ANNEXURE B: AIR QUALITY ASSESSMENT ADDENDUM

Rasp Mine, Broken Hill Air Quality Assessment Addendum - Proposed Relocation of the Processing Area

Prepared for:
Broken Hill Operations Pty Ltd

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Date:
21 September 2010

Project Number:
AS121216

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This document is issued in confidence to Broken Hill Operations Pty Ltd for the purposes informing the environmental impact assessment being undertaken for the Rasp Mine, Broken Hill, NSW. It should not be used for any other purpose.

VERSION CONTROL RECORD

Document File Name	Date Issued	Version	Author	Reviewer
1216_BHOP Air Addendum_Final_21Sep10	21 September 2010	Final	Damon Roddis Scott Fishwick	Damon Roddis

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Executive Summary

ENVIRON Australia Pty Ltd (ENVIRON) has been commissioned by Broken Hill Operations Pty Ltd (BHOP), a wholly owned subsidiary of CBH Resources Limited (CBH) to undertake an air quality assessment for the expansion of the Rasp Mine located on Consolidated Mining Lease 7 (CML7) in Broken Hill, NSW.

BHOP proposes to mine the Western Mineralisation and Centenary Mineralisation and Main Lode Pillars, zinc-lead-silver masses within the Project Area and to produce zinc and lead concentrates. Mining will take place over 15 years including one year to construct the processing plant, one year to complete closure activities and an estimated 13 years for extraction of ore from underground mining, at a maximum rate of 750,000tpa.

The air quality assessment conducted for the Rasp Project as part of the Environment Assessment focussed on emissions of total suspended particulates (TSP), particulate matter less than 10 microns and 2.5 microns in aerodynamic diameter (PM_{10} and $PM_{2.5}$ respectively), dust deposition and a range of individual metals/metalloids.

The air quality assessment was provided in support of the Development Application for the Project (ENVIRON report reference 1150_BHOP Rasp Air_Final_19Mar10, dated 19 March 2010, “the air assessment”).

Following the assessment of adequacy for public exhibition, a revision of the air quality assessment was provided to address comments on the air assessment provided by the NSW Department of Environment, Climate Change and Water (DECCW). The revision comprises ENVIRON report reference 1150_BHOP Rasp Air_Rev1_26May2010, dated 26 May 2010 (“the revised air assessment”).

The current document provides an addendum to the revised air assessment, and evaluates the air quality impacts associated with a proposed relocation of the Rasp Mine’s processing area to the north east of the CML7 site.

This document additionally provides supporting information in relation to the following DECCW requests that were unable to be addressed within the timeframe of the revised air assessment:

- The inclusion of contour plots for at least one metal scenario modeled at a 1-hour averaging period; and
- Additional modelling assessment of ‘upset conditions’ at the Tailings Storage Facility (TSF).

Finally, the report evaluates the potential for reconfiguration of the crushing circuit dust controls and makes comment as to the implications of revised modelling for health risk assessment of the Project.

Proposed Relocation of the Processing Area

The relocated processing plant will use conventional open circuit single stage crushing for the production of grinding circuit feed at a nominal size of 80% passing 100 mm.

Crushing will take place on day shift only to minimise noise disturbance to the local community.

The proposed crushing circuit no longer requires (potentially dust generating) secondary and tertiary crushers and associated screens. This is since material from the jaw crusher passes directly into the SAG mill, which is a wet process.

Ore will be reclaimed from a crushed ore bin via two slot feeders discharging onto two conveyor systems leading to the SAG mill

All subsequent stages within the processing plant (SAG mill, secondary ball mill, lead and zinc flotation) are wet processes and are similar to descriptions provided within the air assessment. They are therefore not discussed further within this document.

The concentrate handling circuit will produce separate, dewatered concentrates with moisture levels suitable for rail transport. Transportable moisture limits have been determined by test work at 8.1% for lead and 11.5% for zinc.

The concentrate handling circuit will operate in conjunction with the flotation circuit, 365 days per year, twenty four hours per day.

Thickener concentrate will be pumped from the concentrate storage tank to a plate and frame pressure filter.

Concentrate is to be direct loaded into concentrate containers. Concentrate filters will be housed in a clad building, sufficiently elevated to allow for the truck holding the concentrate container to pass underneath for direct loading via conveyors.

The lead and zinc concentrate dispatch cycle commences at the rail load out area, at the north end of CML7 lease, when an empty concentrate container is loaded onto the 45 tonne truck with attached drop deck trailer and then driven to a weigh bridge where the truck and container are weighed.

The truck is then driven into the enclosed filter building, and positioned under the shuttle conveyor and the lid removed.

After filling, the lid is replaced and the truck with the container loaded with either lead or zinc concentrate is driven through a washing facility where both truck and container are washed to remove any spilled concentrate material. The wash water and solids are collected and recycled back to the concentrate thickener. The truck and container are weighed to determine weight of concentrate and an identification tag for the container is printed out showing concentrate type, weight and destination.

The truck is driven to the rail load out area and the container unloaded with the 35 tonne capacity forklift, either onto the rail wagon or into storage.

Despatch of the loaded wagons to the Broken Hill rail complex is planned to occur daily.

Process tailings will be disposed as described within the air assessment.

Air Quality Assessment

Dispersion simulations were undertaken for the proposed relocation and results analysed for TSP, PM_{10}, $PM_{2.5}$ and a range of heavy metal concentrations and dust deposition.

Dispersion modelling of particulate emissions from the Rasp Project was conducted utilising the US-EPA regulatory model AERMOD for two complete calendar years, 2008 and 2009.

For all parameters and averaging periods, the maximum predicted incremental impact at the most affected sensitive receptor was anticipated to be reduced compared to the air assessment.

Further, revised dispersion modelling indicates that hat the relocation of the processing area is anticipated to deliver a decrease in key air quality parameter increments to the majority of areas of significant population density relative to the air assessment scenario.

Modelling of TSF 'Upset' Conditions

Significant contingency and redundancy has been built into the design of the TSF to ensure that adequate dust mitigation is available both during normal operations and under 'upset' conditions.

The 'upset' scenario requested to be evaluated by DECCW is as follows:

> *whereby the active cell is assumed to be saturated, with zero emissions, but 100% of the total area of the inactive cell is assumed to be emitting with 90% control efficiency (base the polymer controlling emissions at near capacity effectiveness). This would represent ~10% of total uncontrolled emissions from the inactive TSF cell (100 × 0.1 = 10%).*

Modelling indicates that only those receptors in close proximity to the TSF, specifically R1 and R21-R24 along the southeast boundary, show a noticeable influence due to the variation between normal and upset operations of the TSF.

In all instances, and under the highly conservative assumption that any 'Upset' persists for up to 24-hours, DECCW air quality criteria are anticipated to be satisfied, even at receptors closest to the proposed TSF.

Crushing Circuit Dust Controls

The air assessment evaluated a crushing circuit (primary, secondary and tertiary crushers and associated screens) with all potential particulate emissions contained via full enclosure under negative pressure, with emissions diverted to a baghouse (99.5% control efficiency).

Due both to the technical and operational constraints this yields for the Project, combined with the reduced dust generation potential from the revised crushing circuit (primary crushing only), alternative dust controls have been requested to be evaluated.

This scenario comprises the crusher area being enclosed with noise cladding (70% control efficiency) and particulate emissions captured through hooded extraction to a bag house (83% control efficiency).

The difference in predicted concentrations between the two crusher configuration scenarios is most notable at receptors R26-R30. However, it appears that the selection of crusher configuration (full enclosure under negative pressure with all emissions vented to a baghouse versus acoustic cladding with hooded extraction) is not a critical factor in predicted concentrations from the Project.

Implications of Revised Modelling for Health Risk Assessment

The outcomes of the Health Risk Assessment (HRA) conducted for the proposed Rasp Mine (Toxikos, 2010, hereafter, “the HRA”) were informed directly by the atmospheric dispersion modelling predictions made within the air assessment.

The HRA concluded that at the most affected receptors the total lead intake, including very conservative estimates of background intake from existing soil and diet, was only about 60% of the Tolerable Daily Intake (TDI). The conclusion of the HRA was that lead exposure resulting from the proposed mine presents little risk to the health of nearby residents.

Predicted lead concentrations and deposition rates at the most affected receptor under revised modelling are lower than those predicted at the most affected receptor within the air assessment.

Further, the previously most affected receptor (Receptor 8) was evaluated based on being assigned the highest lead risk zone in terms of background concentrations of lead in soil. Under the present modelling, the majority of receptors experiencing increases project-related lead deposition will be located in areas considered to be in zones of lesser background lead in soil compared to the original modelling.

In view of the above, it is anticipated that the conclusions made within the HRA remain valid and are conservative when the incremental impacts of the proposed processing plant location are considered.

1 Introduction

ENVIRON Australia Pty Ltd (ENVIRON) has been commissioned by Broken Hill Operations Pty Ltd (BHOP), a wholly owned subsidiary of CBH Resources Limited (CBH) to undertake an air quality assessment for the expansion of the Rasp Mine located on Consolidated Mining Lease 7 (CML7) in Broken Hill, NSW.

BHOP proposes to mine the Western Mineralisation and Centenary Mineralisation and Main Lode Pillars, zinc-lead-silver masses within the Project Area and to produce zinc and lead concentrates. Mining will take place over 15 years including one year to construct the processing plant, one year to complete closure activities and an estimated 13 years for extraction of ore from underground mining, at a maximum rate of 750,000tpa.

The air quality assessment conducted for the Rasp Project as part of the Environment Assessment focussed on emissions of total suspended particulates (TSP), particulate matter less than 10 microns and 2.5 microns in aerodynamic diameter (PM_{10} and $PM_{2.5}$ respectively), dust deposition and a range of individual metals/metalloids.

The air quality assessment was provided in support of the Development Application for the Project (ENVIRON report reference 1150_BHOP Rasp Air_Final_19Mar10, dated 19 March 2010, “the air assessment”).

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This document provides an addendum to the revised air assessment, and evaluates the air quality impacts associated with a proposed relocation of the Rasp Mine’s processing area to a location to the north east of the CML7 site.

This document additionally provides supporting information in relation to the following DECCW requests that were unable to be addressed within the timeframe of the revised air assessment:

- The inclusion of contour plots for at least one metal scenario modeled at a 1-hour averaging period; and
- Additional modelling assessment of ‘upset conditions’ at the Tailings Storage Facility (TSF).

Finally, the report evaluates the potential for reconfiguration of the crushing circuit dust controls.

2 Processing Plant Relocation Overview

The following section provides an overview of the proposed changes to the Project as they relate to air quality.

A description of the Project as a whole is provided within the air assessment and the body of the Environmental Assessment.

All other aspects of the proposed Project, including the comprehensive dust management measures proposed, remain as per the air quality assessment.

The exception to this is the investigations undertaken to evaluate the potential for reconfiguration of the crushing circuit dust controls (refer **Section 5.1**).

2.1 Summary of the Processing Plant Relocation

2.1.1 Crushing

The Project will use conventional open circuit single stage crushing for the production of grinding circuit feed at a nominal size of 80% passing 100 mm.

Crushing will take place on day shift only to minimise noise disturbance to the local community, resulting in a design crushing circuit throughput of 350 tonnes per hour. Design crusher availability will be 91% for eleven hours total crushing time per day, seven days per week.

The Run Of Mine (ROM) pad is being designed to hold a maximum of three days capacity. Ore from underground will be delivered twenty four hours per day, seven days per week and dumped on to grade control ore fingers.

ROM ore, at a nominal top size of 800 mm, will be reclaimed from stockpiles by a Front End Loader (FEL) and fed into a steel ROM bin situated in a concrete pocket. The ROM bin will have a live capacity of 150 tonnes. The ROM bin will be fitted with an inclined static 800 mm aperture grizzly for oversize ore protection. Grizzly bars will be inclined toward the ROM pad to permit clearing of oversize with the FEL.

A fixed rock breaker will be installed adjacent to the jaw crusher feed opening.

Ore will discharge from the ROM bin via a 1500 mm wide by 7100 mm long hydraulic drive apron feeder and report to the primary jaw crusher. Jaw crusher product will report via a chute to a series of enclosed conveyors, prior to discharge into the 2,250 tonne crushed ore bin.

It is highlighted that the proposed crushing circuit no longer requires (potentially dust generating) secondary and tertiary crushers and associated screens. This is since material from the jaw crusher passes directly into the SAG mill, which is a wet process.

Two dust control systems have been evaluated within this addendum document (refer **Section 5.1**), namely;

- Crusher circuit particulate emissions contained via full enclosure under negative pressure, with emissions diverted to a baghouse
- Crusher area being enclosed with noise cladding and particulate emissions captured through hooded extraction to a bag house.

Collected dust will be mixed with raw water and pumped to the grinding circuit as a slurry. All conveyors will be covered and dust controlled via insertable bag dust collection units. Strategically placed misting sprays will further assist in the control of fugitive dust.

2.1.2 Ore Storage and Handling

The crushed ore bin will be open bottomed and supported on concrete wings to allow access by mobile equipment in the event of a blockage. Under normal operation crushed material will rill out of the wings and seal the openings to prevent dust emission. An insertable bag dust collector will be installed in the roof of the crushed ore bin to minimise dust emission from the feed entry.

Ore will be reclaimed from the crushed ore bin via two slot feeders discharging onto two conveyor systems leading to the SAG mill

2.1.3 Grinding and Classification

The grinding and classification circuit will operate twenty four hours per day, seven days per week. The design throughput rate will be 750,000 tonnes per annum, resulting in a grinding circuit feed rate of 93.8 tonnes per hour.

The grinding circuit will consist of a primary SAG Mill and secondary ball mill. The target final grind size will be 80% passing 200 microns, identified by test work as the optimum size for lead and zinc flotation.

Crushed ore will be fed via mill feed conveyor into the primary SAG mill feed chute. Grinding water will be added to the feed chute to control grinding and classification pulp density.

All subsequent stages within the processing plant (secondary ball mill, lead and zinc flotation) are wet processes and are similar to descriptions provided within the air assessment. They are therefore not discussed further within this document.

2.1.4 Concentrate Handling (Thickening, Filtration, Storage and Loadout)

The concentrate handling circuit will produce separate, dewatered concentrates with moisture levels suitable for rail transport. Transportable moisture limits have been determined by test work at 8.1% for lead and 11.5% for zinc.

The concentrate handling circuit will operate in conjunction with the flotation circuit, 365 days per year, twenty four hours per day.

Thickener concentrate will be pumped from the concentrate storage tank to a plate and frame pressure filter.

Filter cake will discharge into a collection hopper which is positioned above a fixed speed conveyor.

Concentrate is to be direct loaded into concentrate containers. Concentrate filters will be housed in a clad building, sufficiently elevated to allow for the truck holding the concentrate container to pass underneath for direct loading via conveyors.

2.1.5 Filter and Rail Operation

The lead and zinc concentrate dispatch cycle commences at the rail load out area, at the north end of CML7 lease, when an empty concentrate container is loaded onto the 45 tonne truck with attached drop deck trailer and then driven to a weigh bridge where the truck and container are weighed.

The truck is driven into the enclosed filter building and positioned under the shuttle conveyor and the lid removed.

The filter discharges filter cake into a collecting hopper which is fitted with a load cell.

A conveyor is fitted at the base of the hopper which transfers concentrate to the container filling shuttle conveyor.

The container filling shuttle conveyor is designed to move forward in set increment over the 6.1 meter length of the container to enable the filter cake to be distributed evenly along the length of the container. The shuttle conveyor starting and end position will be 500 mm from each end of the container. The time required to fill the container is estimated at 5 minutes.

The lid is replaced and the truck with the container loaded with either lead or zinc concentrate is driven through a wash facility where both truck and container are washed to remove any spilled concentrate material. The wash water and solids are collected and recycled back to the concentrate thickener. The truck and container are weighed to determine weight of concentrate and an identification tag for the container is printed out showing concentrate type, weight and destination.

The truck is driven to the rail load out area and the container unloaded with the 35 tonne capacity forklift, either onto the rail wagon or into storage.

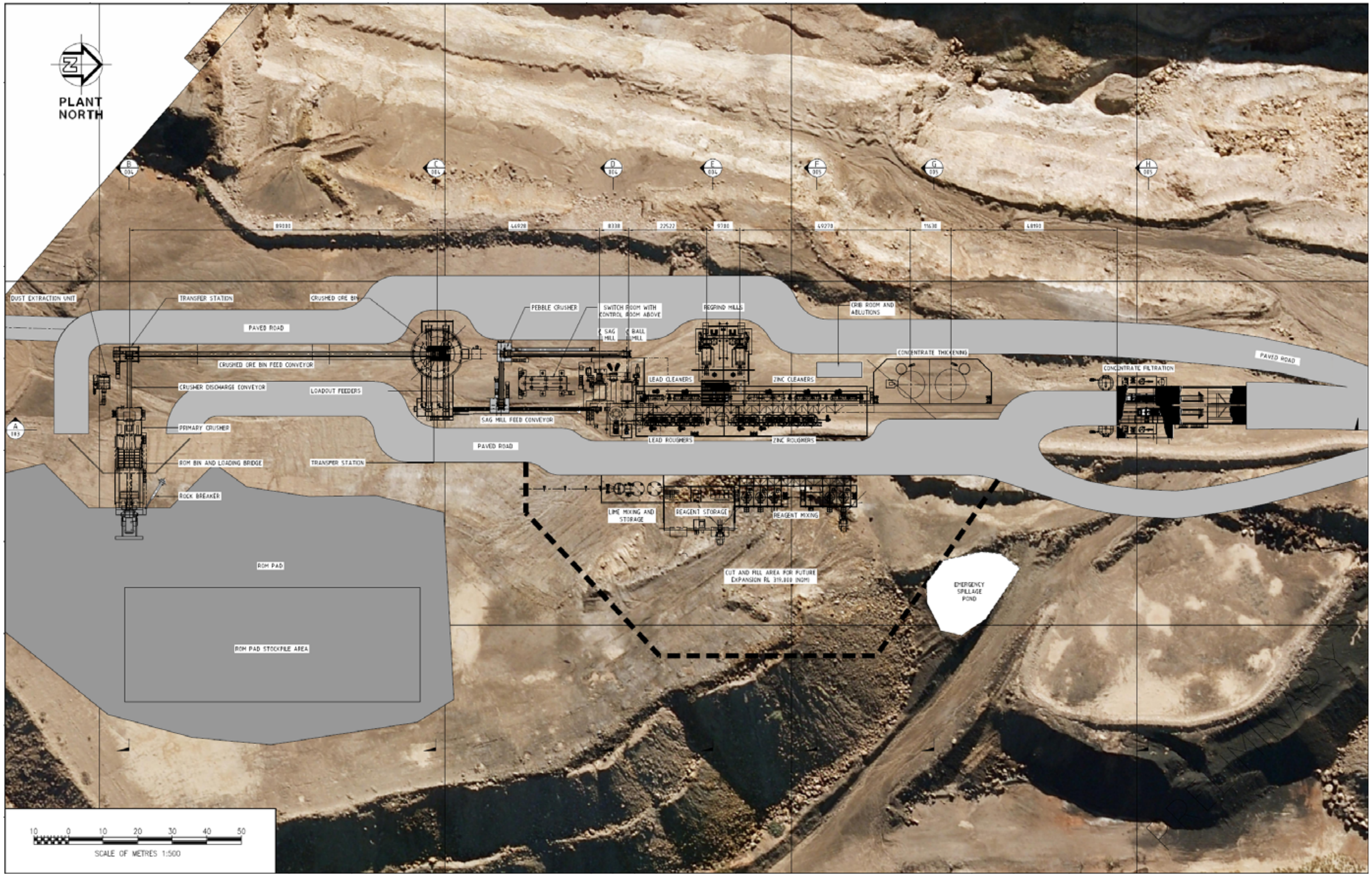
The lead and zinc daily concentrate production requires 8 containers for lead production and 12 containers for zinc production resulting in 20 cycles (from the rail load out area to the filter building and return) for the truck per day.

