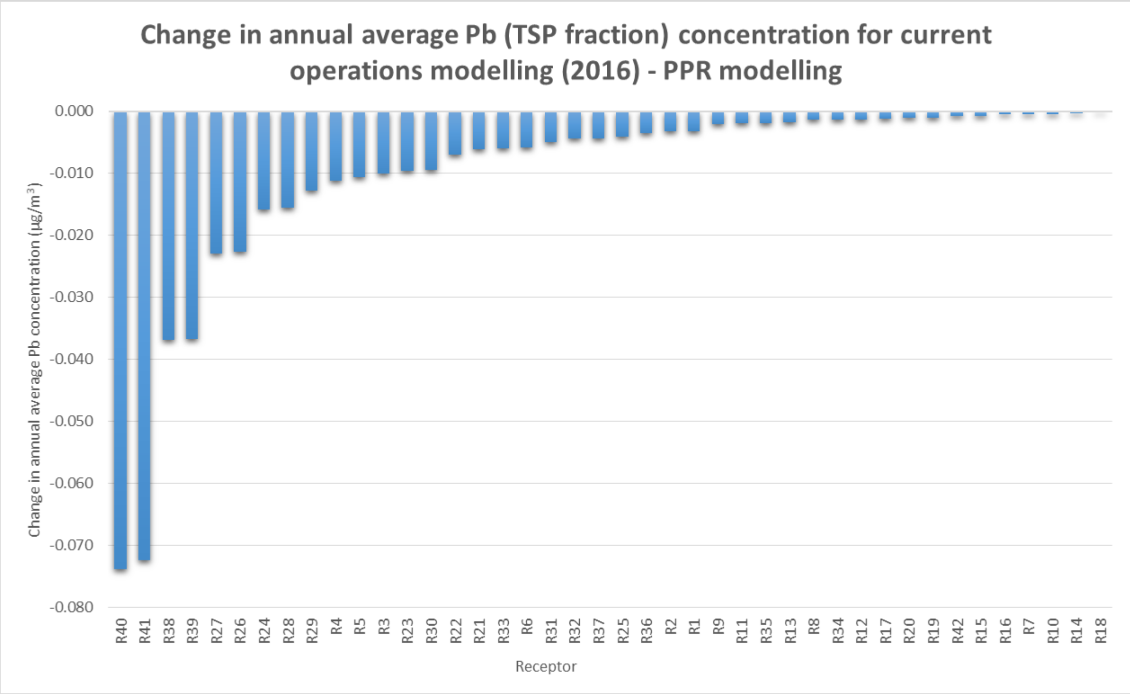
Change in annual average lead deposition for current operations modelling (2016) - PPR modelling
Change in annual average lead deposition (g/m²/year)
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
R27 R28 R26 R29 R24 R30 R3 R23 R31 R22 R4 R37 R32 R33 R21 R2 R36 R35 R25 R34 R5 R6 R42 R1 R40 R8 R41 R12 R11 R10 R9 R20 R19 R15 R16 R18 R38 R39 R17 R7 R14 R13
Receptor


Change in annual average $PM_{2.5}$ concentration for current operations modelling (2016) - PPR modelling
0.0
0.0
0.0
-0.1
-0.1
-0.1
-0.1
-0.1
Change in annual average $PM_{2.5}$ concentration (µg/m³)
R27 R3 R24 R28 R26 R29 R22 R4 R23 R21 R6 R30 R5 R2 R25 R31 R1 R33 R37 R32 R8 R36 R35 R40 R41 R11 R9 R34 R10 R42 R7 R14 R12 R16 R38 R39 R17 R13 R19 R20 R15 R18
Receptor


Change in maximum 24-hour $PM_{2.5}$ concentration for current operations modelling (2016) - PPR modelling
1.0
0.5
0.0
-0.5
-1.0
-1.5
Change in maximum 24-hour average $PM_{2.5}$ concentration (µg/m³)
R26 R24 R6 R22 R21 R29 R23 R27 R2 R33 R31 R3 R1 R32 R28 R30 R8 R12 R25 R13 R35 R4 R11 R38 R36 R5 R19 R7 R37 R39 R16 R9 R18 R20 R15 R17 R14 R40 R10 R41 R34 R42
Receptor


Change in monthly average dust deposition for current operations modelling (2016) - PPR modelling
Change in annual average dust deposition (g/m²/month)
Receptor
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
R26 R24 R22 R27 R23 R29 R21 R28 R4 R3 R30 R25 R1 R37 R31 R36 R6 R32 R33 R35 R5 R2 R34 R42 R41 R40 R8 R10 R9 R11 R12 R17 R13 R14 R16 R39 R7 R19 R20 R15 R38 R18


Change in annual average TSP concentration for current operations modelling (2016) - PPR modelling
Change in annual average TSP concentration (µg/m³)
Receptor
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
R27 R26 R24 R29 R28 R23 R22 R21 R3 R30 R1 R4 R2 R25 R37 R36 R35 R34 R31 R6 R42 R32 R41 R33 R5 R40 R8 R10 R9 R11 R13 R7 R14 R12 R17 R38 R39 R18 R20 R19 R15 R16


Change in annual average Pb (TSP fraction) concentration for current operations modelling (2016) - PPR modelling
0.000
-0.010
-0.020
-0.030
-0.040
-0.050
-0.060
-0.070
-0.080
Change in annual average Pb concentration (µg/m3)
R40 R41 R38 R39 R27 R26 R24 R28 R29 R4 R5 R3 R23 R30 R22 R21 R33 R6 R31 R32 R37 R25 R36 R2 R1 R9 R11 R35 R13 R8 R34 R12 R17 R20 R19 R42 R15 R16 R7 R10 R14 R18
Receptor