Despatch of the loaded wagons to the Broken Hill rail complex is planned to occur daily (7am to 6pm), thus requiring a minimum of a 10 wagons loaded with concentrate containers leaving site.

2.1.6 Tailing Disposal

Process tailings will be disposed as described within the air assessment.

Figure 1: Overview of Proposed Processing Plant Relocation



Source: Abesque Engineering Ltd

2.2 Sensitive Receptors

A number of occupied buildings used for a variety of purposes located near to the Project Area were selected within the air assessment to represent sensitive receptors. These receptors are non-Project related and are presented in **Table 1** and illustrated in **Figure 2**.

These comprise a selection of nearby residences and other sensitive receptors, consistent with the DECCW definition of sensitive receptors (DECCW, 2005) as:

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

Receptor numbers R1 to R10 and R21 to R42 comprise individual residences or commercial offices located in the vicinity of the Project Area. Receptor R26 represents the offices of the quarry located to the south of the relocated processing plant. Receptors R27, R28 and R33 are located on the mining lease (CML7). Receptors R27 and R28 represent unoccupied structures owned by the Line of Lode Association which is in receivership and is currently negotiating a transfer of these buildings to the Broken Hill City Council. These structures are of heritage significance; R27 is a previous mine manager's house dating to the early part of the 20th Century and R28 was constructed in the 1930s as part of offices for the Broken Hill Proprietary Company (BHP). Receptor R33 is a mine manager's house dated to 1910 and is currently occupied by a caretaker on behalf of BHOP.

Receptors R29 and R30 are located on a surface mining lease owned by Perilya Broken Hill Operations Pty Ltd.

Receptor numbers R11 to R20 represent schools, pre-schools and hospitals in the broader area. These localities represent places of greater community exposure potentials and are therefore of specific relevance to the Health Risk Assessment.

Of relevance to the assessment of impacts associated with the relocation of the processing area, **Table 1** highlights whether a receptor may be regarded as a single dwelling/property, or whether a receptor may be regarded as a location representative of several adjacent properties (i.e. represents an area of significant population density).

This information is important in evaluating whether the proposed processing plant relocation should be viewed in the context of an improved environmental impact compared with the plant configuration proposed within the air assessment.

Table 1 – Potentially Affected Non-Project Related Representative Sensitive Receptors

Sensitive Receptor	Description	Status	MGA54 Dwelling Coordinates	
			East (m)	North (m)
R1	Piper Street North	Group of Receptors	544110	6462598

Table 1 – Potentially Affected Non-Project Related Representative Sensitive Receptors

Sensitive Receptor	Description	Status	MGA54 Dwelling Coordinates	
			East (m)	North (m)
R2	Piper Street Central	Group of Receptors	543763	6462312
R3	Eyre Street North	Group of Receptors	543555	6462322
R4	Eyre Street Central	Group of Receptors	543324	6462003
R5	Eyre Street South	Group of Receptors	543140	6461859
R6	South Road	Single Dwelling	542833	6462000
R7	Carbon Lane	Group of Receptors	542604	6462718
R8	Old South Road	Single Commercial	542923	6462744
R9	South Rd	Single Commercial	542926	6463052
R10	Cnr Garnet and Blende Streets	Group of Receptors	543158	6463633
R11	Alma Bugldi Pre-school	School	543150	6461692
R12	Playtime Pre-school	School	543587	6461665
R13	Alma Primary School	School	543631	6461566
R14	Broken Hill High School	School	543019	6463916
R15	Broken Hill Hospital	Hospital	543133	6465290
R16	North Broken Hill Primary School	School	544570	6465713
R17	Broken Hill Public School	School	543245	6464378
R18	Rainbow Pre-school	School	542815	6461151
R19	Willyama High School	School	544599	6466299
R20	Morgan Street Primary School	School	543420	6465782
R21	Eyre Street North	Single Dwelling	544212	6462762
R22	Eyre Street North	Single Dwelling	544288	6462828
R23	Eyre Street North	Single Dwelling	544456	6462974
R24	Eyre Street North	Wood Cutters Yard	544591	6463090
R25	Water tank, Lawton Street	Potential Monitoring Site	544460	6462723

Table 1 – Potentially Affected Non-Project Related Representative Sensitive Receptors

Sensitive Receptor	Description	Status	MGA54 Dwelling Coordinates	
			East (m)	North (m)
R26	Quarry offices	Single Commercial	544723	6463208
R27	Proprietary Square	Heritage Building, on CML7	544666	6463926
R28	Proprietary Square	Heritage Building, on CML7	544731	6463988
R29	Iodide Street	Single Dwelling	544592	6464026
R30	Iodide Street	Single Dwelling	544728	6464112
R31	Crystal Street	Single Commercial	544503	6464328
R32	Crystal Street	Single Commercial	544637	6464415
R33	Dwelling near Brownes Shaft	Heritage Building, on CML7	545231	6464450
R34	Crystal Street	Single Commercial	543572	6463746
R35	Crystal Street	Single Commercial	543748	6463873
R36	Crystal Street	Single Commercial	543934	6464002
R37	Crystal Street	Single Commercial	544127	6464141
R38	Gypsum Street	Group of Receptors	542459	6462467
R39	Gypsum Street	Group of Receptors	542512	6462581
R40	Silver City Hwy	Single Commercial	543099	6463321
R41	Silver City Hwy	Single Commercial	543249	6463439
R42	Silver City Hwy	Single Commercial	543394	6463551

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Level 3, 100 Pacific Hwy, North Sydney, 2060

Figure 2: Representative Sensitive Receptors in the Vicinity of the Project

Figure

Drafter: SF | Date: 23.02.10 | Contract Number: AS121150 | Approved: DAR | Revised:

3 Air Quality Criteria

Air quality criteria for assessment purposes are those adopted within the air assessment, and are consistent with the DECCW Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (2005). These are summarised in **Table 2**, **Table 3** and **Table 4**.

Table 2 – Impact assessment criteria for particulates and lead

Pollutant	Averaging Period	Concentration ($\mu g/m^3$)	Reference
TSP	Annual	90	NSW DECCW(a)(b)
PM_{10}	24 hours	50	NSW DECCW(a)
	24 hours	50(d)	NEPM(c)
	Annual	30	NSW DECCW(a)
$PM_{2.5}$	24 hours	25	NEPM(e)
	Annual	8	NEPM(e)
Lead	Annual	0.5	NSW DECCW(a)

(a) DECCW, 2005 *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*
(b) DECCW impact assessment criterion based on the subsequently rescinded National Health and Medical Research Council (NHMRC) recommended goal.
(c) NEPC, 2003, *National Environment Protection (Ambient Air Quality) Measure, as amended.*
(d) Provision made for up to five exceedances of the limit per year.
(e) Advisory reporting goal issued by the NEPC (NEPC, 2003).

Table 3 - Dust deposition criteria published by the NSW DECCW

Pollutant	Maximum Increase in Dust Deposition	Maximum Total Dust Deposited Level
Deposited dust (assessed as insoluble solids)	$2g/m^2/month$	$4g/m^2/month$

Source: DECCW, 2005 *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales.*

Table 4 – Impact assessment criteria for toxic air pollutants published by NSW DECCW

Substance	Averaging Period	Impact Assessment Criteria (µg/m³)
Antimony and compounds	1 hour	9.0
Arsenic and compounds	1 hour	0.09
Barium (soluble compound)	1 hour	9.0
Beryllium	1 hour	0.004
Cadmium and compounds	1 hour	0.018
Chromium III and compounds	1 hour	9.0
Chromium VI and compounds	1 hour	0.09
Copper dusts and mists	1 hour	18
Manganese and compounds	1 hour	18
Mercury organic	1 hour	0.18
Mercury inorganic	1 hour	1.8
Nickel and compounds	1 hour	0.18
Zinc oxide fumes	1 hour	90

Source: DECCW, 2005 *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales.*

For the air quality indicators documented within **Table 2** and **Table 3**, cumulative air quality impacts (i.e. accounting for existing air quality) are required to be reported.

The evaluation of the existing air quality environment for the purposes of this addendum document is consistent with the information provided within the air assessment.

4 Emissions Inventory

Fugitive dust sources associated with the operation phase of the Project were quantified consistent with the approach within the air assessment, principally through the application of Australian National Pollutant Inventory (NPI) emission estimation techniques and United States Environmental Protection Agency (US-EPA) AP-42 predictive emission factor equations.

4.1 Quantification of (Maximum Production) Operation Phase Emissions

Sources of atmospheric emissions associated with maximum production activities during the operation phase were identified as including the following activities anticipated to occur concurrently:

- Vehicle entrainment of particulate due to the haulage of ore along the haul road between the base of the Kintore Pit and the relocated ROM pad. Estimated 84 truck movements per day along 0.8km unpaved (chemical dust suppressant controlled) road length and 1.3km paved road length to ROM pad. The movement of concentrate from the processing plant to the rail load siding assumes 20 trips per day and a paved road section of 0.9km.There is anticipated to be an additional 6 vehicle movements per day along a 0.6km paved road linking the haul road to the workshop. Emissions assumed to occur 7 days per week, 24 hours per day.
- Trucks dumping of ore to the relocated ROM stockpile.
- Wind erosion associated with a relocated ROM stockpile of area 2,500m^2, located at the ROM pad. Water sprays and wind breaks (perpendicular to the dominant wind direction) applied.
- FEL activities at the relocated ROM pad, including loading apron feeder at a rate of 750,000 tpa (12 hours per day) and stockpile management (12 hours per day).
- Baghouse emissions associated with the baghouse servicing the crushing circuit (primary crusher and associated screen) contained within a permanent structure (refer **Section 4.2** for dust control scenarios evaluated).
- Handling of concentrate as it is transferred via conveyor direct from filters to truck-mounted containers via an overhead loading facility which the trucks pass under. Enclosed building with a rubber curtains at entry and exit. Lid automatically placed on filled containers to maintain moisture content and eliminate any dust emissions during transport to port.
- Wind erosion associated with operation of the Tailings Storage Facilities (TSF). Dust generation controlled via crusting agent application (inactive cell) and tailings deposition management and water sprays (active cell). Tailings pumped to a storage facility at 50% solids. Water sprays are anticipated to be able to cover whole TSF within 30 minutes. An evaluation of a TSF ‘upset’ scenario is provided in **Section 4.3**.
- Wind erosion of both existing free areas and Project-related disturbed areas. All exposed areas are assumed to be controlled using chemical dust suppression.

- Vehicle entrainment of particulate due to the movement of vehicles on site access roads, including deliveries to the workshops (fuel, general, spares), (disused) BHP Pit (explosives), Kintore Pit (underground stores) and processing plant. Primary roads will be paved with secondary access roads unpaved and controlled with chemical dust suppressant. Approximately seven return trips per day over a total of 3km road length attributed to site deliveries.
- Simulation of light vehicle use on the site through the addition of one additional light vehicle movement travelling at 30km/hour on unpaved (chemically stabilised) lease roads 24-hours per day.
- Emissions associated with the ventilation shaft outlet exhausted via a fan located in the existing Little Kintore Pit, including emissions due to underground drilling, blasting and vehicle tailpipe releases.

The comprehensive dust management measures summarised in the air assessment are assumed to be used, and emission reduction factors have been applied consistent with these activities, as documented in **Table 5**. Emissions sources that remain unchanged compared to those incorporated within the air assessment have been shaded in grey.

Table 5 - Estimated Particulate Emissions for Maximum Production Operations

Source	TSP	PM_{10}	$PM_{2.5}$	Emission and Control Factor Applied	Calculation Inputs
	tonnes/ annum	tonnes/ annum	tonnes/ annum		
Paved roads	19.0	3.6	0.5	US-EPA AP-42 Paved Roads (Section 13.2.1) (November 2006) Use of road sweeper assumed to limit silt loadings to <0.5 g/m² (i.e. 90% control efficiency)	Uncontrolled silt loading of 4.3 g/m² estimated based on generic loadings for extractive operations (US-EPA, 2006), and taking into account measured site-specific unpaved road material silt contents. VKT estimated to be approximately 109km per day for the haul road, assuming maximum volumes of material and a paved road section of 1.3km. VKT estimated to be approximately 36km per day for the movement of concentrate from the processing plant to the rail load siding, assuming 20 trips per day and a paved road section of 0.9km. VKT estimated at 3.6 km/day for the haul road to workshop route (6 trips over the 0.6km road section). Additionally accounts for movements on small paved road to the work shop and to core shed. Delivery vehicle VKT estimated to be 8.4 km/day.
Unpaved roads	21.4	6.4	0.6	US-EPA AP-42 Unpaved Roads (Section 13.2.2) (November 2006) 80% control factor applied associated with application of chemical dust suppressant (US-EPA, 2006)	Based on site-specific measurements of unpaved road material, the silt content was taken to be 4.4% and the uncontrolled moisture content 2.05%. Haul truck related VKT were estimated to be 67 km/day (84 trips over the 0.8km unpaved haul road section). Other vehicle activity on unpaved roads across the site was conservatively estimated to be represented by 480 VKT/day (1 vehicle travelling 20 km/day, for 24-hours per day).

Table 5 - Estimated Particulate Emissions for Maximum Production Operations

Source	TSP	PM_{10}	$PM_{2.5}$	Emission and Control Factor Applied	Calculation Inputs
	tonnes/ annum	tonnes/ annum	tonnes/ annum		
					The mean vehicle weight was taken to be 67t (accounting for full and empty trips). The average vehicle weight is greater than for paved roads, as paved roads additionally account for service vehicle movements.
Unloading ore to ROM stockpile	3.0	1.4	0.2	US-EPA AP-42 Aggregate Handling (Section 13.2.4) (November 2006) 0% control efficiency.	A mean wind speed of 4.9m/s (based on site measurements from BHOP Weather Station) was used in the calculations. A material moisture content of 3% was derived for the ore from the reference literature (J de la Vergne, 2000, Hard Rock Miner's Handbook, McIntosh Engineering, Ontario). Unloading occurs at a maximum rate of 750,000tpa ore.
Front End Loader operations	0.7	0.3	0.1	NPI EETM for Mining Version 2.3, Dec 2001 50% control factor conservatively assumed – due to water (atomising) sprays on apron feeder hopper, increased moisture content of material due to stockpile water sprays, and operation of FEL between wind breaks	Front End Loader conservatively assumed to operate 12 hours/day loading 750,000tpa ore to apron feeder and 12 hours/day managing the ROM stockpile (using a 750ktpa throughput).
Crusher Circuit – Negative Pressure/ Baghouse Controlled	0.075	0.075	0.011	NPI EETM for Mining Version 2.3, Dec 2001 99.5% control factor – conservative estimation of control quoted within US-EPA RACT/BACT Clearinghouse for enclosure and baghouse.	Emissions from primary crushing and associated screening calculated based on 750ktpa throughput. Control factor applied associated with use of a permanent full enclosure under negative pressure and vented to a baghouse with a control efficiency of 99.5%. Baghouse stack parameters assumed based on good engineering practice: 10m/s gas exit velocity, 1.5m stack diameter, 15m stack height.
Crushed Ore Storage Bin – transfer to/from	1.5	0.7	0.1	US-EPA AP-42 Aggregate Handling (Section 13.2.4) (November 2006) 0% control efficiency.	A mean wind speed of 4.9m/s (based on site measurements from BHOP Weather Station) was used in the calculations. A material moisture content of 3% was derived for the ore from the reference literature (J de la Vergne, 2000, Hard Rock Miner's Handbook, McIntosh Engineering, Ontario). Unloading occurs at a maximum rate of 750,000tpa ore.
ROM Stockpile Wind Erosion	6.7	3.1	0.9	Wind dependant emission rates calculated based on US-EPA AP-42 Industrial Wind	A ROM stockpile of area 2,500m^2 (maximum height of 5 m) assumed, located at the relocated ROM pad. Water sprays and wind breaks (perpendicular to the dominant wind direction) used for dust control. Threshold wind velocity taken to be 5.4 m/s.

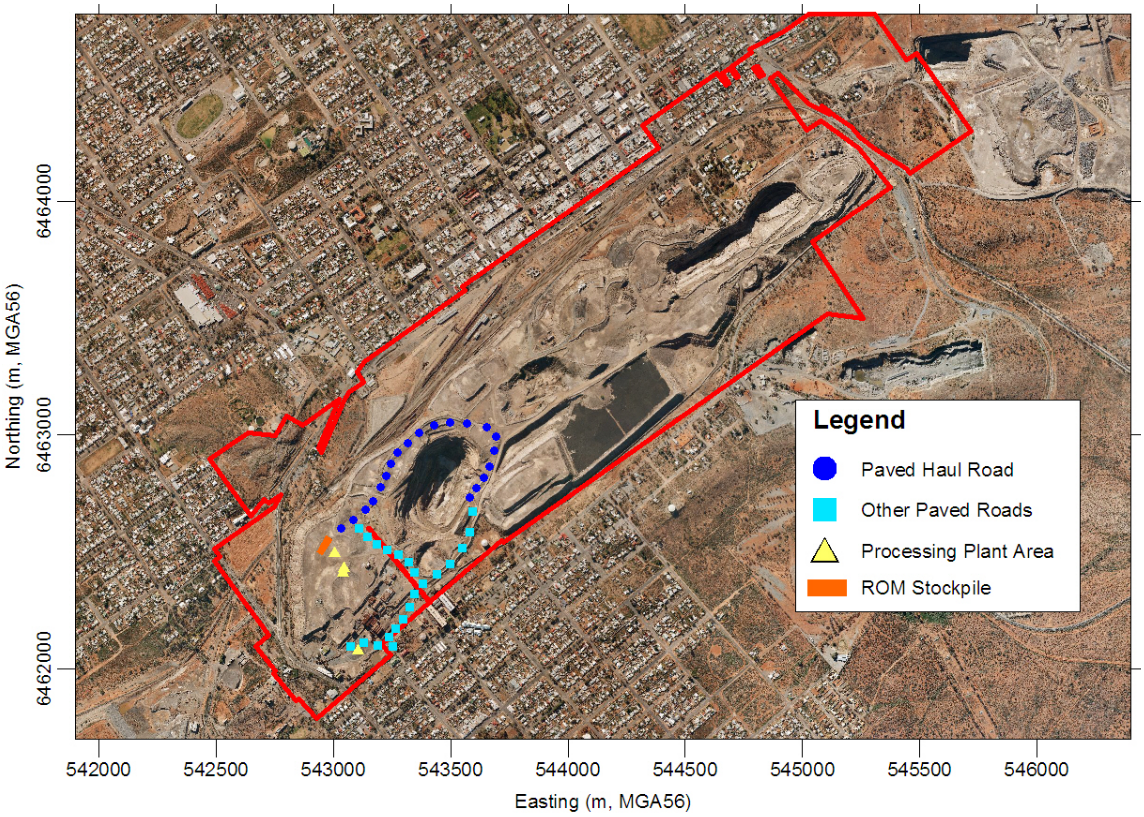
Table 5 - Estimated Particulate Emissions for Maximum Production Operations

Source	TSP tonnes/ annum	PM_{10} tonnes/ annum	$PM_{2.5}$ tonnes/ annum	Emission and Control Factor Applied	Calculation Inputs
				Erosion (Section 13.2.5 (2006) 50% control factor due to water sprays. 65% control factor when winds are perpendicular to wind breaks due to combined use of water sprays and wind breaks (NPI, 2000).	
Concentrate Handling	0.017	0.008	0.001	US-EPA AP-42 Aggregate Handling (Section 13.2.4) (November 2006) 70% control factor for loading to trains due to building enclosure (NPI, 2000).	Uncontrolled emissions were initially estimated based on a mean wind speed of 4.9m/s (based on site measurements from BHOP Weather Station). The minimum material moisture content of 9% was assumed for the concentrate. Following which a 70% control efficiency was applied.
TSF Wind Erosion – Normal Operations	6.4	2.9	0.9	Wind dependant emission rates calculated using US-EPA AP-42 Industrial Wind Erosion equations (Section 13.2.5 (2006). 95% control factor applied to 25% of inactive storage cell (i.e. 1.24 ha) – remainder assumed to have negligible emission potential.	Active storage cell (north cell for modelling scenario) assumed to be continually kept wet, thus zero emissions. Inactive storage cell has chemical dust suppressant applied with surface initially still wet due to recent tailings deposition, with gradual drying until the next deposition cycle. A highly conservative estimate of the maximum surface area of the inactive cell likely to dry out sufficiently to be prone to wind exposure (assuming no controls) is given as 25% of the surface area of the inactive storage cell (personal communication F. Gassner, Golder & Associates). Chemical dust suppression will be applied over the entire inactive storage cell surface including the wet beach and potentially drier areas. The control efficiency of the types of crusting agent products being proposed for use is documented to be >95% (Tundra Bulk Solids Handling Research Associates, July 2009; Introspec Consulting, November 2009). This dust control efficiency is based on wind tunnel testing of various tailings materials, including lead tailings, under wind speeds of 10 m/s. BHOP propose to have the site-specific control efficiency confirmed through field testing (as discussed in Section 3). TSF emissions were estimated based on site specific wind data and particle size distribution (PSD) data for existing *in situ* tailings (as obtained from Golder and Associates, February 2010).