APPENDIX D. DESCRIPTION OF SENSITIVE RECEPTORS AND ALLOCATED BACKGROUND MONITORING LOCATION

Receptor ID	Description	Adopted monitoring location used for background PM_{10}, $PM_{2.5}$	TSP	PM and lead deposition
R1	Piper Street North	TEOM1	HVAS	DG5
R2	Piper Street Central	TEOM1	HVAS	DG5
R3	Eyre Street North	TEOM1	HVAS	DG5
R4	Eyre Street Central	TEOM1	HVAS	DG5
R5	Eyre Street South	TEOM1	HVAS	DG5
R6	South Road	TEOM1	HVAS	DG5
R7	Carbon Lane	TEOM2	HVAS	DG1
R8	Old South Road	TEOM2	HVAS	DG1
R9	South Rd	TEOM2	HVAS	DG2
R10	Cnr Garnet & Blende Streets	TEOM2	HVAS	DG2
R11	Alma Bugldi Preschool	TEOM1	HVAS	DG5
R12	Playtime Pre-school	TEOM1	HVAS	DG7
R13	Alma Primary School	TEOM1	HVAS	DG7
R14	Broken Hill High School	TEOM2	HVAS	DG2
R15	Broken Hill Hospital	TEOM2	HVAS	DG2
R16	N. Broken Hill Primary School	TEOM2	HVAS	DG2
R17	Broken Hill Public School	TEOM2	HVAS	DG2
R18	Rainbow Pre-school	TEOM1	HVAS	DG7
R19	Willyama High School	TEOM2	HVAS	DG2
R20	Morgan Street Primary School	TEOM2	HVAS	DG2
R21	Eyre Street North	TEOM1	HVAS	DG5
R22	Eyre Street North	TEOM1	HVAS	DG5
R23	Eyre Street North	TEOM1	HVAS	DG5
R24	Eyre Street North	TEOM1	HVAS	DG5
R25	Water tank, Lawton Street #	TEOM1	HVAS	DG5
R26	Quarry offices	TEOM1	HVAS	DG5
R27	Proprietary Square	TEOM2	HVAS	DG6
R28	Proprietary Square	TEOM2	HVAS	DG6
R29	Iodide Street	TEOM2	HVAS	DG6
R30	Iodide Street	TEOM2	HVAS	DG6
R31	Crystal Street	TEOM2	HVAS	DG6
R32	Crystal Street	TEOM2	HVAS	DG6
R33	Brownes Shaft Dwelling	TEOM2	HVAS	DG4
R34	Crystal Street	TEOM2	HVAS	DG2
R35	Crystal Street	TEOM2	HVAS	DG2
R36	Crystal Street	TEOM2	HVAS	DG2
R37	Crystal Street	TEOM2	HVAS	DG2
R38	Gypsum Street	TEOM2	HVAS	DG1
R39	Gypsum Street	TEOM2	HVAS	DG1
R40	Silver City Hwy	TEOM2	HVAS	DG2
R41	Silver City Hwy	TEOM2	HVAS	DG2
R42	Silver City Hwy	TEOM2	HVAS	DG2
R43	Bowling Green	TEOM2	HVAS	DG6
R44	Playground	TEOM1	HVAS	DG7

R45	Playground	TEOM1	HVAS	DG7
R46	Playground	TEOM1	HVAS	DG7
R47	Playground	TEOM2	HVAS	DG2
R48	Playground	TEOM2	HVAS	DG2
R49	Playground	TEOM2	HVAS	DG2