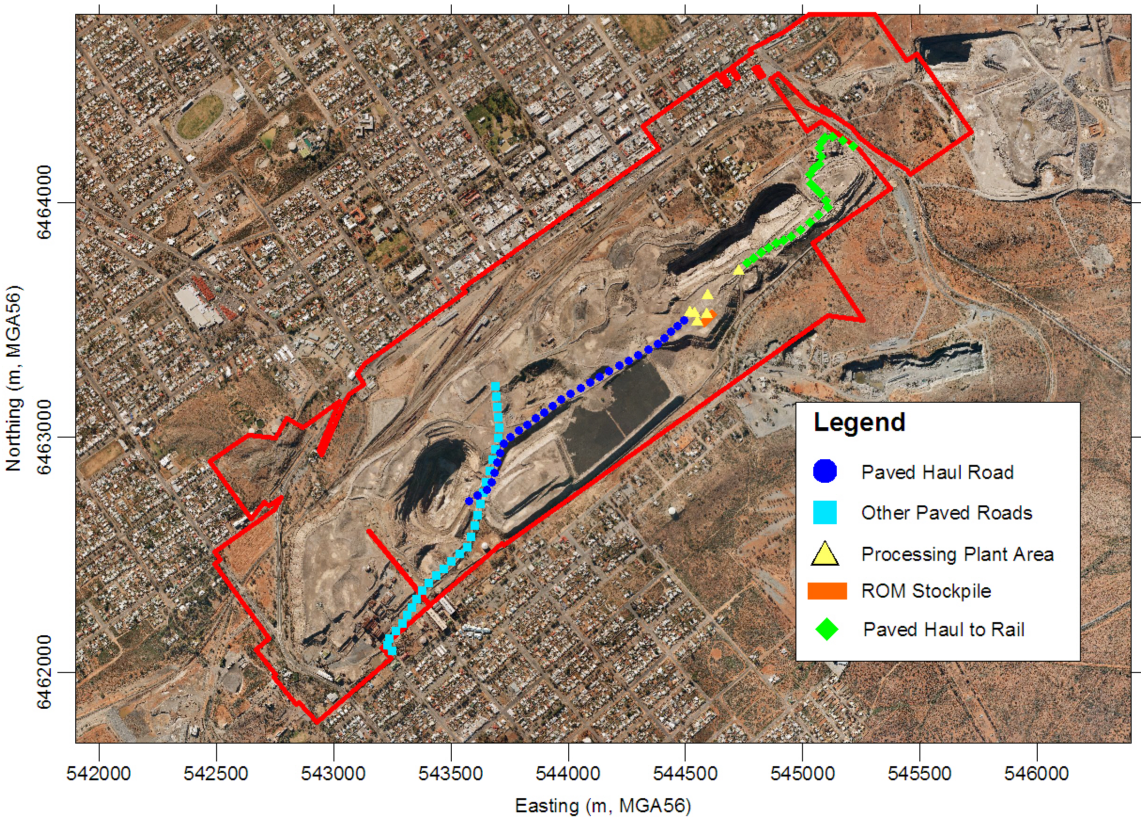
Table 5 - Estimated Particulate Emissions for Maximum Production Operations					
Source	TSP	PM_{10}	$PM_{2.5}$	Emission and Control Factor Applied	Calculation Inputs
	tonnes/ annum	tonnes/ annum	tonnes/ annum		
Exhaust Ventilation to Little Kintore Pit	3.8	2.9	0.9	NPI EETMs for: Mining and Processing of Non-metallic Minerals V2.0 (2000), Explosives Detonation and Firing Ranges V2.0 (2008), and Combustion Engines (2008b) 97%, 95% and 94% control factors applied to TSP, PM_{10} and $PM_{2.5}$ respectively.	Underground emissions quantified based on site specific data for blasting, drilling and underground diesel vehicle activity. 72.5 t/month of ANFO used. 5300 holes drilled per month. 133.7 kL of diesel consumed per month. Control factors estimated based on comparison between estimated uncontrolled ventilation shaft emissions (including blasting, drilling, diesel combustion releases) and vent shaft stack testing data (EML, 2005) for an underground (coal) mine of known annual throughput (5.2 Mtpa). Volumetric flows (300 m^3/s) and vent fan dimensions provided based on preliminary ventilation design work. Modelled as a horizontally discharging point source within the Little Kintore Pit.
Project Related Free Areas	30.9	14.2	4.0	Wind dependant emission rates applied consistent with US-EPA AP-42 Industrial Wind Erosion (Section 13.2.5 (2006). 80% control factor applied associated with application of chemical dust suppressant (US-EPA, 2006)	Project-related disturbed areas taken to coincide with major infrastructure (roads, pits, ROM pad, etc.) (see Section 2.4, yellow areas). These areas exclude the existing exposed 'free areas' (see Section 2.4, red hatched areas) which are separately quantified (see Section 7.3). Threshold wind velocity taken to be 5.4 m/s. A total area of 2.03 ha was taken to comprise Project-related free areas.
TOTAL	93.5	35.6	8.2		

The locations of the sources that have changed within the modelling are summarised in **Figure 3**.

Figure 3: Changes to Emission Modelling Configuration Reflecting Relocation of Processing Area



3(a) Location of Modelled Sources within the Air Assessment



3(b) Location of Modelled Sources for Relocation of Processing Area

4.2 Crushing Circuit Alternative Dust Controls Emissions

The air assessment evaluated a crushing circuit (primary, secondary and tertiary crushers and associated screens) with all potential particulate emissions contained via full enclosure under negative pressure, with emissions diverted to a baghouse (99.5% control efficiency).

As discussed in **Section 2.1.1**, the relocation of the processing plant has also allowed for a reduction in the potential dust generating sources, through removal of the secondary and tertiary crushers and associated screens. The revised crushing circuit requires a primary crusher only, with material then being transferred to the SAG mill, which is a wet process.

Due to the reduced dust generation potential from the revised crushing circuit, combined with technical and operational constraints identified associated with the previous dust control configuration, alternative dust controls have been evaluated.

This scenario comprises the crusher area being enclosed with noise cladding and particulate emissions captured through targeted hooded extraction to a bag house. This allows for effective dust control while reducing the air volumes required to be treated.

The emissions associated with this scenario have been incorporated within the modelling as documented in **Table 6**.

Table 6 - Estimated Particulate Emissions for Crusher Alternative Dust Controls Scenarios

Source	TSP	PM_{10}	$PM_{2.5}$	Emission and Control Factor Applied	Calculation Inputs
	tonnes/ annum	tonnes/ annum	tonnes/ annum		
Crusher Circuit Scenario 1	0.075	0.075	0.011	NPI EETM for Mining Version 2.3, Dec 2001 99.5% control factor – conservative estimation of control quoted within US-EPA RACT/BACT Clearinghouse for enclosure and baghouse.	Emissions from primary crushing and associated screening calculated based on 750ktpa throughput. Control factor applied associated with use of a permanent full enclosure under negative pressure and vented to a baghouse with a control efficiency of 99.5%. Baghouse stack parameters assumed based on good engineering practice: 10m/s gas exit velocity, 1.5m stack diameter, 15m stack height.
Crusher Circuit Scenario 2	7.65	0.77	0.11	NPI EETM for Mining Version 2.3, Dec 2001 70% control factor associated with enclosure. Additional 83% control factor associated with hooding with fabric filters (Table 3 of NPI EETM for Mining Version 2.3)	Control factors are multiplicative with total control factor thus anticipated to be 94.9%. Emissions from primary crushing and associated screening simulated as a volume source and calculated based on 750ktpa throughput. Control factor applied associated with enclosure with noise cladding material. Emissions captured through hooded extraction and vented to a baghouse.

Inspection of **Table 6** indicates that the Scenario 2 configuration of the crushing circuit has a higher annual emission rate of TSP, PM_{10} and $PM_{2.5}$ than the Scenario 1 configuration. The large discrepancy shown between the TSP emission rates is associated with the previous modelling assuming that all post-baghouse emissions are in the PM_{10} size fraction.

Additionally, Scenario 1 was simulated based on all crushing emissions being emitted as a point source associated with the baghouse stack. Scenario 2 is modelled as a diffuse volume source to conservatively account for the presence of fugitive emissions from the crusher building.

4.3 Emissions Associated with TSF 'Upset' Conditions

Significant contingency and redundancy has been built into the design of the TSF to ensure that adequate dust mitigation is available both during normal operations and under 'upset' conditions.

The 'upset' scenario requested to be evaluated by DECCW is as follows:

> *whereby the active cell is assumed to be saturated, with zero emissions, but 100% of the total area of the inactive cell is assumed to be emitting with 90% control efficiency (base the polymer controlling emissions at near capacity effectiveness). This would represent ~10% of total uncontrolled emissions from the inactive TSF cell (100 × 0.1 = 10%).*

The emissions associated with this scenario have been incorporated as documented in **Table 7**.

Table 7 - Estimated Particulate Emissions for TSF 'Upset' Scenario

Source	TSP	PM_{10}	$PM_{2.5}$	Emission and Control Factor Applied	Calculation Inputs
	tonnes/ annum	tonnes/ annum	tonnes/ annum		
TSF Wind Erosion – 'Upset' Scenario	25.8	11.7	3.7	Wind dependant emission rates calculated using US-EPA AP-42 Industrial Wind Erosion equations (Section 13.2.5 (2006). 90% control factor associated with the use of chemical dust suppressants - 100% of inactive storage cell capable of generating dust.	Active storage cell (north cell for modelling scenario) assumed to be continually kept wet, thus zero emissions. 'Upset' scenario (as specified by DECCW) assumes the chemical dust suppressant on the inactive storage cell has reduced effectiveness (90%) and that the whole cell (i.e. 4.96 ha) has the ability to generate dust.

The modelling of the TSF 'Upset' under Scenario 1 crusher dust controls is referred to as Scenario 3 in the results presented in **Section 5**.

The modelling of the TSF 'Upset' under Scenario 2 crusher dust controls is referred to as Scenario 4 in the results presented in **Section 5**.

5 Air Quality Impact Assessment

AERMOD was identified as the most suitable model for application for the Project due to the source types and nature of terrain (e.g. location of sources at elevated heights compared to surrounding receptor sites). Its use was discussed with, and approved by the DECCW, pending adequate implementation.

A detailed account of the model selection and modelling methodology is presented in the air assessment.

Incremental Project-related concentrations and deposition rates occurring due to maximum production emissions were modelled (termed '**Project-related incremental**').

In addition to the model predictions presented within the air assessment, model predictions for the following scenarios are provided:

- **SCENARIO 1**: Relocated processing area with normal TSF operations and all crusher emissions contained via full enclosure under negative pressure;
- **SCENARIO 2**: Relocated processing area with normal TSF operations and crusher area enclosed with noise cladding and emissions captured through hooded extraction;
- **SCENARIO 3**: Relocated processing area with 'Upset' TSF operations and all crusher emissions contained via full enclosure under negative pressure, with emissions diverted to a baghouse; and
- **SCENARIO 4**: Relocated processing area with 'Upset' TSF operations and crusher area enclosed with noise cladding and emissions captured through hooded extraction.

Model results are expressed as the maximum predicted concentration for each averaging period at the sensitive receptors over the two years period that was modelled.

Contour plots presented in the report Appendices do not represent the dispersion pattern on any individual day, but rather illustrate the maximum concentration that was simulated to be possible at each receptor point given the range of meteorological conditions occurring over the two year period modelled.

5.1 Crushing Circuit Alternative Dust Controls Emissions

The difference between the modelling of Scenario 1 and Scenario 2 dust controls at the crushing circuit is illustrated in **Figure 4**, **Figure 5, Figure 6** and **Figure 7**.

These figures additionally inform as to changes in incremental impacts of the key particulate size fractions at Project receptors compared to the modelling undertaken within the air assessment.

Figure 4: Change in Predicted 24-hour Average PM_{10} Concentrations from Original Modelling – Comparison between Crusher Scenario Modelling

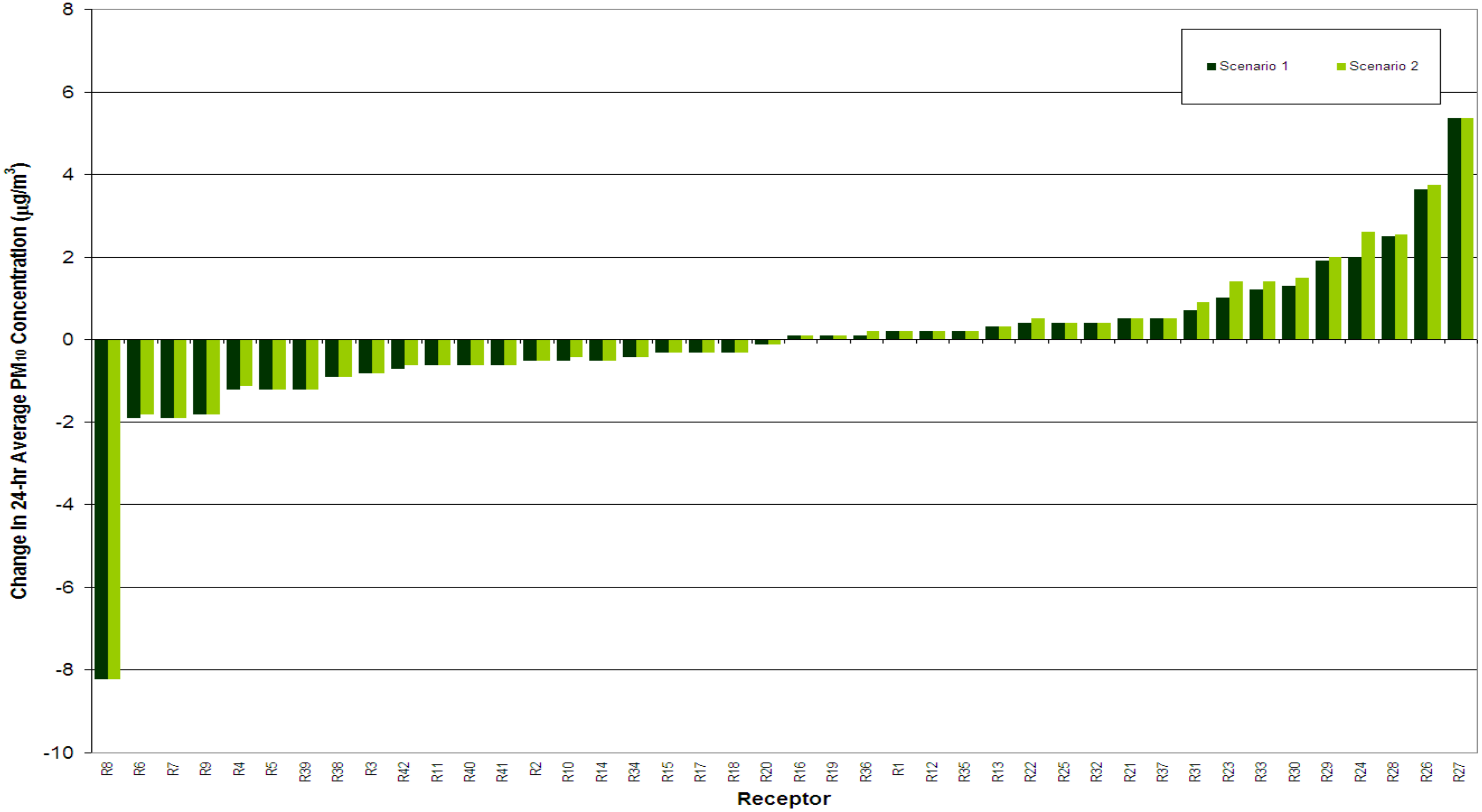


Figure 5: Change in Predicted Annual Average PM_{10} Concentrations from Original Modelling – Comparison between Crusher Scenario Modelling

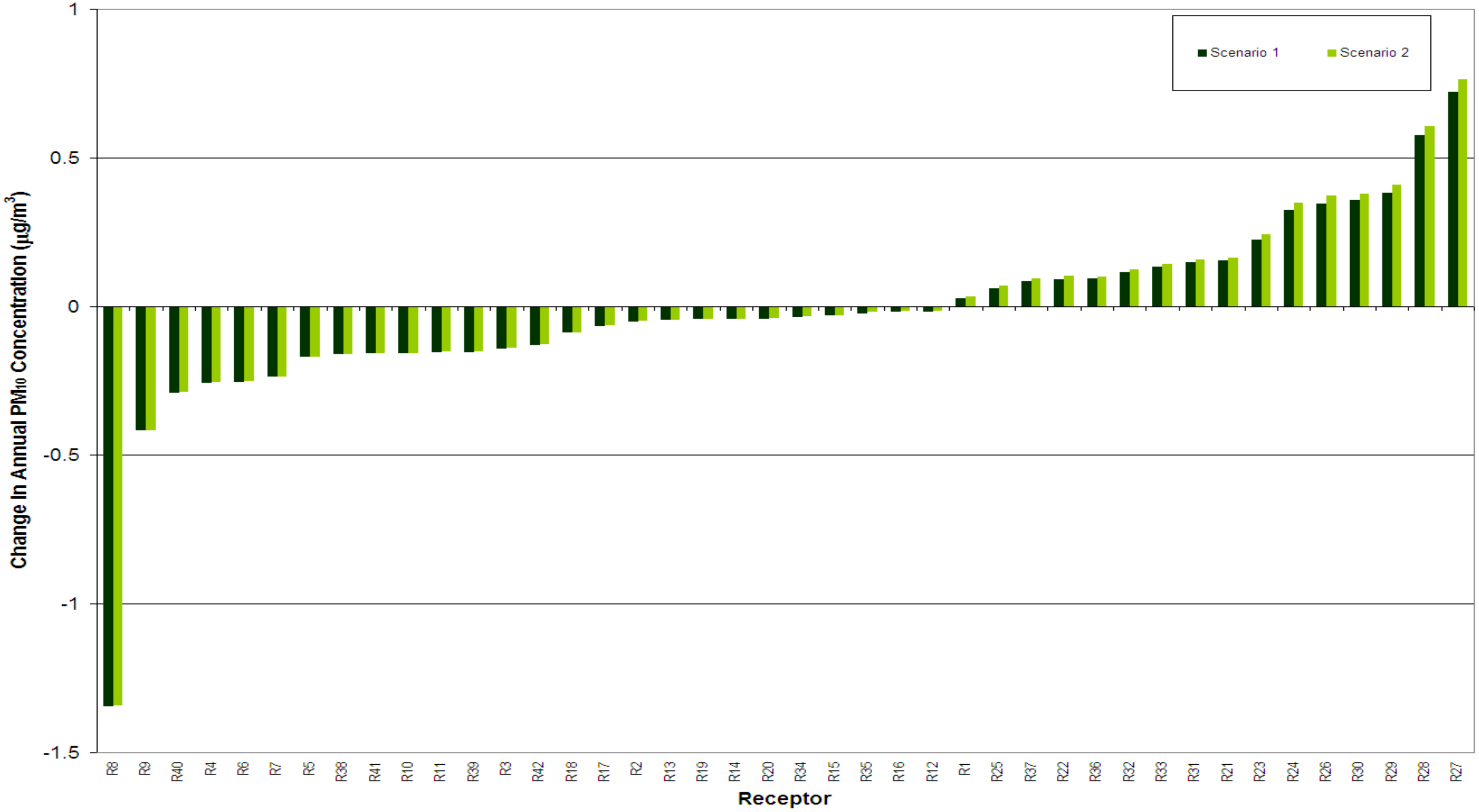


Figure 6: Change in Predicted Annual Average Monthly Dust Deposition from Original Modelling – Comparison between Crusher Scenario Modelling