APPENDIX E. MONITORING DATA REVIEW

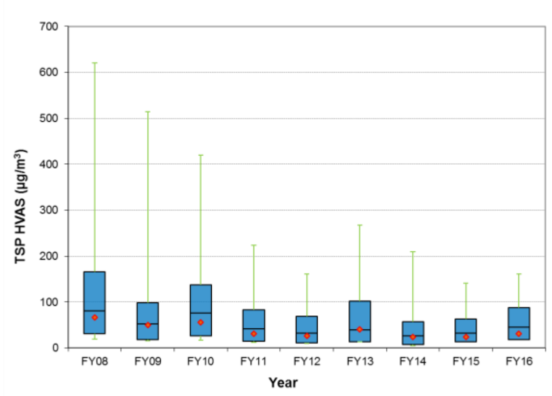


Figure E- 1: TSP concentration measured by HVAS

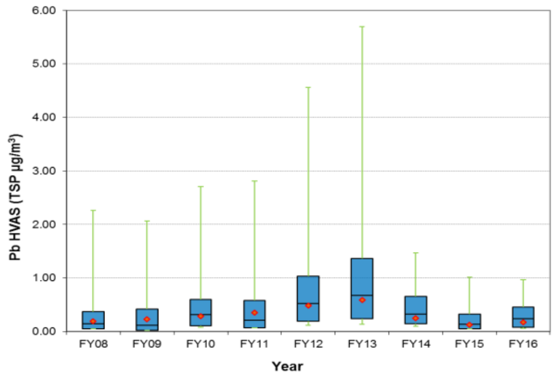


Figure E- 2: Pb concentration measured by HVAS

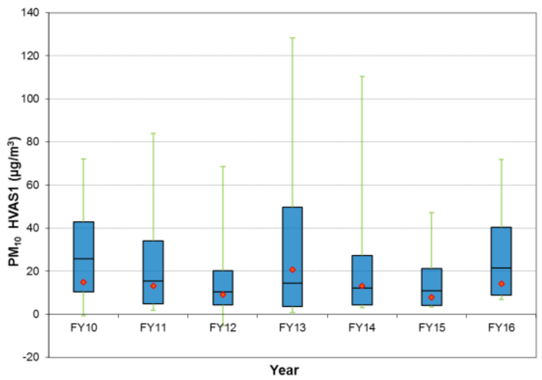


Figure E- 3: PM_{10} concentration measured by HVAS1

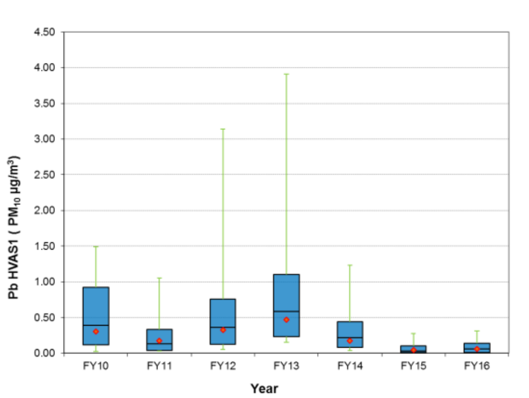


Figure E- 4: Pb concentration measured by HVAS1

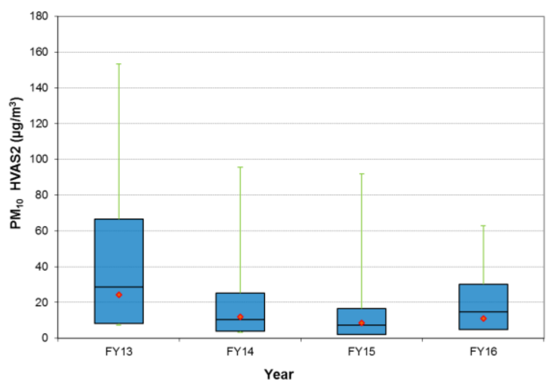


Figure E- 5: PM_{10} concentration measured by HVAS2

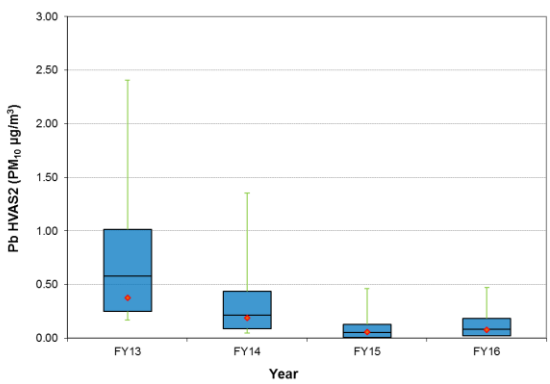


Figure E- 6: Pb concentration measured by HVAS2

Note: The extents of the box denote the 25th and 75th percentile of the data and the median is the line across the box. The mean is the red dot and the green error bars are the maximum and minimum values.

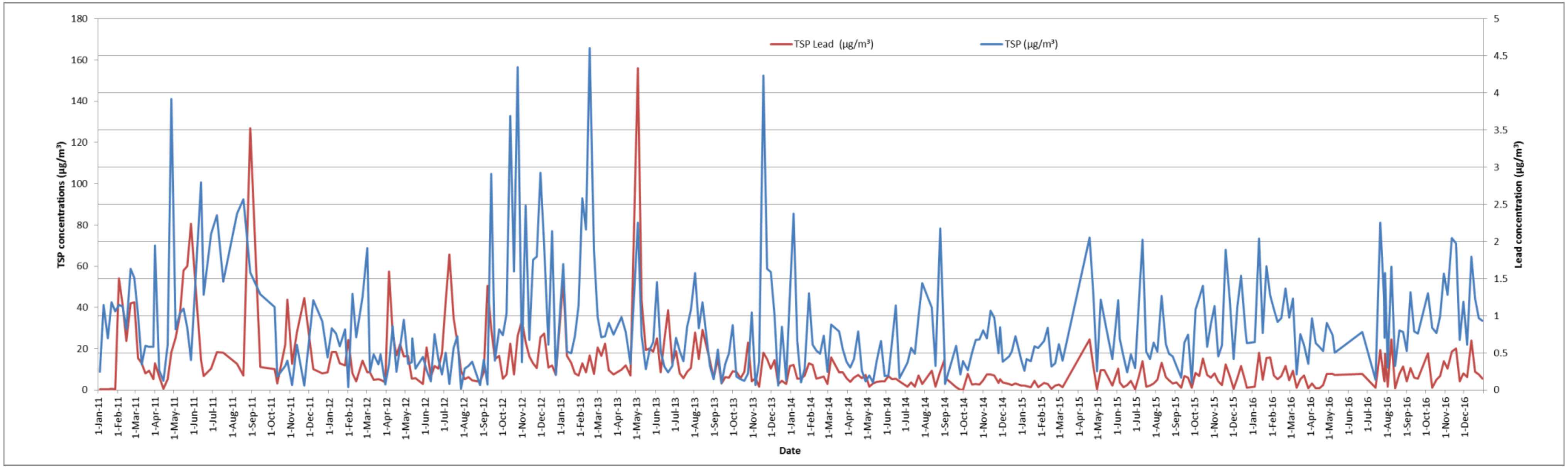


Figure E- 7: Time series of HVAS data showing a reduction in TSP and Pb concentrations

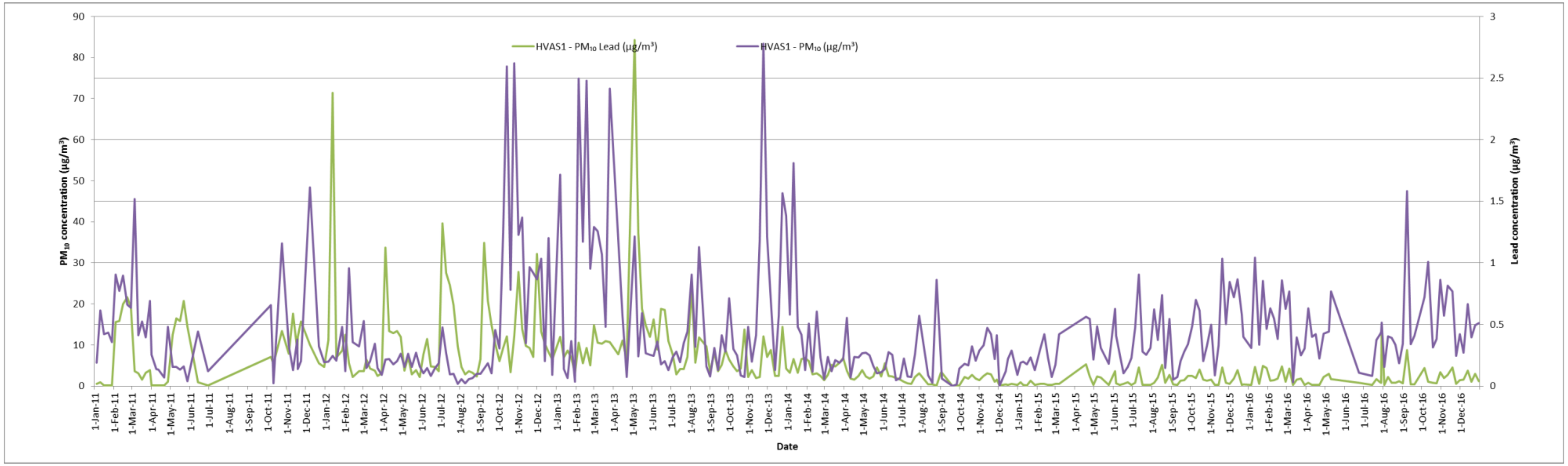


Figure E- 8: Time series of HVAS1 data showing a reduction in PM_{10} and Pb concentrations

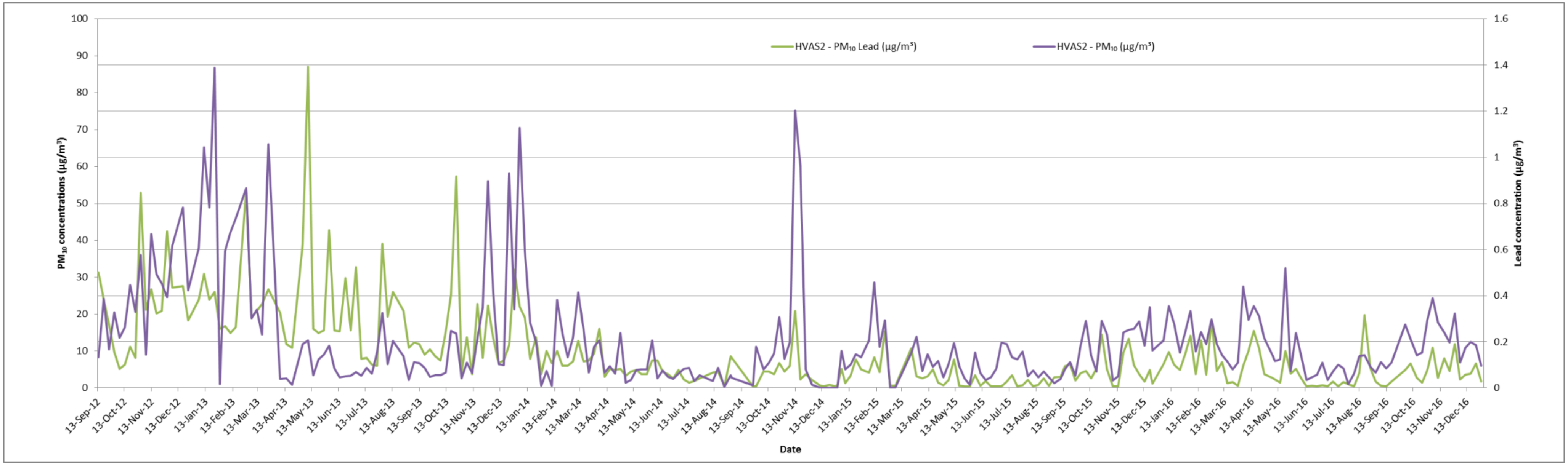


Figure E- 9: Time series of HVAS2 data showing a reduction in PM_{10} and Pb concentrations