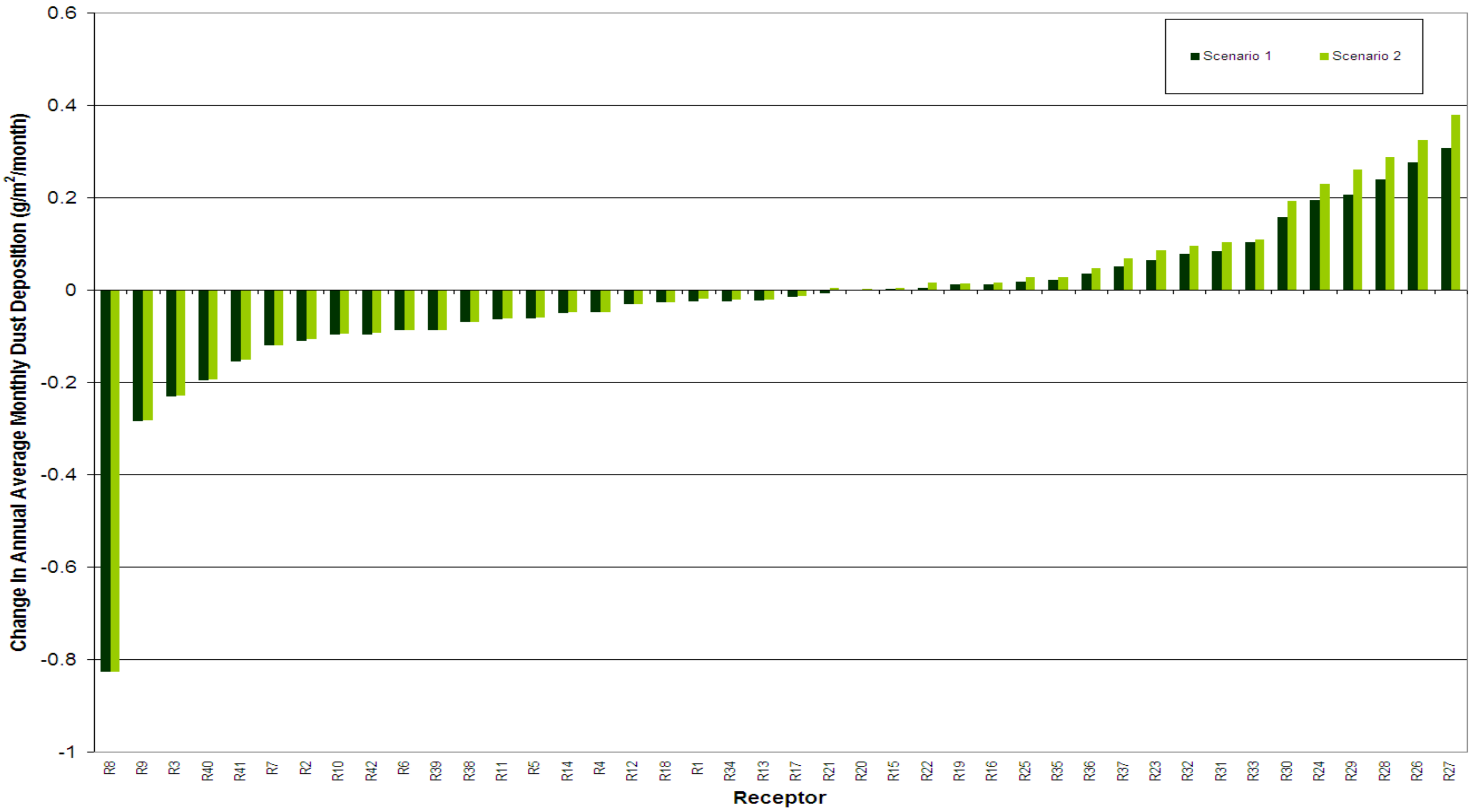


Figure 7: Change in Predicted Annual Average Lead Deposition from Original Modelling – Comparison between Crusher Scenario Modelling

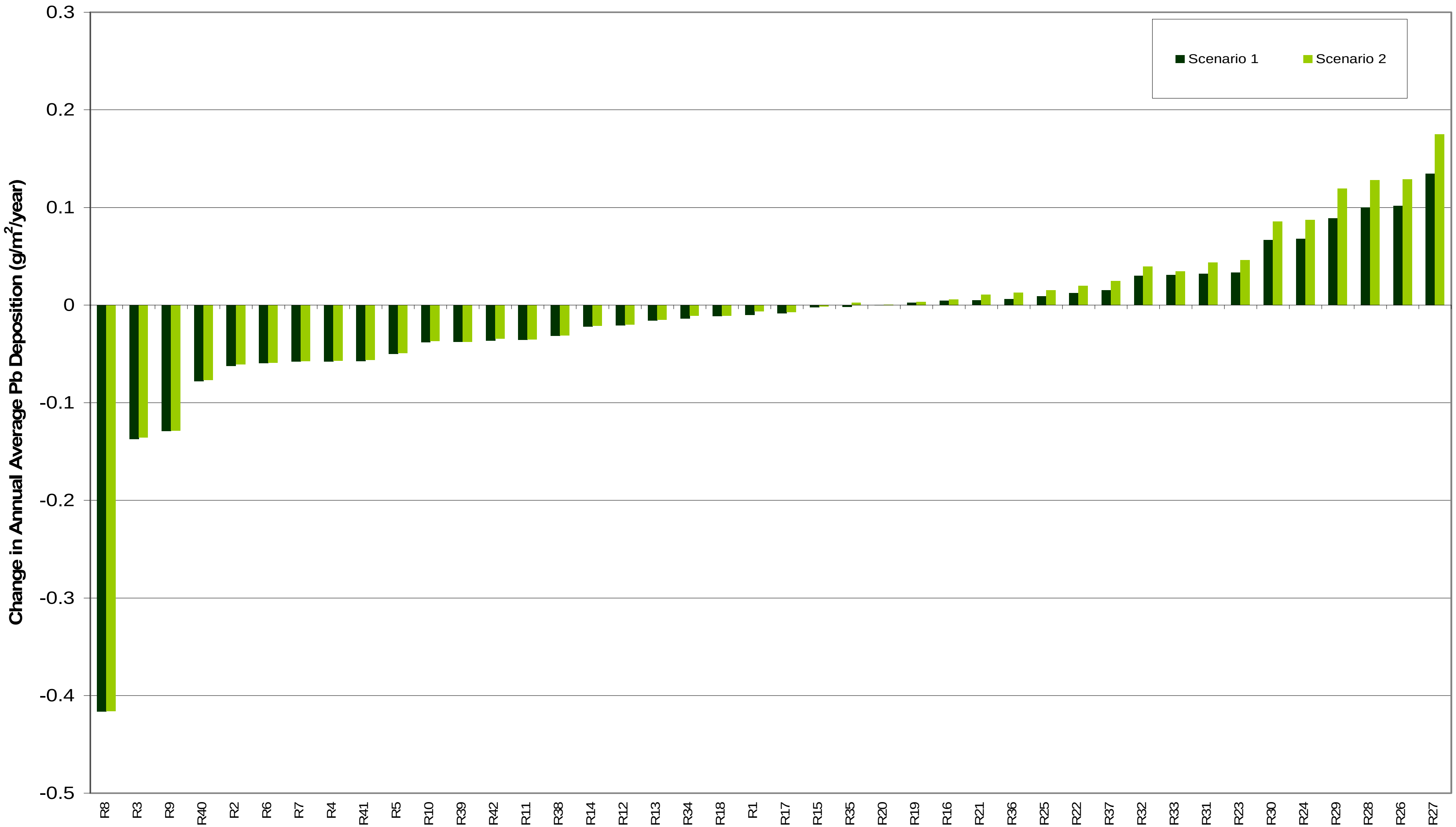


Figure 4, **Figure 5, Figure 6** and **Figure 7** indicate that the difference in predicted concentrations between the two crusher configuration scenarios is most notable at receptors R26-R30. However, it appears that the selection of crusher configuration (full enclosure under negative pressure with all emissions vented to a baghouse versus acoustic cladding with hooded extraction) is not a critical factor in predicted concentrations from the Project. The maximum change in incremental predictions of key air quality indicators across all sensitive receptors between the two dust control scenarios are as follows:

- 24-hour PM_{10}: 0.6µg/m^3 (Receptor R24; a change from 4.4 µg/m^3 to 5.0 µg/m^3);
- Annual PM_{10}: 0.1µg/m^3 (Receptors R6 (now 0.6 µg/m^3), R11 (now 0.3 µg/m^3), R26 (now 0.8 µg/m^3), R27 (now 1.0 µg/m^3), R31 (now 0.4 µg/m^3), R39 (now 0.2 µg/m^3));
- Annual Average Dust Deposition: 0.07g/m^2/month (Receptor R27; a change from 0.40µg/m^3 to 0.47µg/m^3); and
- Annual Average Lead Deposition: 0.04g/m^2/year (Receptor R27; a change from 0.135g/m^2/year to 0.175g/m^2/year).

Examination of **Figure 4**, **Figure 5, Figure 6** and **Figure 7** in combination with **Table 1** illustrates that overall incremental impacts are predicted to reduce at receptor locations representative of groups of receptors. Broadly, incremental impacts are predicted to increase relative to the air assessment predictions at locations representative of single dwellings.

Additionally, locations with the highest predicted increases occur relative to the air assessment predictions represent industrial premises (receptor R26) or unoccupied heritage buildings on the CML7 mining lease (receptors R27 and R28).

5.2 24-Hour PM_{10}

The incremental highest 24-hour average PM_{10} concentrations predicted to occur at nearby receptor locations due to operations at maximum production levels for the modelled years 2008 and 2009 are summarised in **Table 8**.

Predicted concentrations are presented spatially as contours in **Appendix A**. These represent the predicted maximum 24-hour concentrations across both modelled years.

Under normal operations, the Project-incremental concentration of PM_{10} is predicted to contribute up to 15% of the DECCW criterion of 50µg/m^3 for the worst case 24-hour period across all receptors and the two years of modelling.

Previous modelling predicted incremental contributions of up to 20% of the DECCW criterion.

5.3 Annual Average PM_{10}

Annual average PM_{10} concentrations simulated to occur at nearby receptor locations due to operations at maximum production levels are summarised in **Table 9**, expressed as maximum predictions over the model years 2008 and 2009. They are presented spatially as contours in **Appendix A**. These contours represent a composite of predicted worst case concentrations across both model years (i.e. are the maximum annual average concentration predicted for either model year).

Scenario 3 and Scenario 4 are not applicable to annual average criteria since any TSF 'Upset' condition will be a short-term event.

Annual average PM_{10} concentrations are predicted to be below the DECCW air quality criterion of 30µg/m³. Taking background particulate concentrations into account, the maximum (cumulative) concentration predicted over the two years of modelling is anticipated to be between 92% and 95% of the DECCW criterion across all sensitive receptors.

It is noted that the maximum predicted Project-related increment in annual PM_{10} concentrations across all receptors and modelled years is 1.0µg/m³, or 3% of the DECCW criterion.

Previous modelling predicted Project-related increment was 1.7µg/m³ contributing up to 6% of the DECCW criterion.

Table 8 – Predicted 24-hour Average PM_{10} – Original and Revised Modelling

Receptors	Original Assessment Predictions (µg/m³)	Predictions for Revised Scenarios (µg/m³)			
		Scenario 1	Scenario 2	Scenario 3	Scenario 4
R1	2.3	2.5	2.5	7.4	7.4
R2	3.6	3.1	3.1	3.1	3.1
R3	5.9	5.1	5.1	5.1	5.1
R4	4.2	3	3.1	3	3.1
R5	4.3	3.1	3.1	3.1	3.1
R6	6.5	4.6	4.7	4.8	4.8
R7	3.1	1.2	1.2	1.2	1.2
R8	10.5	2.3	2.3	2.3	2.3
R9	3.4	1.6	1.6	1.6	1.6
R10	1.8	1.3	1.4	1.4	1.4
R11	2.8	2.2	2.2	2.2	2.2
R12	1.7	1.9	1.9	1.9	1.9
R13	1.5	1.8	1.8	1.8	1.8
R14	1.5	1	1	1.1	1.1
R15	0.9	0.6	0.6	0.6	0.6
R16	0.7	0.8	0.8	0.8	0.8
R17	1.2	0.9	0.9	0.9	0.9
R18	1.3	1	1	1	1
R19	0.5	0.6	0.6	0.6	0.6
R20	0.7	0.6	0.6	0.6	0.6
R21	3.0	3.5	3.5	11.8	11.8
R22	3.6	4	4.1	11.6	11.6
R23	2.6	3.6	4	8.3	8.3
R24	2.4	4.4	5	5.3	5.3
R25	1.9	2.3	2.3	4.8	4.9
R26	2.6	6.2	6.3	6.3	6.3
R27	2.0	7.3	7.4	7.7	7.8
R28	2.2	4.7	4.7	5.4	5.5
R29	1.8	3.7	3.8	4.3	4.3
R30	1.5	2.8	3	3.2	3.3
R31	1.4	2.1	2.3	2.6	2.6
R32	1.4	1.8	1.8	2.2	2.3
R33	1.6	2.8	3	3	3
R34	2.2	1.8	1.8	2.2	2.2
R35	2.0	2.2	2.2	2.7	2.7
R36	1.5	1.6	1.7	3	3
R37	1.4	1.9	1.9	2.6	2.6
R38	2.3	1.4	1.4	1.4	1.4
R39	2.5	1.3	1.3	1.3	1.3
R40	2.6	2	2	2	2
R41	2.7	2.1	2.1	2.1	2.1
R42	2.7	2	2.1	2.3	2.3

Note: Shaded Cells indicate increase in predictions from original assessment

Table 9 – Predicted Annual Average PM_{10} – Original and Revised Modelling

Receptors	Original Assessment Predictions (µg/m³)	Predictions for Revised Scenarios (µg/m³)	
		Scenario 1	Scenario 2
R1	0.4	0.4	0.4
R2	0.5	0.5	0.5
R3	0.9	0.8	0.8
R4	0.8	0.5	0.5
R5	0.6	0.4	0.4
R6	0.8	0.5	0.6
R7	0.4	0.2	0.2
R8	1.7	0.4	0.4
R9	0.7	0.3	0.3
R10	0.4	0.2	0.2
R11	0.4	0.2	0.3
R12	0.2	0.2	0.2
R13	0.2	0.2	0.2
R14	0.2	0.2	0.2
R15	0.1	0.1	0.1
R16	0.1	0.1	0.1
R17	0.2	0.1	0.1
R18	0.2	0.1	0.1
R19	0.1	0.1	0.1
R20	0.1	0.1	0.1
R21	0.4	0.6	0.6
R22	0.5	0.6	0.6
R23	0.4	0.6	0.6
R24	0.4	0.7	0.7
R25	0.3	0.4	0.4
R26	0.4	0.7	0.8
R27	0.2	0.9	1.0
R28	0.2	0.8	0.8
R29	0.3	0.7	0.7
R30	0.2	0.6	0.6
R31	0.2	0.3	0.4
R32	0.2	0.3	0.3
R33	0.2	0.3	0.3
R34	0.4	0.4	0.4
R35	0.4	0.4	0.4
R36	0.3	0.4	0.4
R37	0.3	0.4	0.4
R38	0.3	0.1	0.1
R39	0.3	0.1	0.2
R40	0.6	0.3	0.3
R41	0.5	0.3	0.3
R42	0.5	0.4	0.4

Note: Shaded Cells indicate increase in predictions from original assessment

5.4 Total Suspended Particulate

Annual average TSP concentrations predicted to occur at representative receptor locations due to operations at maximum production levels are summarised in **Table 10**, expressed as maximum concentrations over the model years 2008 and 2009. They are presented spatially as contours in **Appendix A**. These contours represent a composite of predicted worst case concentrations across both model years.

Scenario 3 and Scenario 4 are not applicable to annual average criteria since any TSF ‘Upset’ condition will be a short-term event.

Annual average concentrations of TSP from Project-related sources are predicted to be significantly below the DECCW air quality criterion of 90µg/m³ ranging from 0.2µg/m³ to 2.4µg/m³. Taking background particulate concentrations into account (64.9µg/m³), the maximum (cumulative) concentration predicted over the two years of modelling is anticipated to be 76% of the DECCW criterion of 90µg/m³ across all sensitive receptors.

5.5 Dust Deposition

Annual average dust deposition rates simulated to occur at representative receptor locations due to the Project are summarised in **Table 11**, expressed as the average monthly dust deposition rate (maximum across two model years) deposition rate over the model years 2008 and 2009. They are presented spatially as contours in **Appendix A**. These contours represent a composite of predicted worst case deposition across both model years.

Scenario 3 and Scenario 4 are not applicable to annual average criteria since any TSF ‘Upset’ condition will be a short-term event.

A maximum incremental annual average dust deposition rate of 0.47g/m²/month (receptor R27 located on the CML7 mining lease) was predicted to occur across the receptor locations due to maximum production activities. This rate is within the NSW DECCW incremental dust deposition limit of 2 g/m²/month.

Previous modelling predicted incremental annual average dust deposition rates of up to 0.94 g/m²/month.

Table 10 – Predicted Annual Average TSP – Original and Revised Modelling

Receptors	Original Assessment Predictions (µg/m³)	Predictions for Revised Scenarios (µg/m³)	
		Scenario 1	Scenario 2
R1	0.7	1.4	1.5
R2	1	1.3	1.4
R3	1.8	2.0	2.1
R4	1.4	1.3	1.4
R5	1.1	1.0	1.0
R6	1.5	1.2	1.2
R7	0.7	0.4	0.5
R8	3	0.9	0.9
R9	1.3	0.8	0.8
R10	0.7	0.7	0.8
R11	0.6	0.6	0.7
R12	0.4	0.5	0.5
R13	0.3	0.4	0.5
R14	0.4	0.5	0.5
R15	0.1	0.2	0.2
R16	0.1	0.2	0.2
R17	0.3	0.4	0.4
R18	0.3	0.3	0.3
R19	0.1	0.2	0.2
R20	0.1	0.2	0.2
R21	0.8	1.7	1.8
R22	0.9	1.8	1.9
R23	0.8	1.8	2.0
R24	0.8	2.0	2.2
R25	0.5	1.1	1.2
R26	0.8	2.0	2.3
R27	0.3	2.4	2.9
R28	0.3	2.0	2.3
R29	0.5	1.8	2.2
R30	0.4	1.5	1.7
R31	0.4	0.9	1.1
R32	0.3	0.8	1.0
R33	0.6	0.8	0.9
R34	0.8	1.1	1.2
R35	0.7	1.1	1.2
R36	0.7	1.1	1.2
R37	0.5	1.1	1.2
R38	0.5	0.4	0.4
R39	0.6	0.4	0.4
R40	1.1	0.9	0.9
R41	1.2	1.1	1.1
R42	1	1.1	1.2

Note: Shaded Cells indicate increase in predictions from original assessment

Table 11 – Predicted Annual Average Dust Deposition – Original and Revised

Receptors	Original Assessment Predictions (g/m²/month)	Predictions for Revised Scenarios (g/m²/month)	
		Scenario 1	Scenario 2
R1	0.21	0.19	0.19
R2	0.29	0.18	0.18
R3	0.55	0.32	0.32
R4	0.30	0.25	0.25
R5	0.22	0.16	0.16
R6	0.25	0.16	0.17
R7	0.16	0.04	0.04
R8	0.94	0.11	0.12
R9	0.37	0.09	0.09
R10	0.18	0.08	0.09
R11	0.14	0.08	0.08
R12	0.09	0.06	0.06
R13	0.07	0.05	0.05
R14	0.10	0.05	0.05
R15	0.02	0.02	0.02
R16	0.02	0.03	0.03
R17	0.06	0.05	0.05
R18	0.05	0.02	0.02
R19	0.01	0.02	0.02
R20	0.02	0.02	0.02
R21	0.28	0.27	0.28
R22	0.30	0.30	0.32
R23	0.22	0.28	0.31
R24	0.14	0.33	0.37
R25	0.14	0.16	0.17
R26	0.11	0.39	0.43
R27	0.09	0.40	0.47
R28	0.08	0.32	0.37
R29	0.08	0.29	0.34
R30	0.07	0.23	0.26
R31	0.06	0.14	0.16
R32	0.05	0.13	0.15
R33	0.04	0.14	0.15
R34	0.17	0.15	0.15
R35	0.13	0.15	0.16
R36	0.11	0.14	0.16
R37	0.09	0.14	0.16
R38	0.10	0.03	0.03
R39	0.12	0.03	0.04
R40	0.30	0.11	0.11
R41	0.28	0.13	0.13
R42	0.24	0.14	0.15

Note: Shaded Cells indicate increase in predictions from original assessment

5.6 24-Hour Average $PM_{2.5}$

Incremental highest daily average $PM_{2.5}$ concentrations simulated to occur at nearby receptor locations due to maximum production activities are summarised in **Table 12** and are presented spatially as contour plots in **Appendix A**.