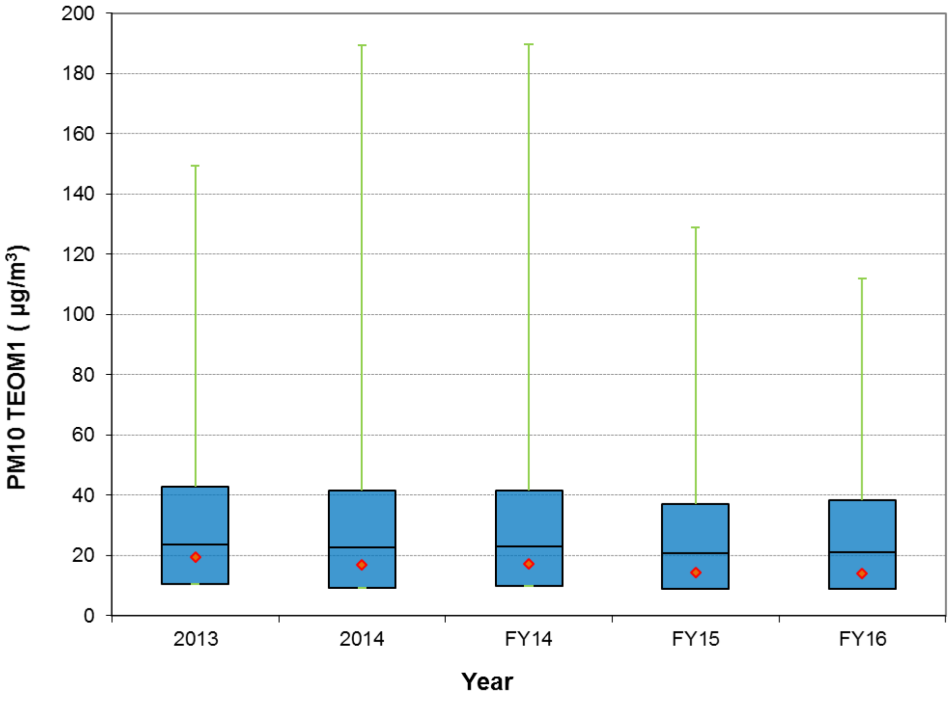


Figure E- 10: PM_{10} concentrations (µg/m³) measured by TEOM1

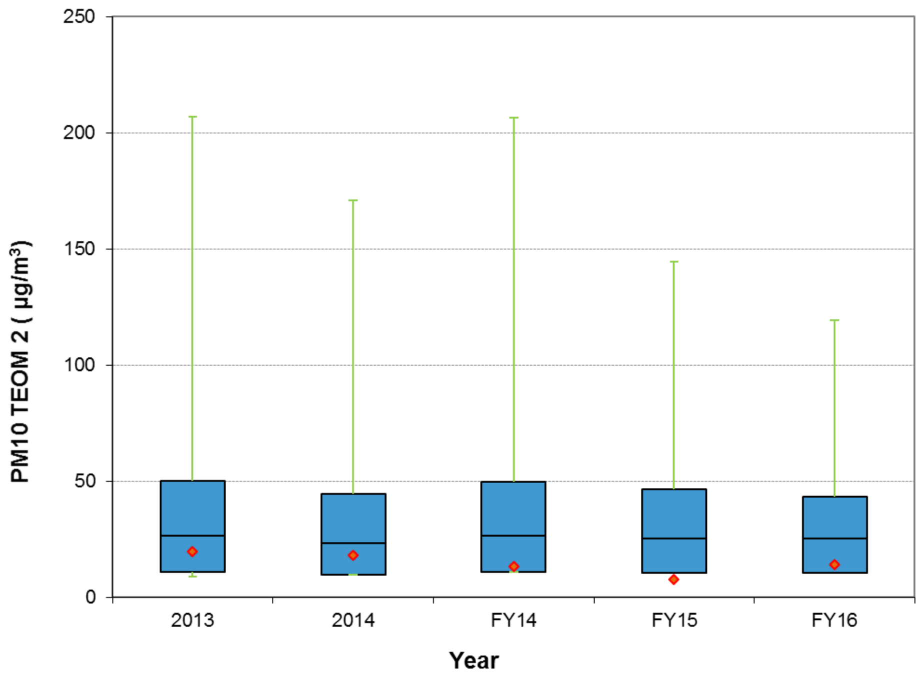


Figure E- 11: PM_{10} concentrations (µg/m³) measured by TEOM2

Note: The extents of the box denote the 25th and 75th percentile of the data and the median is the line across the box. The mean is the red dot and the green error bars are the maximum and minimum values.

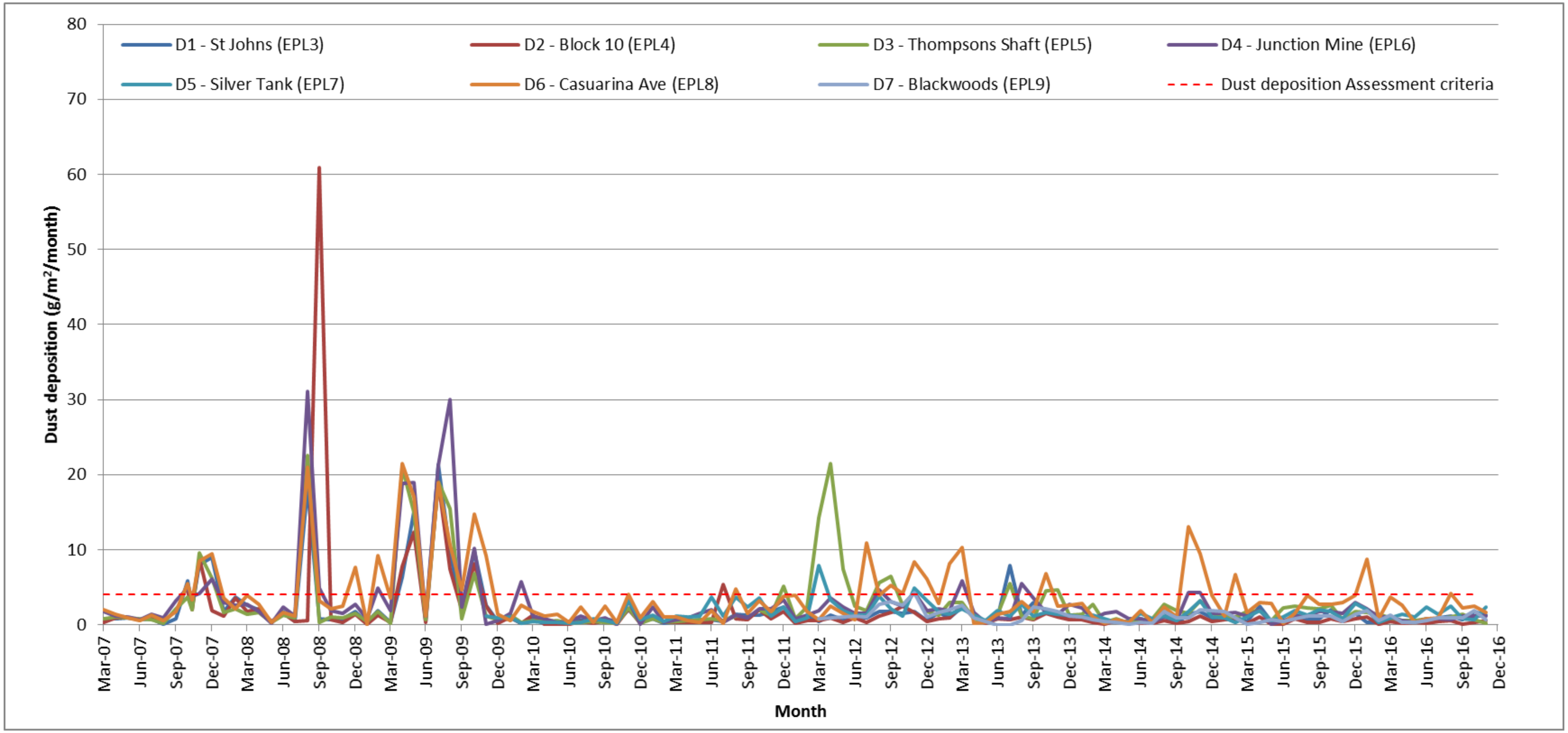


Figure E- 12: Time series of dust deposition data from DG1-DG7 (D1-D7)