Under normal operations, daily average $PM_{2.5}$ concentrations at the representative sensitive receptor sites due to maximum production emissions are predicted to peak at 9% of the 24-hour air quality criterion of 25µg/m³. Taking into account the $PM_{2.5}/PM_{10}$ ratios characteristic of rural environments, and the proportion of fines in Project-related emissions it is anticipated that the PM_{10} air quality criterion will be sufficiently protective of incremental $PM_{2.5}$ exposure potentials.

5.7 Annual Average $PM_{2.5}$

Incremental annual average $PM_{2.5}$ concentrations simulated to occur at nearby receptor locations due to maximum production activities are summarised in **Table 13** and are presented spatially as contour plots in **Appendix A**.

Scenario 3 and Scenario 4 are not applicable to annual average criteria since any TSF 'Upset' condition will be a short-term event.

Annual average $PM_{2.5}$ concentrations at the representative sensitive receptor sites due to maximum production emissions are predicted to peak at 3% of the DECCW air quality criterion of 8µg/m³. Taking into account the $PM_{2.5}/PM_{10}$ ratios characteristic of rural environments, and the proportion of fines in Project-related emissions it is anticipated that the PM_{10} air quality criterion will be sufficiently protective of incremental $PM_{2.5}$ exposure potentials.

Table 12 – Predicted 24-hour Average $PM_{2.5}$ – Original and Revised Modelling

Receptors	Original Assessment Predictions (µg/m³)	Predictions for Revised Scenarios (µg/m³)			
		Scenario 1	Scenario 2	Scenario 3	Scenario 4
R1	0.9	1.0	1.0	3.2	3.2
R2	1.3	1.1	1.1	1.1	1.1
R3	1.6	1.5	1.5	1.5	1.5
R4	1.4	0.9	0.9	0.9	0.9
R5	1.1	0.9	0.9	0.9	0.9
R6	1.8	1.6	1.6	1.7	1.7
R7	0.8	0.5	0.5	0.5	0.5
R8	3.5	0.8	0.8	0.8	0.8
R9	1.1	0.5	0.5	0.5	0.5
R10	0.4	0.3	0.3	0.5	0.5
R11	0.6	0.6	0.6	0.6	0.6
R12	0.5	0.6	0.6	0.6	0.6
R13	0.5	0.5	0.5	0.5	0.5
R14	0.3	0.2	0.2	0.4	0.4
R15	1.2	0.1	0.1	0.2	0.2
R16	0.2	0.2	0.2	0.3	0.3
R17	0.3	0.2	0.2	0.3	0.3
R18	0.3	0.3	0.3	0.3	0.3
R19	0.1	0.2	0.2	0.2	0.2
R20	0.2	0.1	0.1	0.2	0.2
R21	1.2	1.4	1.4	4.9	4.9
R22	1.2	1.4	1.4	4.4	4.4
R23	0.9	1.1	1.1	3.4	3.4
R24	0.9	1.5	1.5	2.1	2.1
R25	0.6	0.7	0.7	1.9	1.9
R26	0.9	1.8	1.8	2.1	2.1
R27	0.6	2.3	2.3	2.5	2.5
R28	0.6	1.6	1.6	1.9	1.9
R29	0.6	1.3	1.3	1.6	1.6
R30	0.5	1.0	1.0	1.2	1.2
R31	0.4	0.7	0.7	1.0	1.0
R32	0.4	0.6	0.6	0.9	0.9
R33	0.8	1.0	1.0	1.1	1.1
R34	0.6	0.5	0.5	0.8	0.8
R35	0.6	0.6	0.6	1.1	1.1
R36	0.6	0.6	0.6	1.2	1.2
R37	0.5	0.5	0.5	1.1	1.1
R38	0.6	0.4	0.4	0.4	0.4
R39	0.7	0.4	0.4	0.4	0.4
R40	0.6	0.4	0.4	0.5	0.5
R41	0.6	0.5	0.5	0.6	0.6
R42	0.7	0.5	0.5	0.9	0.9

Note: Shaded Cells indicate increase in predictions from original assessment

Table 13 – Predicted Annual Average $PM_{2.5}$ – Original and Revised Modelling

Receptors	Original Assessment Predictions (µg/m³)	Predictions for Revised Scenarios (µg/m³)	
		Scenario 1	Scenario 2
R1	0.10	0.12	0.12
R2	0.14	0.13	0.13
R3	0.25	0.24	0.24
R4	0.22	0.17	0.17
R5	0.17	0.13	0.13
R6	0.21	0.14	0.14
R7	0.12	0.05	0.05
R8	0.46	0.11	0.11
R9	0.19	0.08	0.08
R10	0.10	0.07	0.07
R11	0.10	0.07	0.07
R12	0.07	0.05	0.05
R13	0.06	0.04	0.04
R14	0.06	0.05	0.05
R15	0.03	0.02	0.02
R16	0.02	0.03	0.03
R17	0.04	0.04	0.04
R18	0.04	0.03	0.03
R19	0.02	0.02	0.02
R20	0.02	0.02	0.02
R21	0.13	0.16	0.16
R22	0.13	0.17	0.18
R23	0.12	0.17	0.17
R24	0.12	0.19	0.19
R25	0.08	0.10	0.11
R26	0.12	0.20	0.20
R27	0.11	0.24	0.25
R28	0.10	0.20	0.21
R29	0.09	0.18	0.19
R30	0.08	0.15	0.15
R31	0.06	0.10	0.10
R32	0.06	0.09	0.09
R33	0.07	0.09	0.09
R34	0.10	0.10	0.10
R35	0.09	0.10	0.10
R36	0.08	0.10	0.10
R37	0.07	0.10	0.10
R38	0.08	0.04	0.04
R39	0.09	0.04	0.04
R40	0.15	0.09	0.09
R41	0.14	0.10	0.10
R42	0.12	0.10	0.10

Note: Shaded Cells indicate increase in predictions from original assessment

5.8 Heavy Metal Concentrations

A synopsis of maximum Project-related incremental 99.9th percentile hourly and annual average heavy metal concentrations predicted to maximum production activities across all discrete receptor locations is given in **Table 14**, with reference made to relevant DECCW impact assessment criteria. Such criteria are reported at the predicted 99.9th percentile (or 9th highest 1-hourly average) concentration, consistent with Section 7.2.2 of the DECCW Approved Methods.

Predictions under Scenario 2 are presented as these are the maximum of the normal operation scenarios. Scenario 1 predictions should be viewed as equivalent or slightly lower than the Scenario 2 predictions shown.

Contour plots indicative of the spatial distribution of these metal concentrations, showing both Scenario 2 and Scenario 4 (TSF 'Upset') are provided in **Appendix B**.

Table 14 – Predicted Incremental 99.9th Percentile Hourly Heavy Metal Concentrations Predicted – Original and Scenario 2

Substance	Original Assessment		Scenario 2		DECCW Criterion (µg/m³)	Incremental concentration (Scenario 2) as % DECCW Criterion
	99.9th Percentile (µg/m³) across all Receptors	Receptor	99.9th Percentile (µg/m³) across all Receptors	Receptor		
Antimony	3.6×10^{-3}	R8	1.1×10^{-3}	R26	9	0.01%
Arsenic	2.1×10^{-2}	R8	6.5×10^{-3}	R26	0.09	7.22%
Barium	1.1×10^{-4}	R22	2.7×10^{-5}	R22	9	0.0003%
Beryllium	2.8×10^{-6}	R22	3.0×10^{-6}	R22	0.004	0.08%
Cadmium	8.6×10^{-3}	R8	2.7×10^{-3}	R26	0.018	15.0%
Chromium	8.6×10^{-4}	R28	1.8×10^{-3}	R6	9 (as Cr III)	0.02%
					0.09 (as Cr VI)	2.0%
Copper	3.8×10^{-2}	R8	2.5×10^{-2}	R26	18	0.14%
Manganese	6.2×10^{-2}	R28	1.3×10^{-1}	R26	18	0.72%
Mercury	9.9×10^{-5}	R28	2.2×10^{-4}	R6	0.18	0.12%
Nickel	6.1×10^{-4}	R28	1.3×10^{-3}	R6	0.18	0.72%
Silver	2.0×10^{-3}	R8	1.3×10^{-3}	R26	0.18	0.72%

No exceedances of the relevant DECCW impact assessment criteria for the above toxic air pollutants were predicted to occur under maximum production conditions.

No data is available concerning the partitioning of chromium (Cr) between Cr III and Cr VI oxidation states. However, inspection of **Table 14** indicates that even using the highly conservative assumption that all Cr is found as Cr VI (Cr III is the most stable oxidation state), Cr is anticipated to comprise 2% of the DECCW 1-hour criterion.

DECCW specify an annual air quality criterion for lead that is specific for cumulative concentrations. Performance against this criterion is evaluated in **Table 15**.

Table 15 – Predicted Annual Average Lead (Pb) Concentrations due to Maximum Production Activities (Scenario 2) at Representative Sensitive Receptors – Maximum for Model Years 2008 and 2009

	Receptors	Pb Concentrations (µg/m³)			Cumulative Pb as % of DECCW Criterion	Original Assessment Cumulative Pb as % of DECCW Criterion
		"Future Baseline" (Existing Free Areas, 80% Control Efficiency)	Project-Related Increment	Cumulative Pb (Baseline + Project Increment)		
R1	Piper Street North	0.041	0.010	0.051	10%	11%
R2	Piper Street Central	0.026	0.012	0.038	8%	10%
R3	Eyre Street North	0.028	0.026	0.054	11%	15%
R4	Eyre Street Central	0.018	0.020	0.038	8%	11%
R5	Eyre Street South	0.014	0.018	0.032	6%	9%
R6	South Road	0.023	0.014	0.037	7%	13%
R7	Carbon Lane	0.017	0.004	0.021	4%	8%
R8	Old South Road	0.119	0.009	0.128	26%	46%
R9	South Rd	0.046	0.008	0.054	11%	17%
R10	Cnr Garnet & Blende Streets	0.028	0.006	0.034	7%	9%
R11	Alma Bugldi Pre-school	0.010	0.007	0.017	3%	6%
R12	Playtime Pre-school	0.008	0.005	0.013	3%	4%
R13	Alma Primary School	0.007	0.005	0.012	2%	3%
R14	Broken Hill High School	0.015	0.004	0.019	4%	5%
R15	Broken Hill Hospital	0.006	0.002	0.008	2%	2%
R16	N. Broken Hill Primary School	0.006	0.002	0.008	2%	2%
R17	Broken Hill Public School	0.012	0.004	0.016	3%	4%
R18	Rainbow Pre-school	0.004	0.003	0.007	1%	2%
R19	Willyama High School	0.004	0.002	0.006	1%	1%
R20	Morgan Street Primary School	0.005	0.002	0.007	1%	2%
R21	Eyre Street North	0.050	0.013	0.063	13%	13%
R22	Eyre Street North	0.042	0.014	0.056	11%	11%

Table 15 – Predicted Annual Average Lead (Pb) Concentrations due to Maximum Production Activities (Scenario 2) at Representative Sensitive Receptors – Maximum for Model Years 2008 and 2009

	Receptors	Pb Concentrations (µg/m³)			Cumulative Pb as % of DECCW Criterion	Original Assessment Cumulative Pb as % of DECCW Criterion
		"Future Baseline" (Existing Free Areas, 80% Control Efficiency)	Project-Related Increment	Cumulative Pb (Baseline + Project Increment)		
R23	Eyre Street North	0.031	0.017	0.048	10%	9%
R24	Eyre Street North	0.030	0.024	0.054	11%	9%
R25	Water tank, Lawton Street #	0.025	0.009	0.034	7%	7%
R26	Quarry offices	0.031	0.033	0.064	13%	10%
R27	Proprietary Square	0.056	0.036	0.092	18%	14%
R28	Proprietary Square	0.042	0.026	0.068	14%	11%
R29	Iodide Street	0.047	0.022	0.069	14%	12%
R30	Iodide Street	0.033	0.017	0.050	10%	9%
R31	Crystal Street	0.026	0.010	0.036	7%	7%
R32	Crystal Street	0.021	0.009	0.030	6%	6%
R33	Brownes Shaft Dwelling	0.027	0.010	0.037	7%	7%
R34	Crystal Street	0.044	0.009	0.053	11%	13%
R35	Crystal Street	0.037	0.009	0.046	9%	11%
R36	Crystal Street	0.030	0.010	0.040	8%	9%
R37	Crystal Street	0.027	0.010	0.037	7%	8%
R38	Gypsum Street	0.010	0.004	0.014	3%	5%
R39	Gypsum Street	0.017	0.004	0.021	4%	7%
R40	Silver City Hwy	0.044	0.008	0.052	10%	15%
R41	Silver City Hwy	0.045	0.008	0.053	11%	15%
R42	Silver City Hwy	0.048	0.009	0.057	11%	14%

Baseline lead concentrations have been estimated based on modelled contributions from lead-bearing existing “free” areas (areas susceptible to wind erosion) across CML7 (refer to the air assessment for further detail). Given the Proponent’s commitment to stabilise existing free areas using chemical dust suppressants the “future baseline” lead concentration (assuming 80% control efficiency for existing free areas) is shown as a reflection of background lead concentrations during the operation phase.

In all cases, the DECCW cumulative (baseline plus Project increment) lead criterion of 0.5µg/m³ is predicted to be satisfied at all receptors, with maximum cumulative impacts predicted to comprise 26% of the DECCW criterion. Receptor R8 is predicted to have the highest levels under both plant locations due to the contribution lead-bearing existing ‘free” areas described above. However, with the new plant location the lead concentration has almost halved from a cumulative (baseline plus Project increment) of 0.228µg/m³ (Project increment 0.109µg/m³ to 0.128µg/m³ (Project increment 0.009µg/m³).

Previous modelling predicted cumulative lead concentration impacts of up to 46% of the DECCW criterion.

5.9 Lead Deposition

DECCW do not specify performance criteria in relation to lead deposition. However, predicted rates of lead deposition have implications for the health risk assessment component of the Environment Assessment. It is therefore instructive to present predictions of lead deposition rates for both the original assessment and the revised plant location. In this way, the impact of the revised plant location can be evaluated relative to the original inputs to the health risk assessment.

A summary of annual average lead deposition rates predicted under the previous modelling and associated with the plant relocation are provided in **Table 16**.

Table 16 – Predicted Annual Average Incremental Lead (Pb) Deposition due to Maximum Production Activities (Original and Scenario 2) at Representative Sensitive Receptors – Maximum for Model Years 2008 and 2009

	Receptors	Pb Deposition Rate (g/m²/year)		Scenario 2 Assessment as % of Original Maximum Prediction across all Receptors
		Original Assessment	Scenario 2 Assessment	
R1	Piper Street North	0.05	0.04	-90%
R2	Piper Street Central	0.11	0.05	-89%
R3	Eyre Street North	0.22	0.09	-80%
R4	Eyre Street Central	0.12	0.06	-86%
R5	Eyre Street South	0.09	0.04	-91%
R6	South Road	0.10	0.04	-91%
R7	Carbon Lane	0.07	0.01	-97%
R8	Old South Road	0.45	0.03	-93%
R9	South Rd	0.15	0.02	-95%
R10	Cnr Garnet & Blende Streets	0.06	0.02	-95%
R11	Alma Bugldi Pre-school	0.06	0.02	-95%
R12	Playtime Pre-school	0.04	0.02	-96%
R13	Alma Primary School	0.03	0.01	-97%
R14	Broken Hill High School	0.04	0.01	-97%
R15	Broken Hill Hospital	0.01	0.01	-98%
R16	N. Broken Hill Primary School	0.01	0.01	-98%
R17	Broken Hill Public School	0.02	0.01	-97%
R18	Rainbow Pre-school	0.02	0.01	-98%
R19	Willyama High School	0.00	0.01	-98%
R20	Morgan Street	0.01	0.01	-99%

Table 16 – Predicted Annual Average Incremental Lead (Pb) Deposition due to Maximum Production Activities (Original and Scenario 2) at Representative Sensitive Receptors – Maximum for Model Years 2008 and 2009

	Receptors	Pb Deposition Rate (g/m^2/year)		Scenario 2 Assessment as % of Original Maximum Prediction across all Receptors
		Original Assessment	Scenario 2 Assessment	
	Primary School			
R21	Eyre Street North	0.04	0.05	-88%
R22	Eyre Street North	0.04	0.06	-87%
R23	Eyre Street North	0.03	0.08	-83%
R24	Eyre Street North	0.03	0.11	-75%
R25	Water tank, Lawton Street #	0.03	0.04	-91%
R26	Quarry offices	0.02	0.15	-66%
R27	Proprietary Square	0.02	0.20	-56%
R28	Proprietary Square	0.02	0.15	-67%
R29	Iodide Street	0.02	0.14	-69%
R30	Iodide Street	0.02	0.10	-77%
R31	Crystal Street	0.02	0.06	-87%
R32	Crystal Street	0.01	0.05	-88%
R33	Brownes Shaft Dwelling	0.01	0.05	-90%
R34	Crystal Street	0.05	0.04	-91%
R35	Crystal Street	0.04	0.04	-91%
R36	Crystal Street	0.03	0.04	-90%
R37	Crystal Street	0.02	0.05	-89%
R38	Gypsum Street	0.04	0.01	-98%
R39	Gypsum Street	0.05	0.01	-98%
R40	Silver City Hwy	0.11	0.03	-94%
R41	Silver City Hwy	0.09	0.03	-92%
R42	Silver City Hwy	0.07	0.04	-91%

In all cases, lead deposition rates are predicted to be less than the maximum deposition rate across all receptors under the original modelling. The highest rate of lead deposition (0.20g/m^2/year at Receptor R27) is anticipated to be less than 50% of the maximum deposition rate under the original modelling (0.45g/m^2/year at Receptor R8).

5.10 Comparison Between Previous Configuration and Proposed Relocation

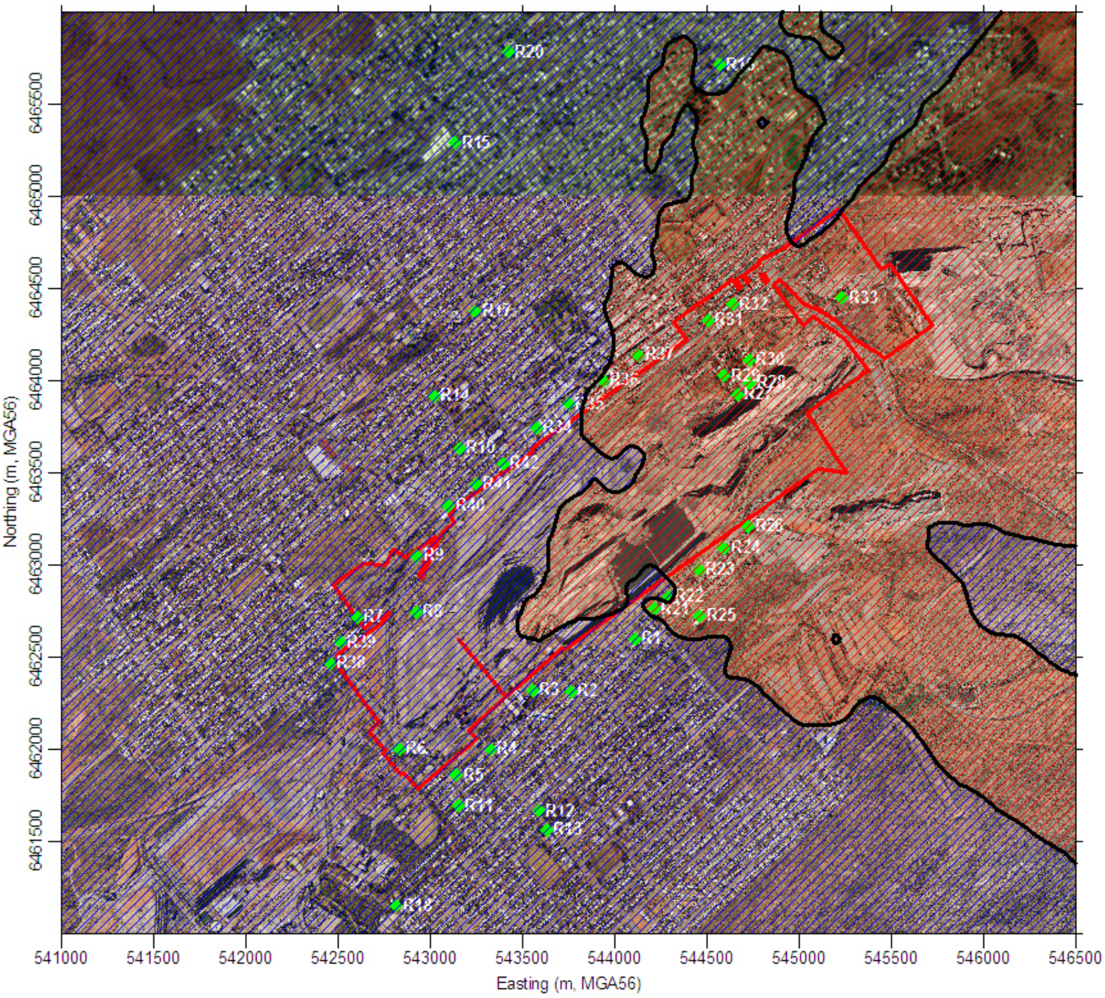
Examination of **Figure 4**, **Figure 5, Figure 6** and **Figure 7** in combination with the receptors listed in **Table 1** illustrates that overall incremental impacts are predicted to reduce at the majority of receptor locations, and in particular at those locations representative of groups of receptors. Broadly, incremental impacts are predicted to increase relative to the air assessment predictions at locations representative of single dwellings.

The anticipated changes compared to the modelling undertaken in the air assessment are illustrated further. **Figure 8** and **Figure 9** show predicted zones of incremental concentration increase and decrease relative to the air assessment, for 24-hour and annual PM_{10} respectively.

It is highlighted that these spatial plots do not show the magnitude of any increase/decrease, simply whether the change is positive or negative. The line dividing the two areas is thus indicative of no change relative to the air assessment modelling.

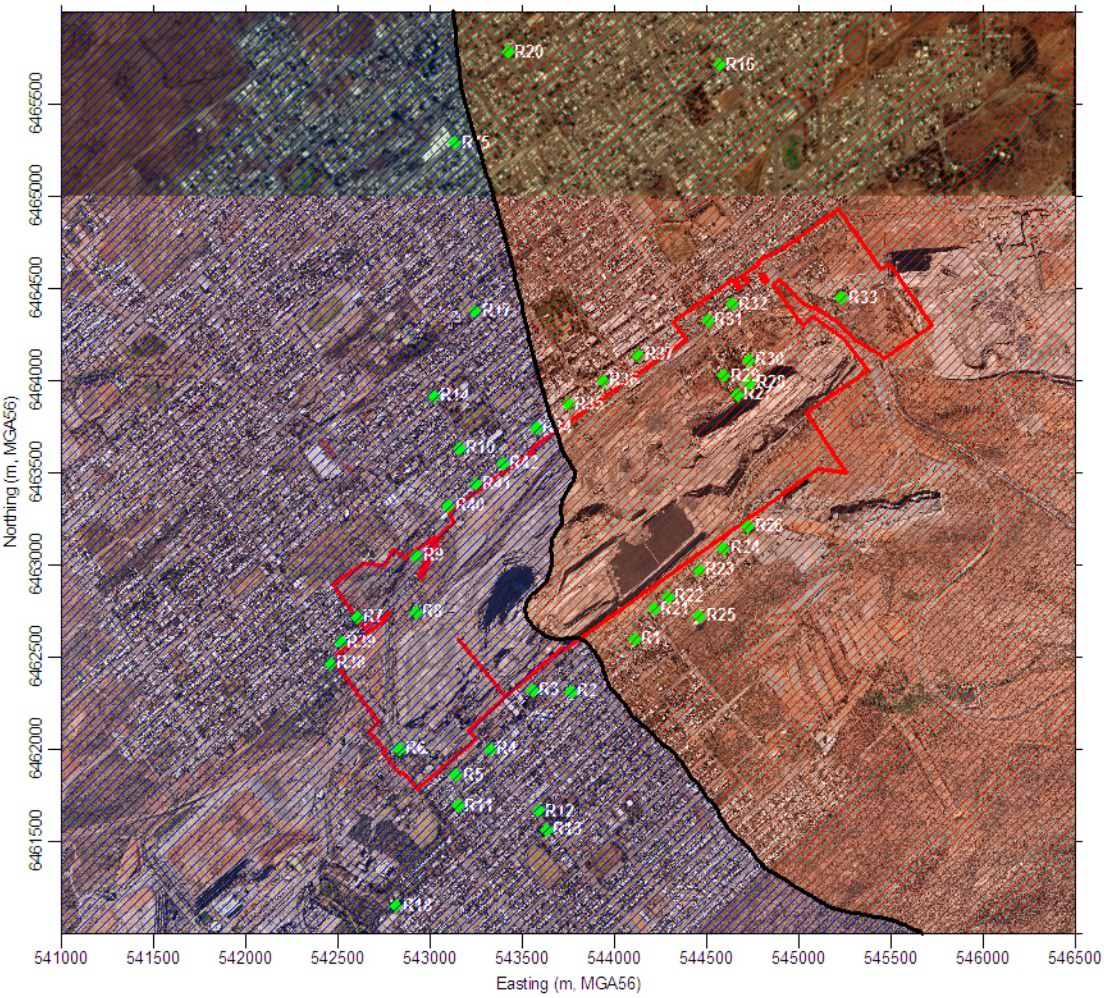
Indeed, while a change is observed, the magnitude of change may be below the level typically reported within modelling assessments. This is illustrated using the example of receptor R20, which shows a decrease in **Figure 8** and an increase in **Figure 9** compared to the original modelling. However **Table 8** and **Table 9** report no change. This is since the magnitude of the change is not captured within the decimal places reported within these tables.

Figure 8: Increase-Decrease in Predicted 24-hour Average PM_{10} from Original Modelling



Note: Blue shaded areas indicate decrease in Project related increments relative to the air assessment. Red shaded areas indicate an increase.

Figure 9: Increase-Decrease in Predicted Annual Average PM_{10} from Original Modelling



Note: Blue shaded areas indicate decrease in Project related increments relative to the air assessment. Red shaded areas indicate an increase.

Figure 8 clearly shows that the relocation of the processing area is anticipated to deliver a decrease in PM_{10} increments to the majority of areas of significant population density relative to the air assessment scenario. Additionally, the zone where Project related increments are anticipated to increase compared to the original modelling represents a zone of sparser population density, combined with a mining / industrial area (i.e. Perilya north mine, Mawsons quarry). **Figure 9** again shows that the zone of decreased predictions compared to previous modelling is located in an area of high population density. The zone of increase compared to previous predictions is also located over a less populated area. Further, inspection of **Table 9** illustrates that the magnitude of any increases is negligible (i.e. less than 0.8µg/m³) across all receptor sites. Additionally, highest increases are located at receptor sites that are not residences. **Figure 9** should therefore be viewed in this context.

As a final illustration of the impact of the relocation of the processing plant on nearby receptors, the top three maximum increments at receptor sites have been compared for different air quality indicators under the air assessment and Scenario 2 conditions, as shown in **Figure 10**, **Figure 11**, **Figure 12**, **Figure 13** and **Figure 14**.

Figure 10: Comparison of Top Three Maximum Predicted Receptor Increments for 24-hour PM_{10} – Original Modelling vs. Scenario 2

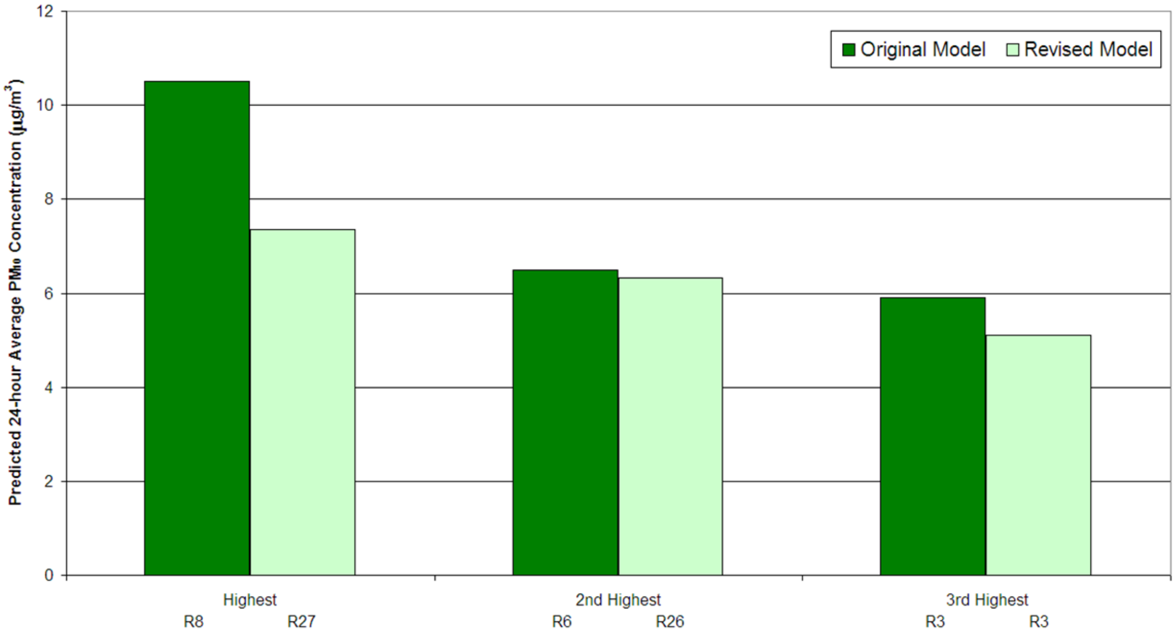


Figure 11: Comparison of Top Three Maximum Predicted Receptor Increments for Annual Average PM_{10} – Original Modelling vs. Scenario 2

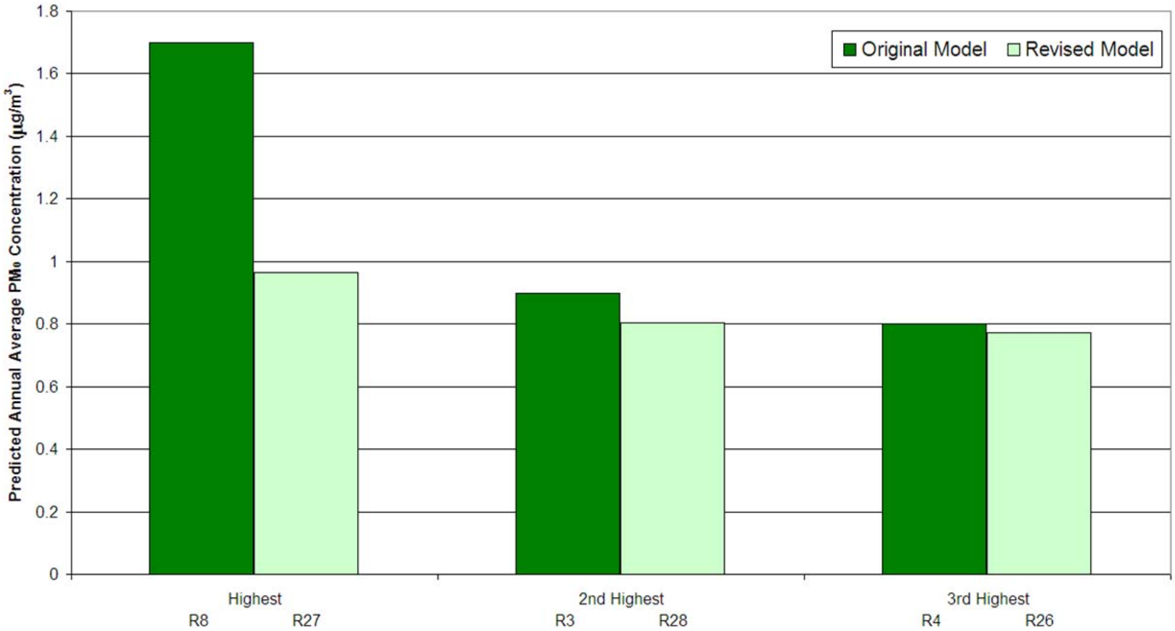


Figure 12: Comparison of Top Three Maximum Predicted Receptor Increments for Average Monthly Dust Deposition – Original Modelling vs. Scenario 2

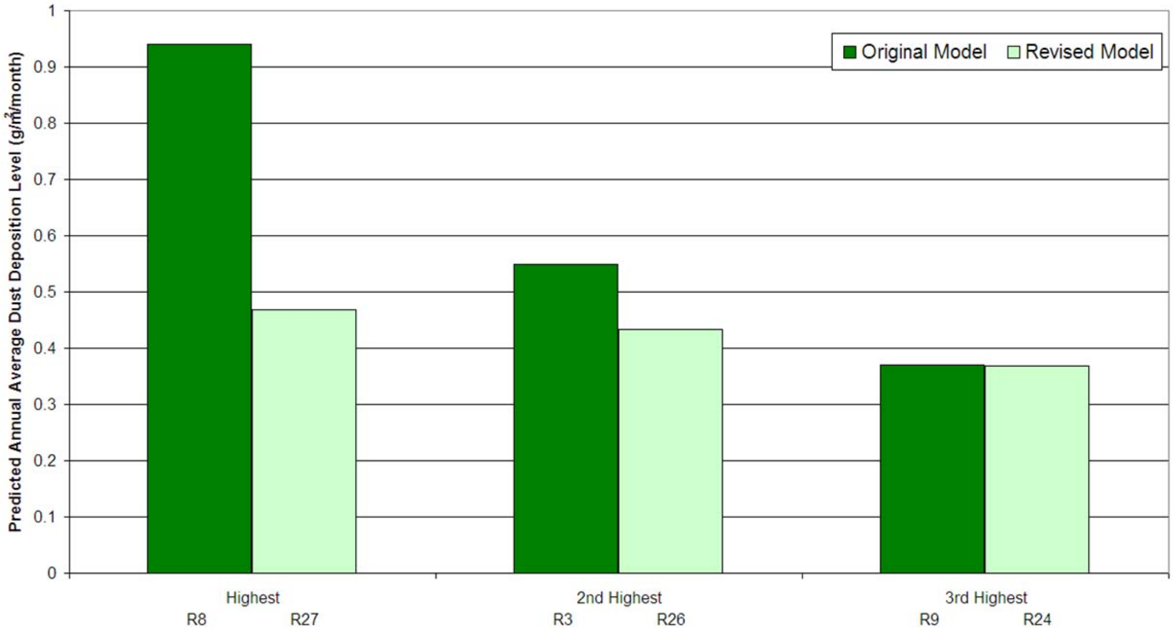


Figure 13: Comparison of Top Three Maximum Predicted Receptor Increments for Annual Lead Concentration – Original Modelling vs. Scenario 2

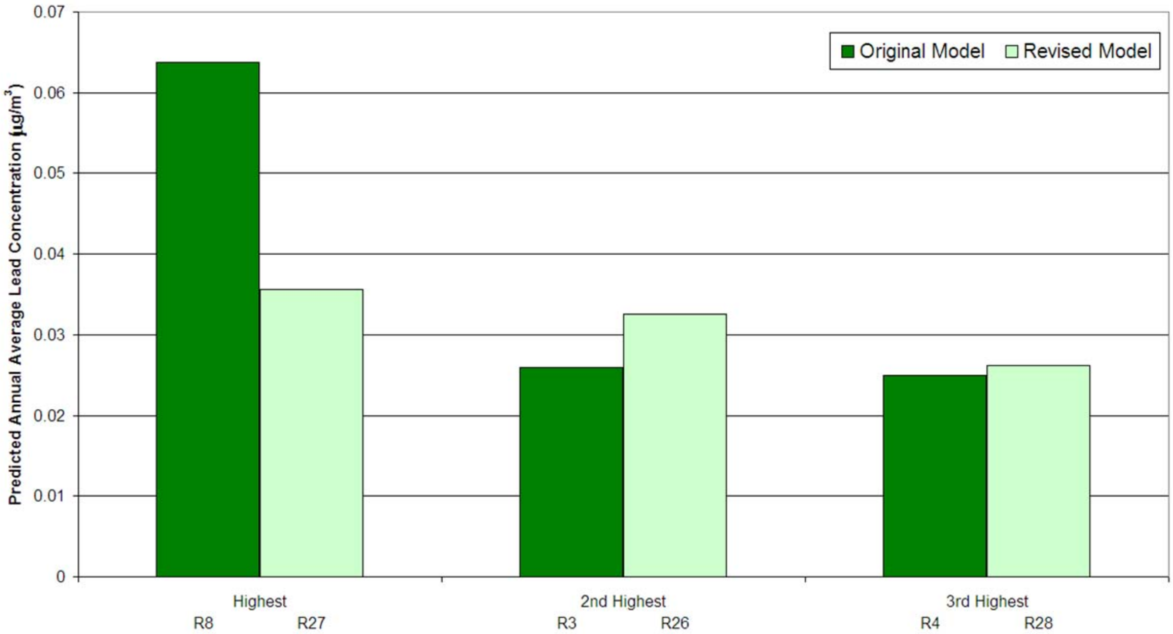


Figure 14: Comparison of Top Three Maximum Predicted Receptor Increments for Annual Lead Deposition – Original Modelling vs. Scenario 2

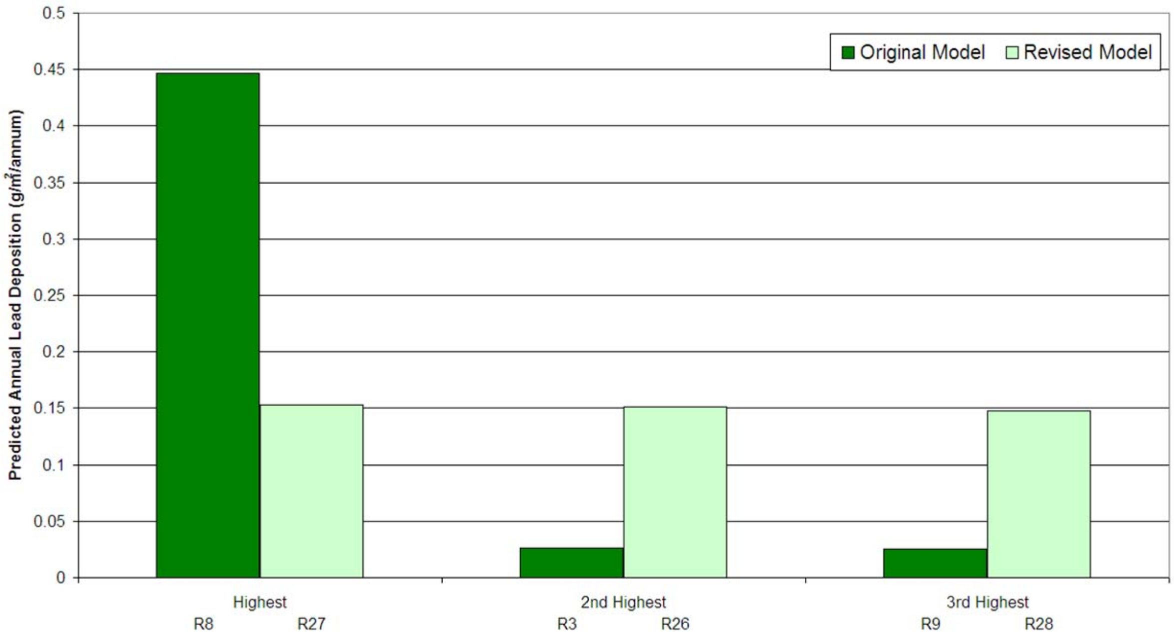


Figure 10, **Figure 11**, **Figure 12**, **Figure 13** and **Figure 14** illustrate visually that compared to the air assessment predictions, the maximum incremental increases for all key air quality indicators is significantly reduced. Additionally, for the majority of indicators, the second and third highest receptor increments are also reduced. The exception to this is predicted incremental lead concentrations and deposition rates shown in **Figure 13** and **Figure 14**. In this instance, top three increments under Scenario 2 are more evenly distributed. This reflects the proximity of the top three Scenario 2 receptor increment locations to the revised processing plant location, which is anticipated to be the principal source of airborne lead associated with the Project.