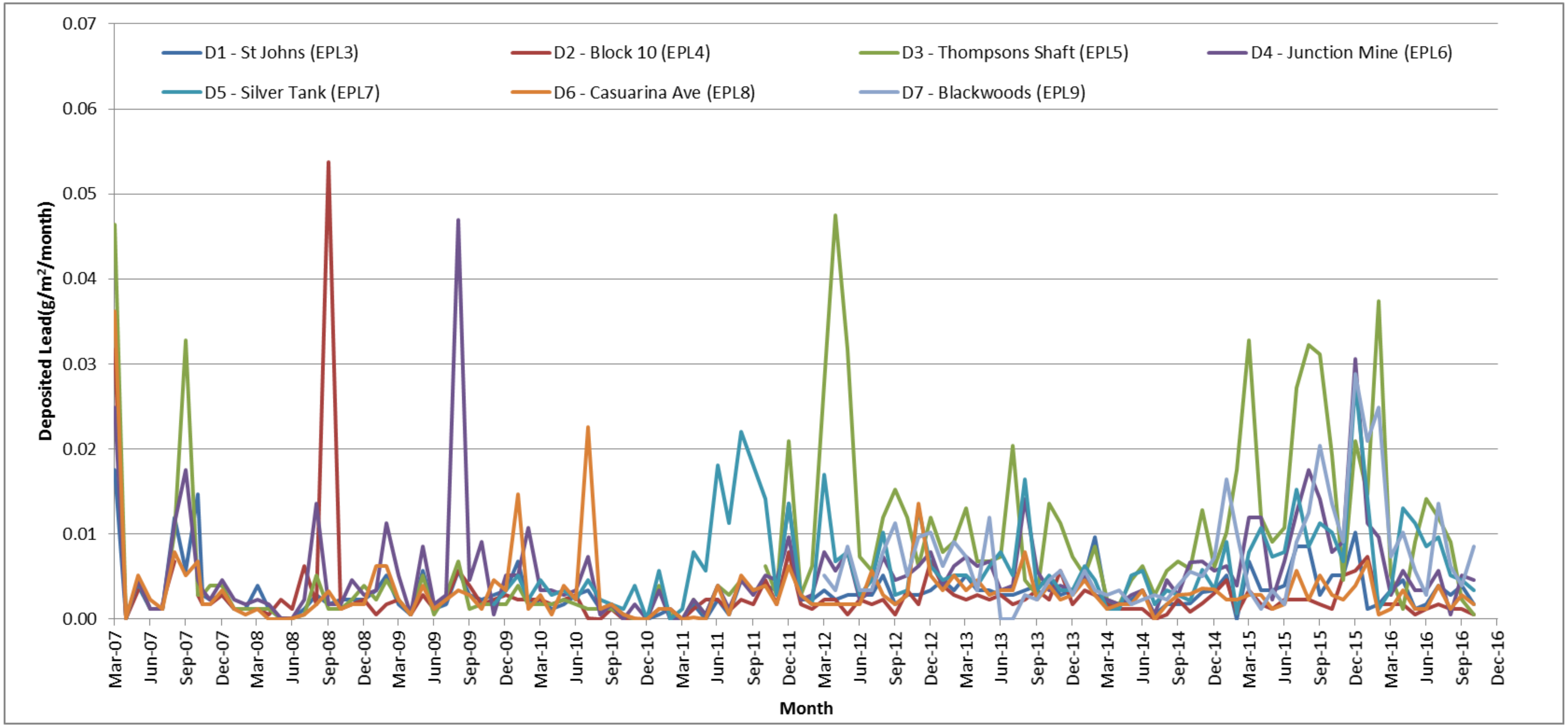


Figure E- 13: Time series of deposited lead from DG1-DG7 (D1-D7)

APPENDIX F. Contour Plots

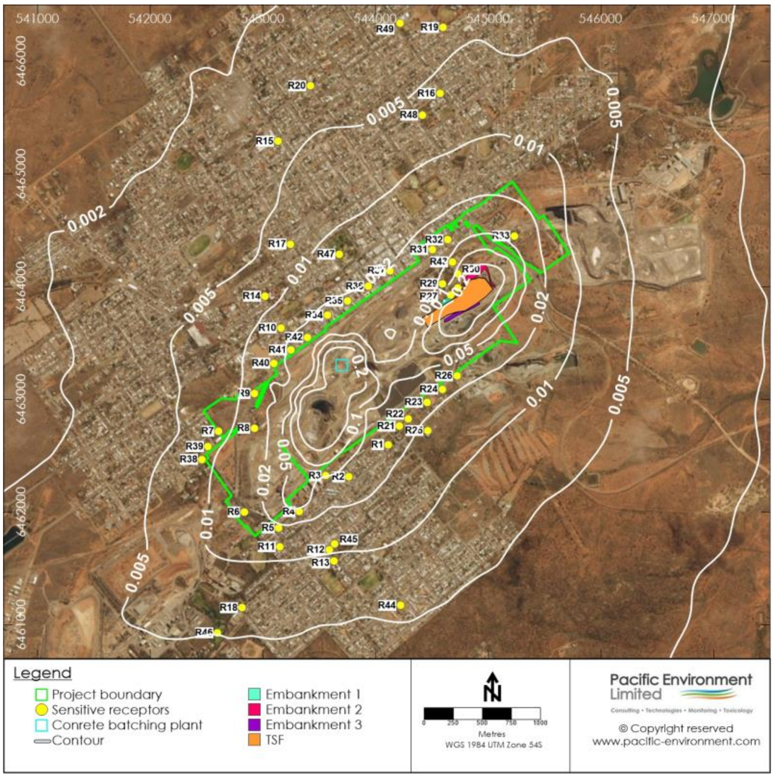


Figure C- 1: Predicted incremental annual average PM_{10} concentrations (µg/m^3)

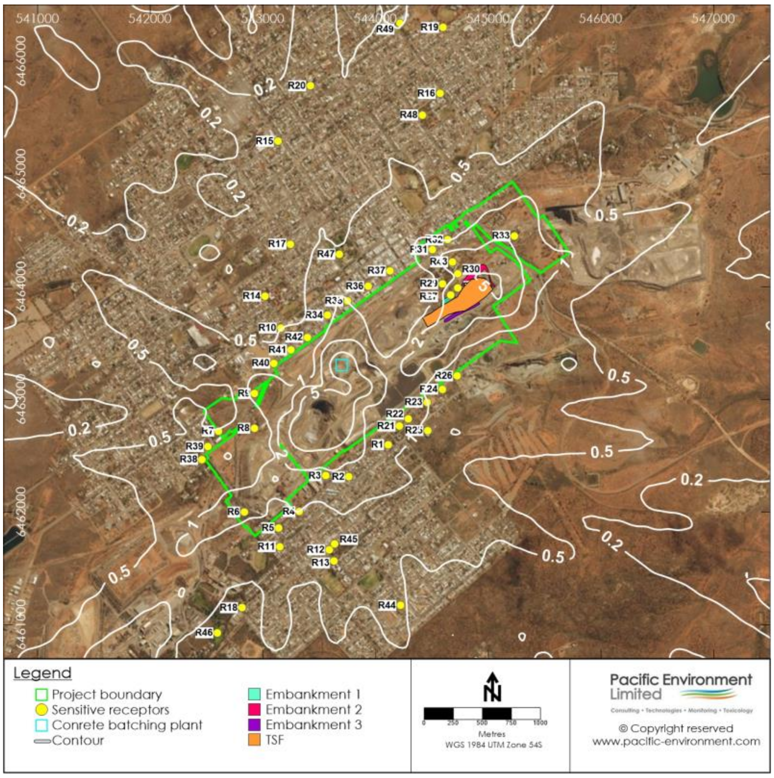


Figure C- 2: Predicted incremental maximum 24-hour average PM_{10} concentrations (µg/m^3)