It is useful to acknowledge status of the highest ranking receptors when interpreting **Figure 10**, **Figure 11**, **Figure 12**, **Figure 13** and **Figure 14,** namely:

- Receptor R3 – group of (residential) receptors;
- Receptor R4 – group of (residential) receptors;
- Receptor R6 - group of (residential) receptors;
- Receptor R8 Single commercial (RSPCA – additionally representative of three houses);
- Receptor R26 – offices of operating quarry;
- Receptor R27 – unoccupied heritage building on CML7 mining lease; and
- Receptor R28 – unoccupied heritage building on CML7 mining lease.

5.11 Emissions Associated with TSF1 'Upset' Conditions

The modelling of TSF1 'Upset' conditions is shown in the results tables provided above as Scenario 3 and Scenario 4 predictions.

The spatial impacts of the TSF1 'Upset' is additionally shown as contours within **Appendix B** for particulate indicators with short-term (24-hour) averaging periods. Comparison between normal and TSF1 'Upset' scenarios in terms of the spatial distribution of metals is provided in **Appendix C**.

Modelling indicates that only those receptors in close proximity to the TSF1, specifically R1 and R21-R24 along the southeast boundary, show a noticeable influence due to the variation between normal and upset operations of the TSF1.

In all instances, and under the highly conservative assumption that any 'Upset' persists for up to 24-hours, DECCW air quality criteria are anticipated to be satisfied, even at receptors closest to the proposed TSF1. Maximum incremental predictions occur at Receptor R21, as a Project-related 24-hour increment of 11.8µg/m³.

Upset conditions at the TSF1 have only been predicted for the 24-hour averaging period, as this time period is considered to be a highly conservative time period for upset conditions to occur without any of the mine's contingencies for TSF1 dust control being implemented.

5.12 Implications of Revised Modelling for Health Risk Assessment

The outcomes of the Health Risk Assessment (HRA) conducted for the proposed Rasp Mine (Toxikos, 2010, hereafter, "the HRA") were informed directly by the atmospheric dispersion modelling predictions made within the air assessment.

Calculating the intake of a substance from all exposure pathways and comparing the resulting intake to the Tolerable Daily Intake (TDI) is a standard risk characterisation procedure commonly performed in human health risk assessments.

Of the exposure pathways evaluated within the HRA, ingestion contributed 95 – 98% of the total intake; the majority (again 95 – 98%) of the ingested intake was the result of background intake assumptions for lead. The total daily intake by a child was only approximately 35 – 60% of the TDI for lead, the range being due to the risk zone in which the receptor was located.

Compared to the TDI incremental lead intake due to the cumulative exposure from the mine lease area (i.e. exposure to dust from free areas 80% controlled plus mine activities) was negligible for most receptors. Even for the most impacted receptor identified within the air assessment (Receptor 8) the intake was less than 5% of the TDI and much of this intake was associated with dust from the free areas (80% controlled).

At the most affected receptors (Receptors R8 and R3) the total lead intake, including very conservative estimates of background intake from existing soil and diet, was about 60% of the TDI. The HRA thus concluded that lead exposure resulting from the proposed mine presents little risk to the health of nearby residents.

Predicted lead concentrations and deposition rates at the most affected receptor under revised modelling are lower than those predicted at the most affected receptor within the air assessment (refer **Figure 13** and **Figure 14**).

Maximum predicted lead concentrations and deposition rates at the most affected receptor are summarised as follows:

- Maximum incremental lead concentrations of 0.064µg/m^3 at R8 under previous modelling compared to 0.036µg/m^3 at R27 for Scenario 2 modelling (representing a reduction of approximately over 40%); and
- Lead deposition rates of 0.45g/m^2/annum at R8 under previous modelling compared to 0.20g/m^2/annum at R27 for Scenario 2 modelling (representing a reduction of over 55%).

Further, the previously most affected receptor in terms of Project-related increment (Receptor 8) was evaluated based on being assigned the highest lead risk zone in terms of background concentrations of lead in soil. Under the present modelling, the majority of receptors experiencing increases in project-related lead deposition will be located in areas considered to be in zones of lesser background lead in soil compared to the original modelling.

This is illustrated in **Figure 15**, which shows predicted zones of incremental lead deposition increase and decrease relative to the air assessment, as well as showing lead Risk Zones within Broken Hill (after Boreland et al. 2009, as referenced within the HRA).

According to the HRA, Boreland et al. (2009) defined five risk zones in describing hazards posed for soil lead concentrations based on the 1992 soil lead concentration measurements documented in Lyle et al. (2006). Soil lead concentrations during the 1992 BHCC study, and soil lead levels more recently recorded (2004-2008) are presented by Risk Zone in **Table 17**, as referenced within the HRA.

Table 17 – Historical and Recently Recorded Soil Lead Concentrations by Risk Zone (as referenced within the HRA)

Risk Zone	Soil Lead and Indoor Dust Levels Measured in 1992 (as published by Lyle et al. 2006)[a]		Soil Lead Measured during 2004-2008 (as obtained from Boreland 2010)
	Geometric Mean Soil Lead (mg/kg)	Geometric Mean Indoor Dust (µg/m^2/30 days)	Geometric Mean Soil Lead (mg/kg)[b]
1	1967	946	1350
2	794	717	540
3	621	490	580
4	365	216	260
5	262	201	220

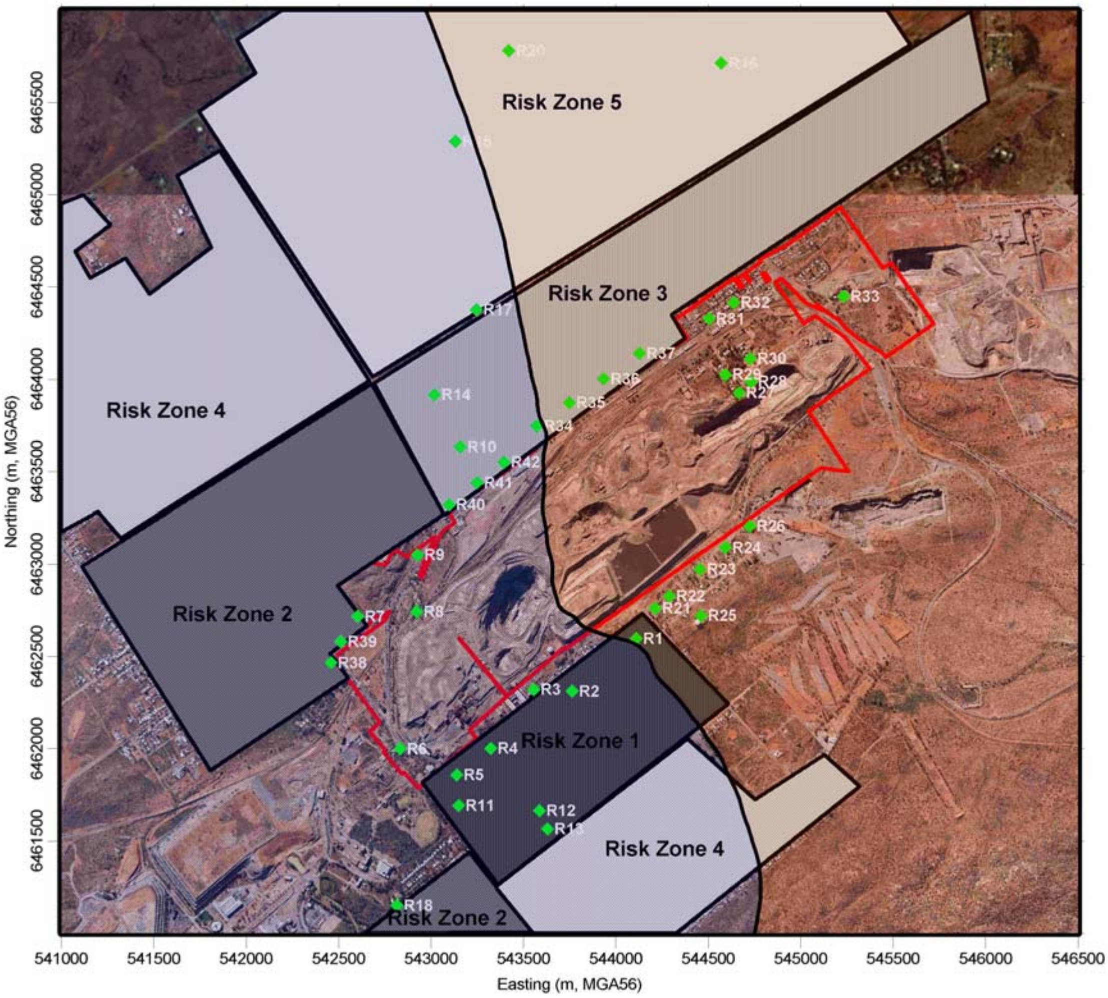
[a] Soil lead concentration data is from the BHCC survey undertaken in 1992 as reported by Lyle et al. (2006) and described according to city districts by Boreland et al. (2002). These concentrations are prior to remediation work undertaken in the late 1990's and completed in 2003/4 (Boreland et al. 2008).

[b] Soil lead levels for the 2004-2008 dataset (n=148 houses) as provided for Broken Hill districts by Boreland (2010). For comparison with the Lyle et al. (2006) soil lead data in this table the data provided by Boreland (2010) was translated to risk zones as per Boreland et al. (2009) by averaging the geometric mean values for the districts within a risk zone. The average geometric means were rounded to the nearest ten.

It is highlighted that the spatial plot shown in **Figure 15** does not show the magnitude of any increase/decrease, simply whether the change is positive or negative. The line dividing the two areas is thus indicative of no change relative to the air assessment modelling.

It should be acknowledged that, as shown in **Table 16**, the highest rate of lead deposition (0.20g/m^2/year at Receptor R27) is anticipated to be less than 50% of the maximum deposition rate under the original modelling (0.45g/m^2/year at Receptor R8).

Figure 15: Increase-Decrease in Predicted Annual Lead Deposition from Original Modelling Combined with Lead Risk Zones



Note: Blue shaded areas indicate decrease in Project related increments relative to the air assessment. Red shaded areas indicate an increase.

Figure 15 shows that the relocation of the processing area is anticipated to deliver a decrease in lead deposition increments both within areas of higher population density and the higher soil lead Risk Zones (e.g. Risk Zones 1-2) relative to the air assessment scenario.

It is acknowledged that mining lease areas were not included in the original Lead Risk Groups. It is reasonable to assume that Receptors R27 and R28 (on the CML7 mining lease) and Receptors R29 and R30 (on the Perilya mine lease) would be located on areas representative of higher soil lead. For conservatism, these receptors may be awarded the same lead Risk Zone status as the most affected receptor within the HRA (Receptor R8; Risk Zone 1). All other inputs used within the HRA at these locations (Project-related increments of both airborne and deposited lead) are anticipated to be less than the most affected receptor values used to reach the conclusions made within the HRA.

In view of the above, it is considered that the following conclusions made within the HRA remain valid:

- Lead is the metal of most concern regarding potential health effects of dust emissions from the Rasp Mine site.
- Conservatively high exposure assumptions, inclusive of identifiable background exposures, for the most impacted receptor resulted in lead intake by a child that was 60% of the TDI.
- Lead in dust emissions from the proposed Project are therefore unlikely to result in health effects for the surrounding community.
- Predicted increments in child blood lead levels that would occur as a result of mine approval are quite low. Indeed a net benefit on blood lead concentrations is anticipated as a result of the additional dust controls that would occur if the mine proceeds.
- The cancer risks from exposure to the metals of potential concern are very low.

Furthermore, lead intakes as a percentage of the TDI and associated blood lead levels at the most impacted receptor would be lower given the relocated processing plant scenario. This is due both to lower maximum incremental lead concentrations due to emissions from the mine lease area, and due to the location of this receptor within zones of lower background lead concentrations in soil.

6 Conclusion

ENVIRON have been requested by BHOP to provide an addendum to the revised air assessment, evaluating the air quality impacts associated with a proposed relocation of the Rasp Mine's processing area to a location to the north east of the CML7 site.

The addendum additionally provides supporting information in relation to the following DECCW requests that were unable to be addressed within the timeframe of the revised air assessment:

- The inclusion of contour plots for at least one metal scenario modeled at a 1-hour averaging period; and
- Additional modelling assessment of 'upset conditions' at the Tailings Storage Facility (TSF).

Dispersion simulations were undertaken for the proposed relocation and results analysed for TSP, PM_{10}, $PM_{2.5}$ and a range of heavy metal concentrations and dust deposition.

Dispersion modelling of particulate emissions from the Rasp Project was conducted utilising the US-EPA regulatory model AERMOD for two complete calendar years, 2008 and 2009.

For all parameters and averaging periods, the maximum predicted incremental impact at the most affected sensitive receptor was predicted to be reduced compared to the air assessment. Maximum predicted Project related increments across all receptors and modelling years are anticipated to represent:

- a 25% reduction in 24-hour average PM_{10} compared to the original modelling;
- a 50% reduction in annual average PM_{10} compared to the previous modelling; and
- over a 40% reduction in cumulative (baseline plus Project increment) annual lead concentration compared to the previous modelling.

In all cases, lead deposition rates are predicted to be less than the maximum deposition rate predicted across all receptors under the original modelling. The highest rate of lead deposition (0.20g/m^2/year at Receptor R27) representing a reduction of over 55% compared to the maximum deposition rate under the original modelling (0.45g/m^2/year at Receptor R8).

Further, revised dispersion modelling indicates that the relocation of the processing area is anticipated to deliver a decrease in key air quality parameter increments to the majority of areas of significant population density, as well as within the higher soil lead Risk Zones relative to the air assessment scenario.

With regard to evaluation of TSF 'Upset' conditions, modelling indicates that only those receptors in close proximity to the TSF, specifically R1 and R21-R24 along the southeast boundary, show a noticeable influence due to the variation between normal and upset operations of the TSF.

In all instances, and under the highly conservative assumption that any 'Upset' persists for up to 24-hours, DECCW air quality criteria are anticipated to be satisfied, even at receptors closest to the proposed TSF.

It appears that the selection of crusher configuration (full enclosure under negative pressure with all emissions vented to a baghouse versus acoustic cladding with hooded extraction) is not a critical factor in predicted concentrations from the Project.

It is anticipated that the conclusions made within the HRA remain valid and represent an even more conservative approach when the incremental impacts of the proposed processing plant location are considered.

7 References

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World Health Organisation (WHO), 2000. *Guidelines for Air Quality*, WHO, Geneva, 2000.

8 Glossary of Acronyms And Symbols

AERMOD	US-EPA Regulatory Atmospheric Dispersion Model AERMOD Version 09292
AMMAAP	Approved Methods for the Modelling and Assessment of Air Pollutants in NSW,
BoM	Australian Bureau of Meteorology
BHOP	Broken Hill Operations Pty Ltd
CBH	CBH Resources Ltd
ML	Consolidated Mine Lease
DECCW	NSW Department of the Environment, Climate Change and Water
EETM	Emission Estimation Technique Manual
ENVIRON	ENVIRON Australia Pty Ltd
mg	Milligram (g x 10-3)
µg	Microgram (g x 10-6)
µm	Micrometre or micron (metre x 10-6)
m^3	Cubic metre
RL	Reference Level
Mtpa	Megatonnes per annum
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NPI	National Pollutant Inventory
PM_{10}	Particulate matter less than 10microns in aerodynamic diameter
$PM_{2.5}$	Particulate matter less than 2.5microns in aerodynamic diameter
ROM	Run-of-Mine
The Project	The Rasp Mine expansion, Broken Hill
TSP	Total Suspended Particulate
USEPA	United States Environmental Protection Agency
VKT	Vehicle kilometres travelled
WHO	World Health Organization

Appendices

Appendix A
Incremental Suspended Particulate and Dust Deposition Contour Plots (Maximum Production Operation)

Figure A1 Operation Scenario 2 (Project Increment) – Maximum Predicted 24 Hour Average PM_{10} Concentrations ($\mu g/m^3$) Criterion = $50 \mu g/m^3$

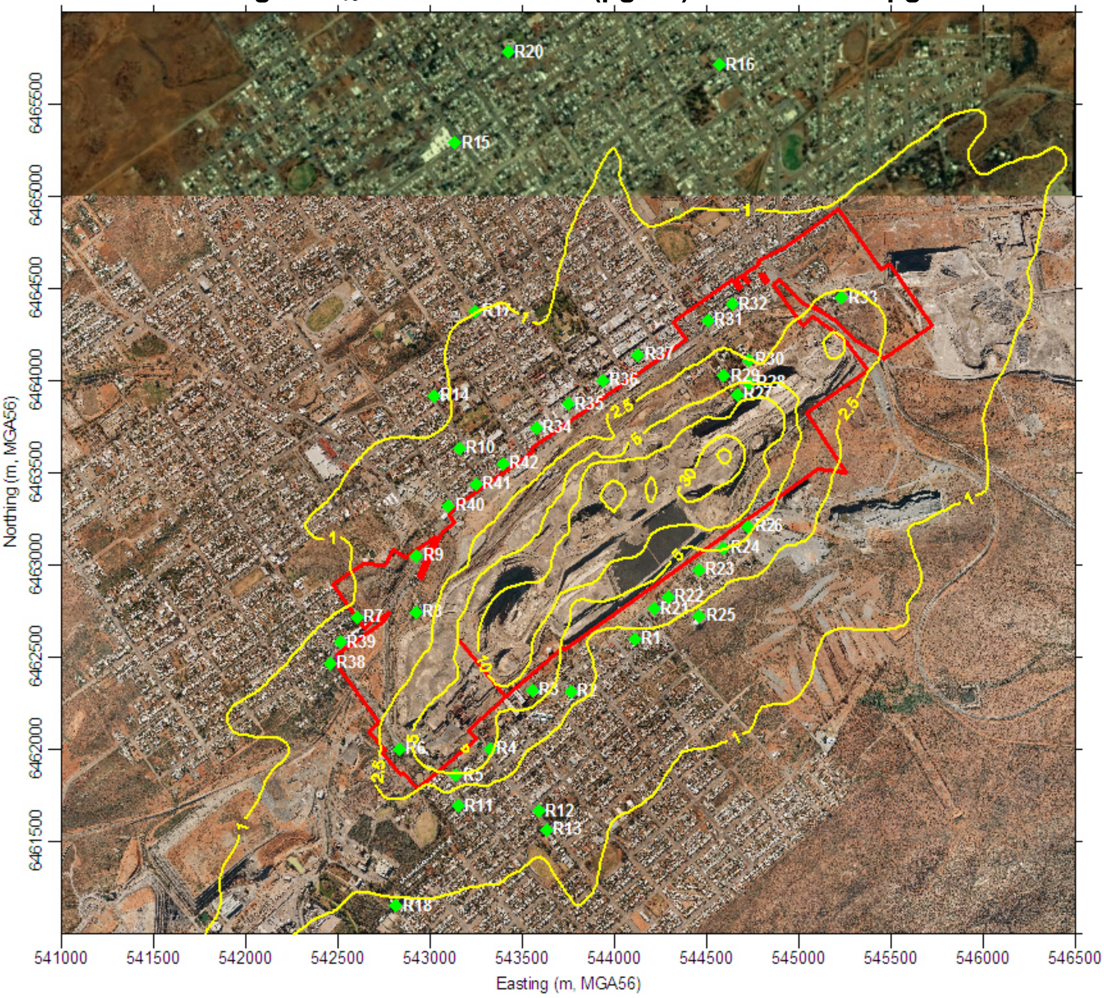


Figure A2 Operation Scenario 2 (Project Increment) –Predicted Annual Average PM_{10} Concentrations (µg/m³) Criterion = 30µg/m³ (cumulative)