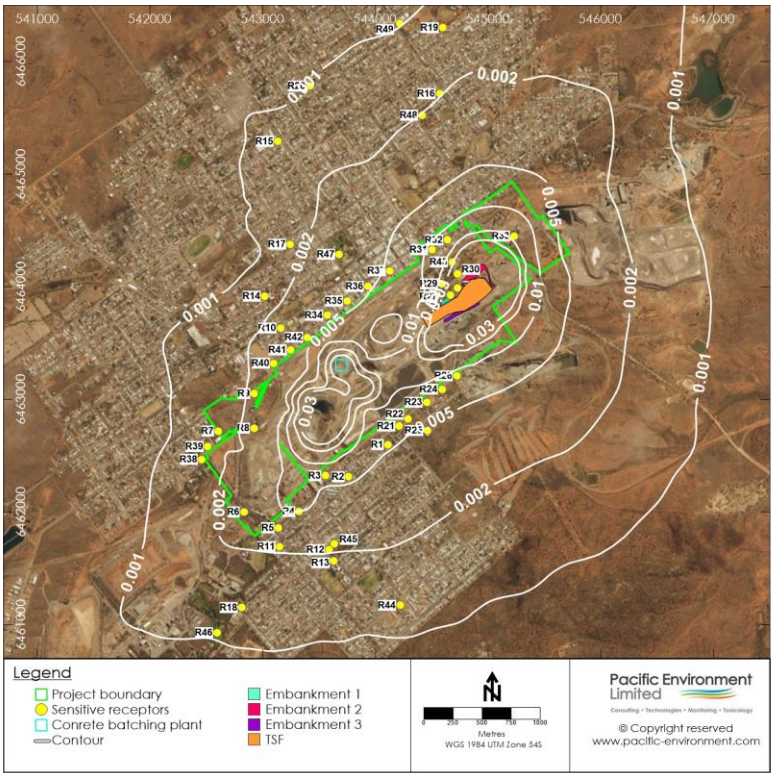


Figure C- 3: Predicted incremental annual average $PM_{2.5}$ concentrations (µg/m^3)

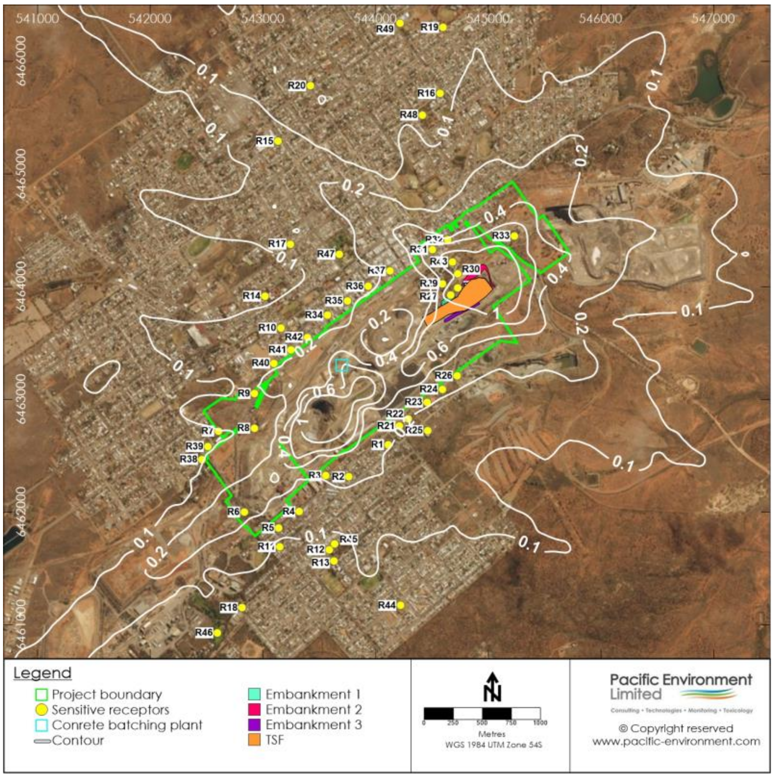


Figure C- 4: Predicted incremental maximum 24-hour average $PM_{2.5}$ concentrations (µg/m^3)

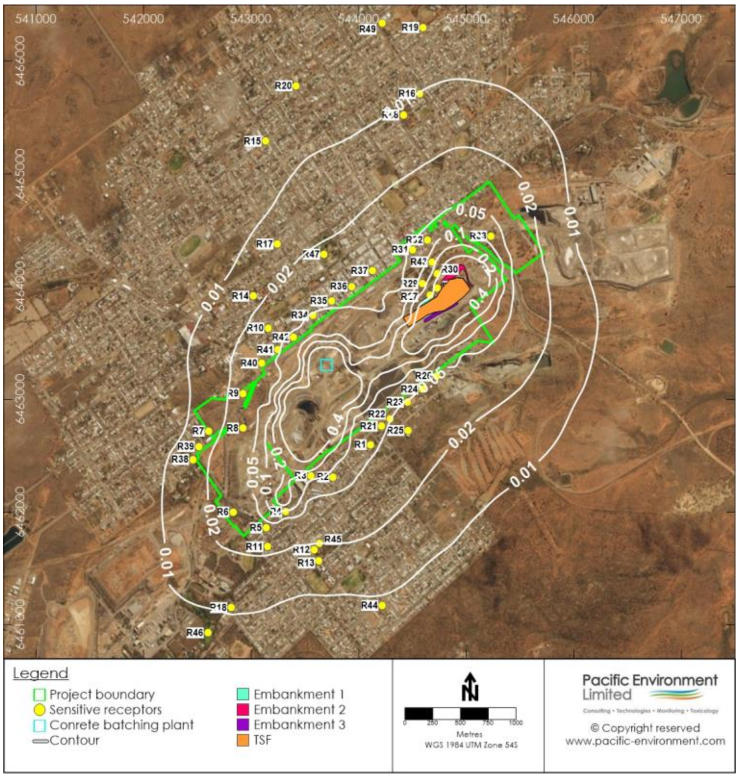


Figure C- 5: Predicted incremental annual average TSP concentrations (µg/m³)

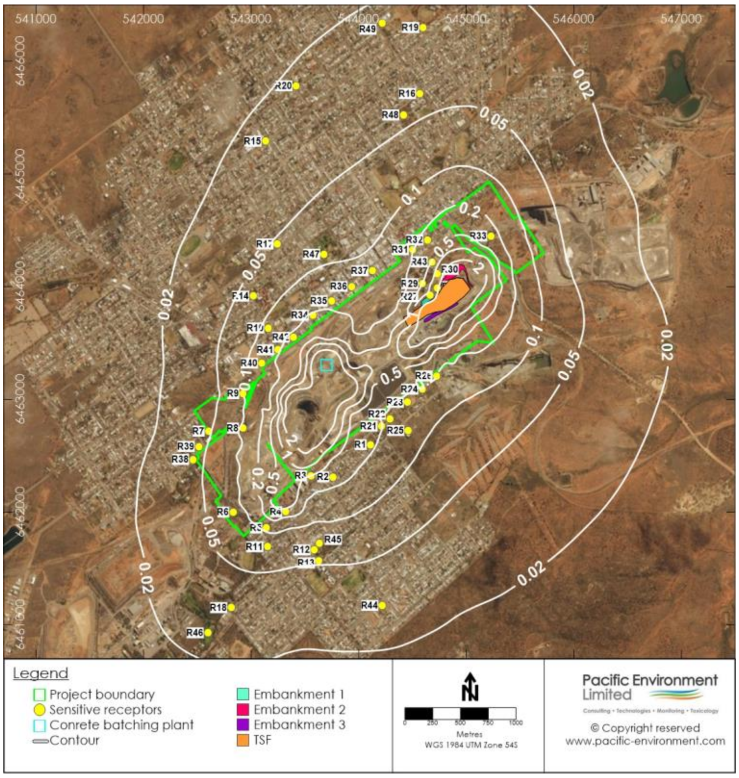


Figure C- 6: Predicted incremental monthly average deposited dust (g/m²/month)

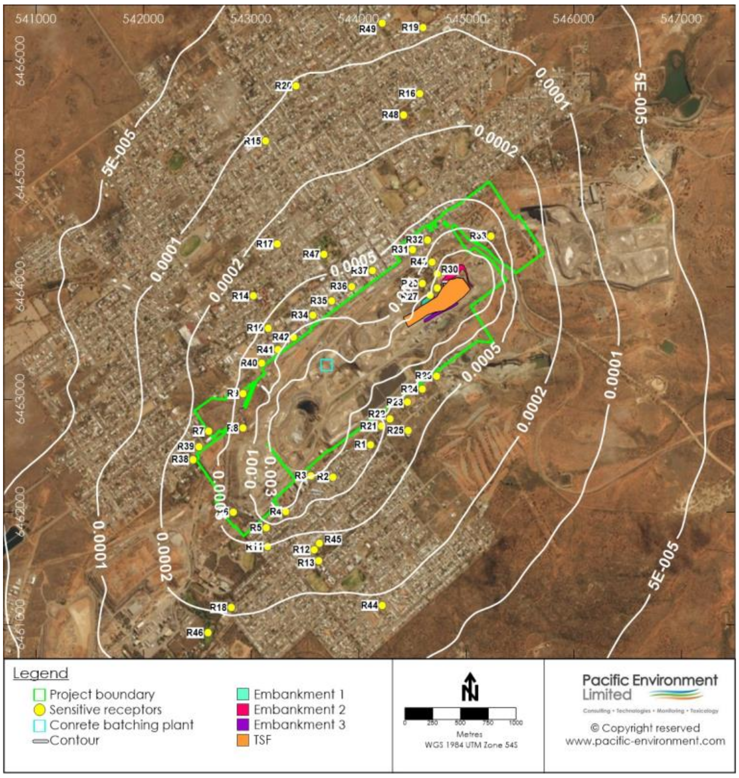


Figure C- 7: Predicted incremental annual average lead concentrations (µg/m³)

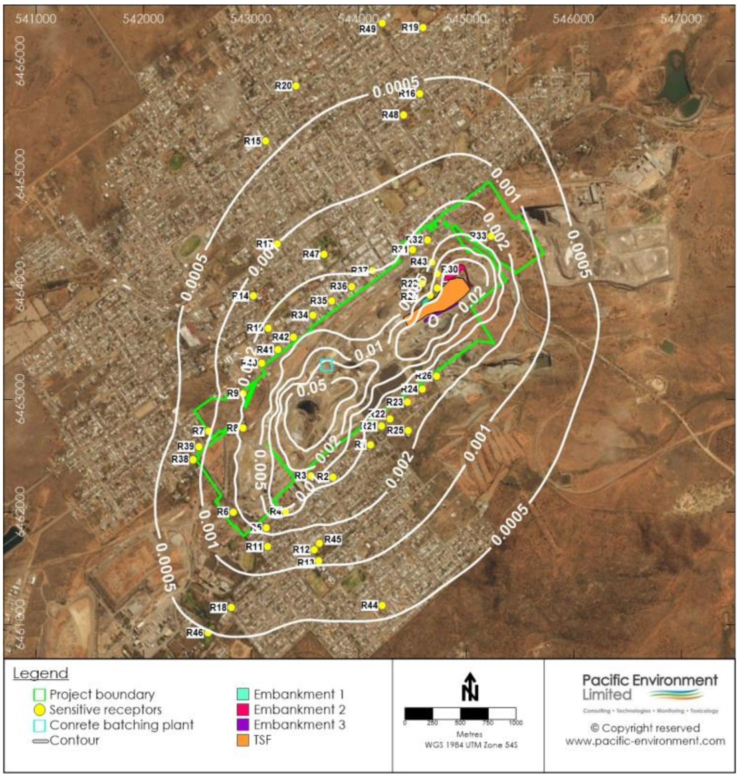


Figure C- 8: Predicted annual average lead deposition (g/m²/year)

APPENDIX G. CABC Monitoring Report