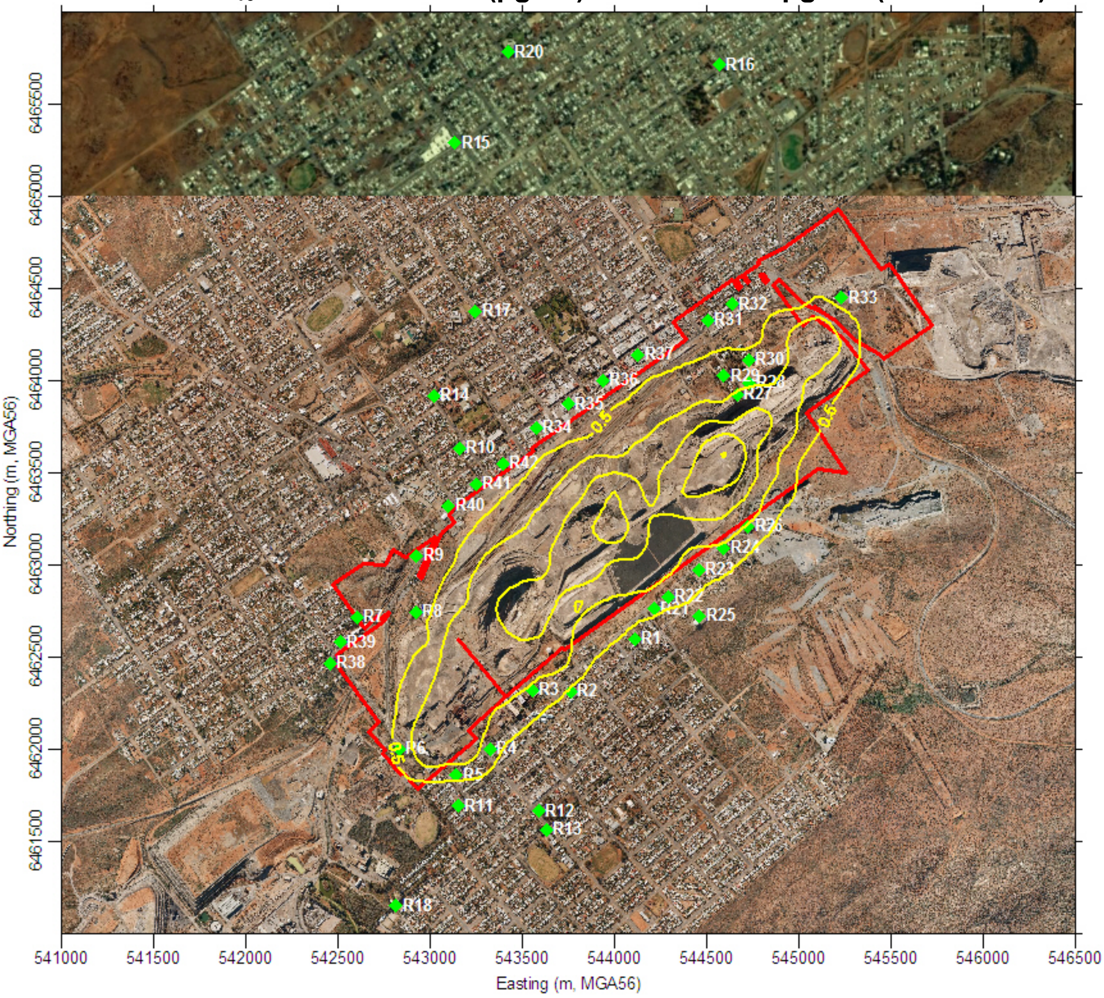


Figure A3 Operation Scenario 2 (Project Increment) – Maximum Predicted 24 Hour Average $PM_{2.5}$ Concentrations (µg/m^3) Criterion = 25µg/m^3 (cumulative)

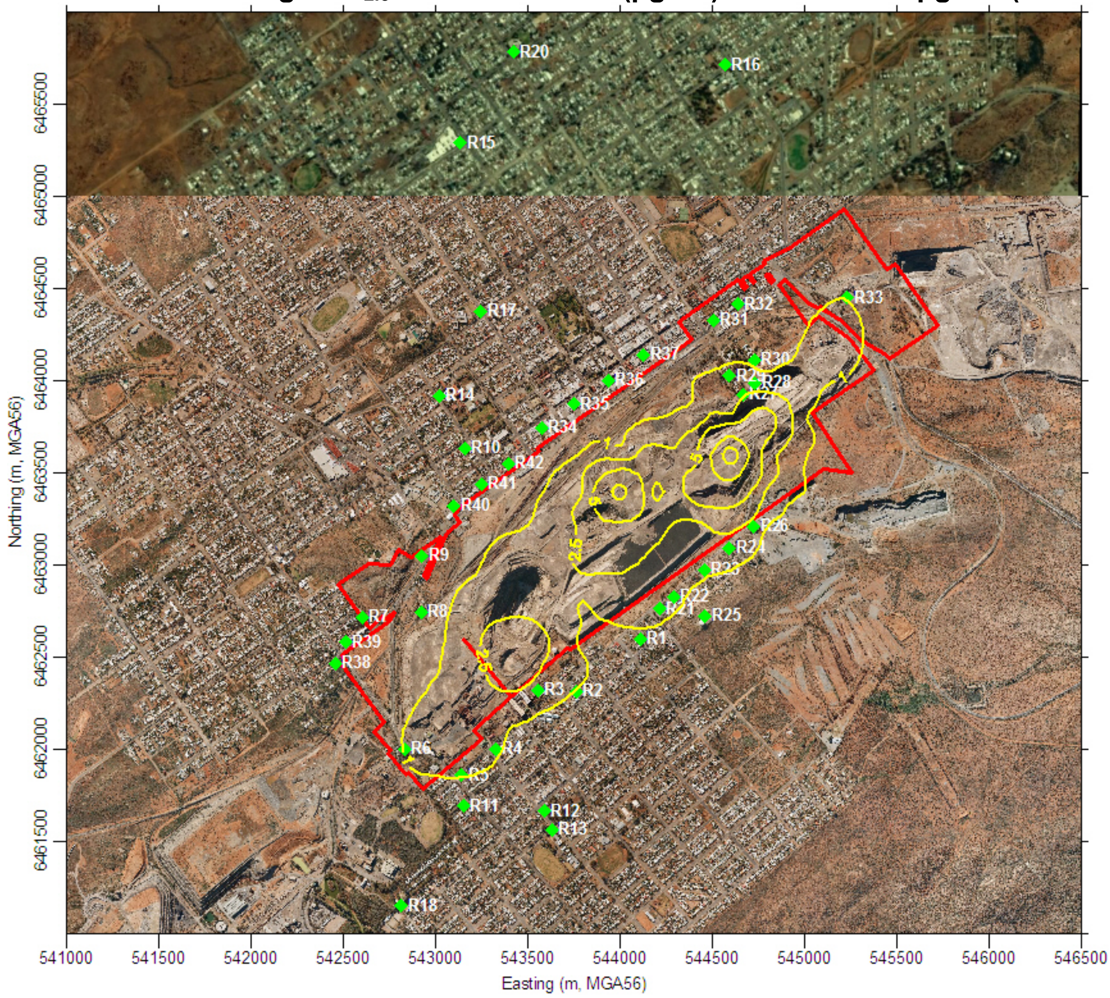


Figure A4 Operation Scenario 2 (Project Increment) – Predicted Annual Average $PM_{2.5}$ Concentrations (μg/m^3) Criterion = 8μg/m^3 (cumulative)

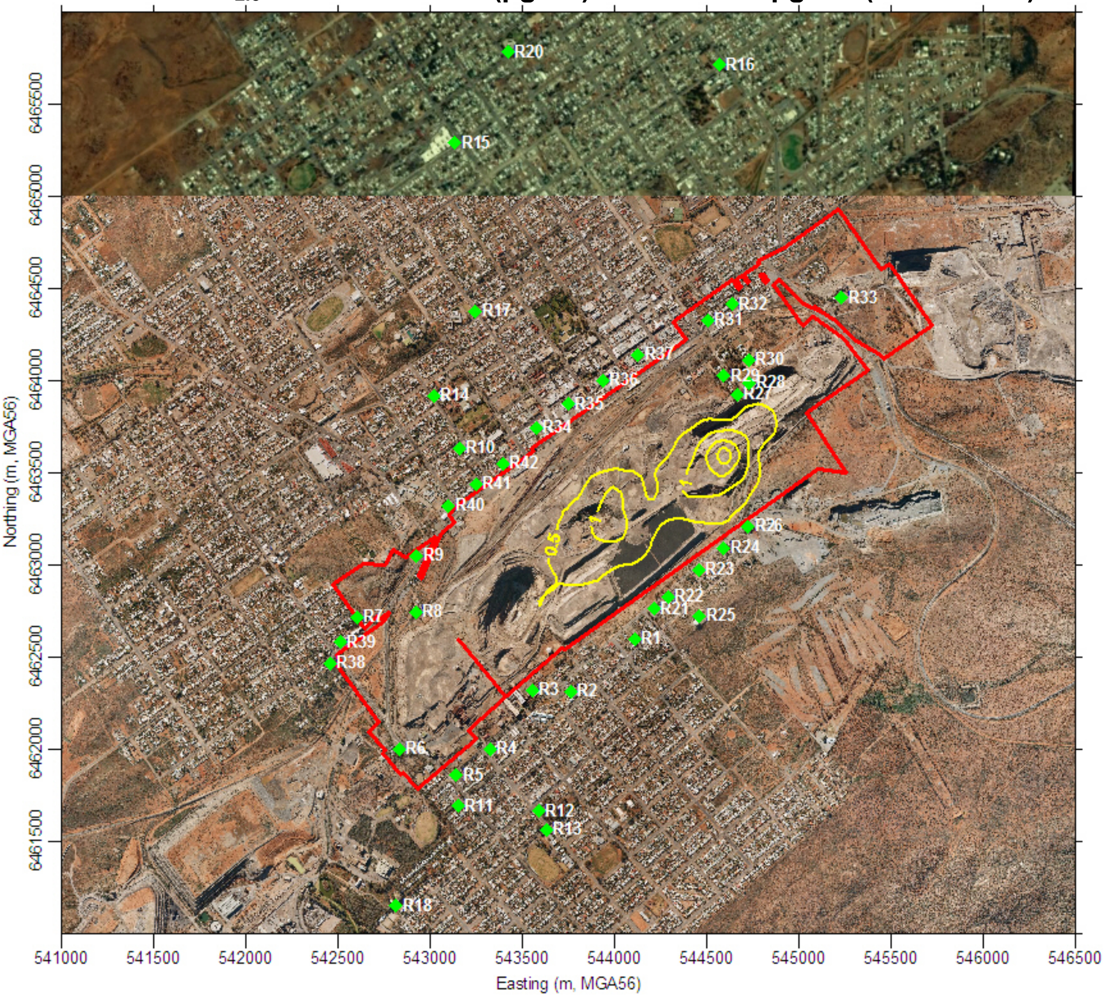


Figure A5 Operation Scenario 2 (Project Increment) – Predicted Annual Average TSP Concentrations (µg/m^3) Criterion = 90µg/m^3 (cumulative)

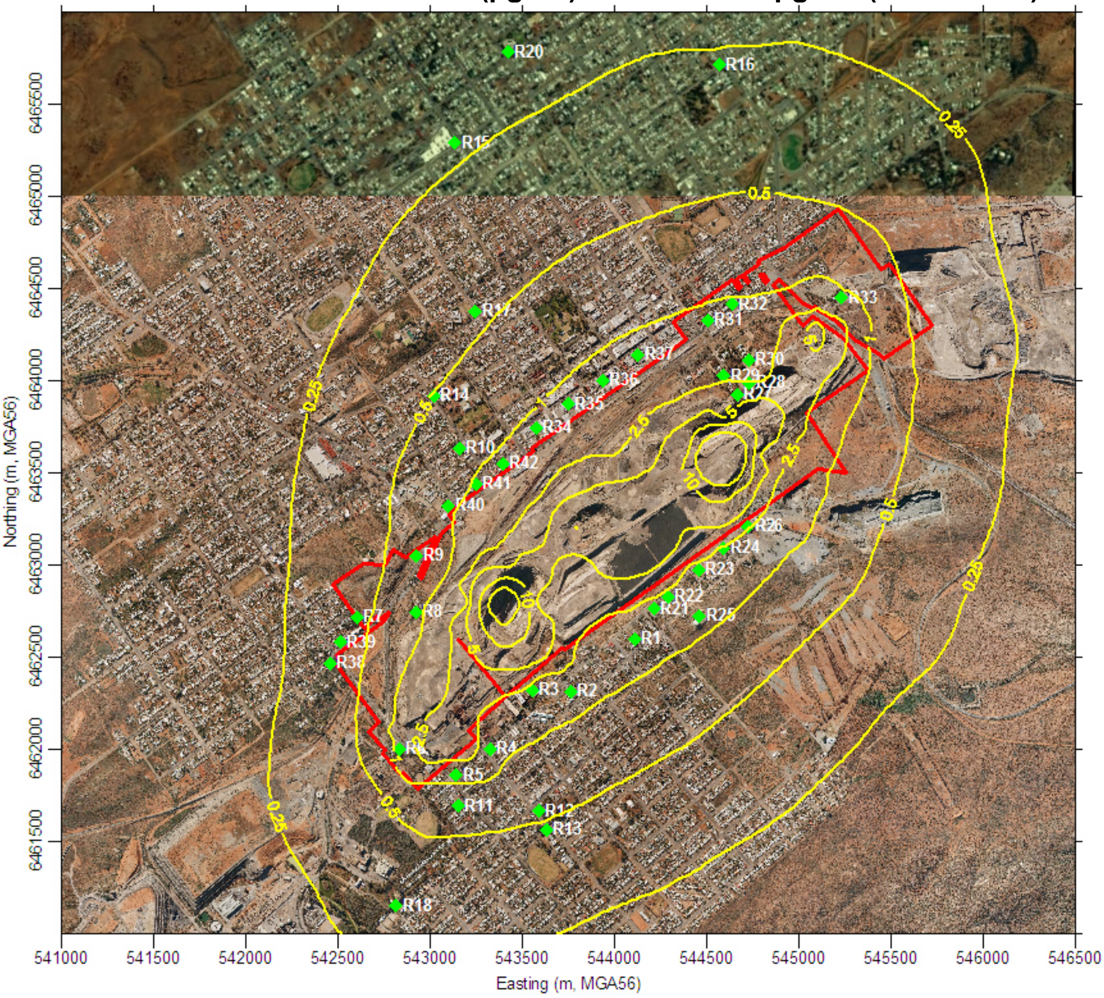
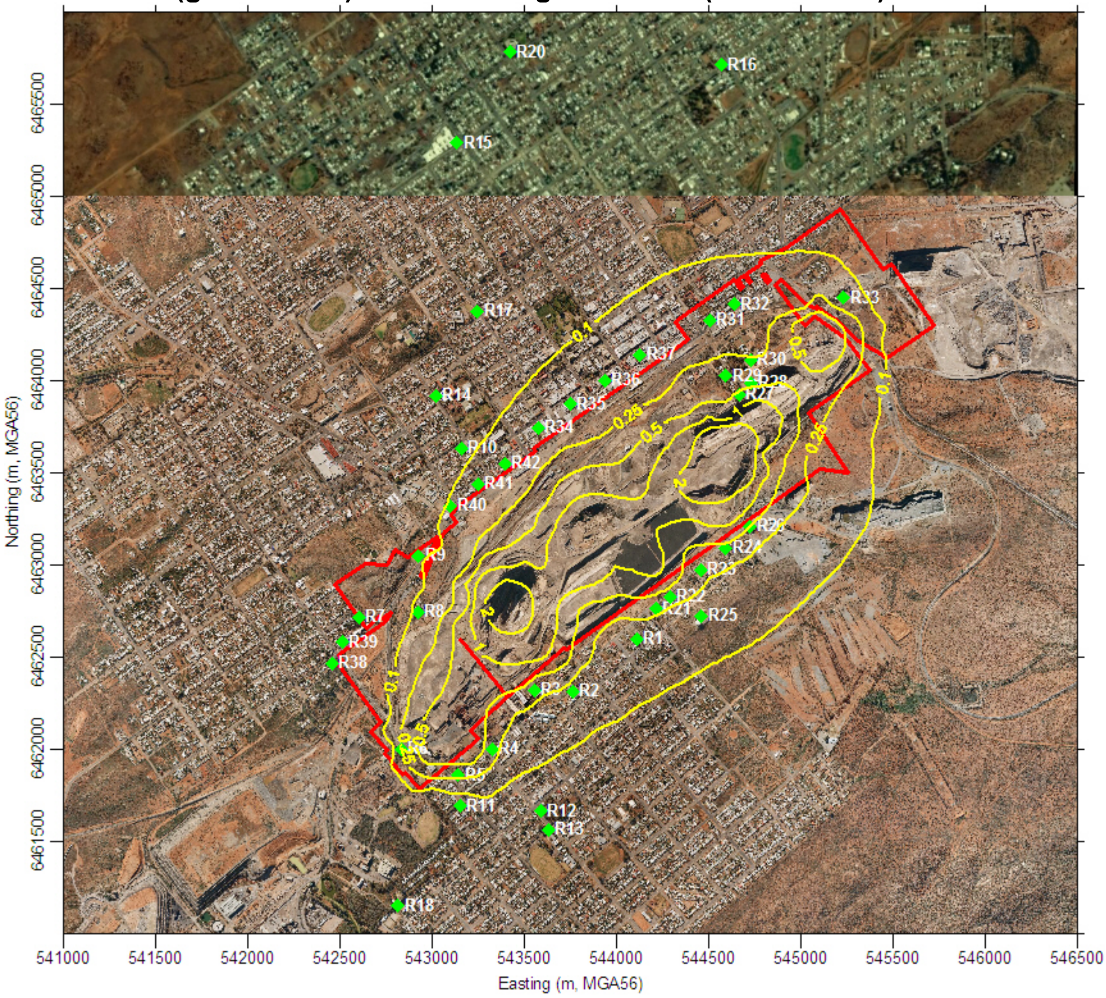


Figure A6 Operation Scenario 2 (Project Increment) –Predicted Dust Deposition ($g/m^2/month$) Criterion = $2g/m^2/month$ (incremental)



Appendix B
Incremental 24-hour Average Suspended Particulate Contour Plots (TSF 'Upset' Scenario)

Figure B1 Operation Scenario 4 (Project Increment) – Maximum Predicted 24 Hour Average PM_{10} Concentrations (µg/m^3) Criterion = 50µg/m^3

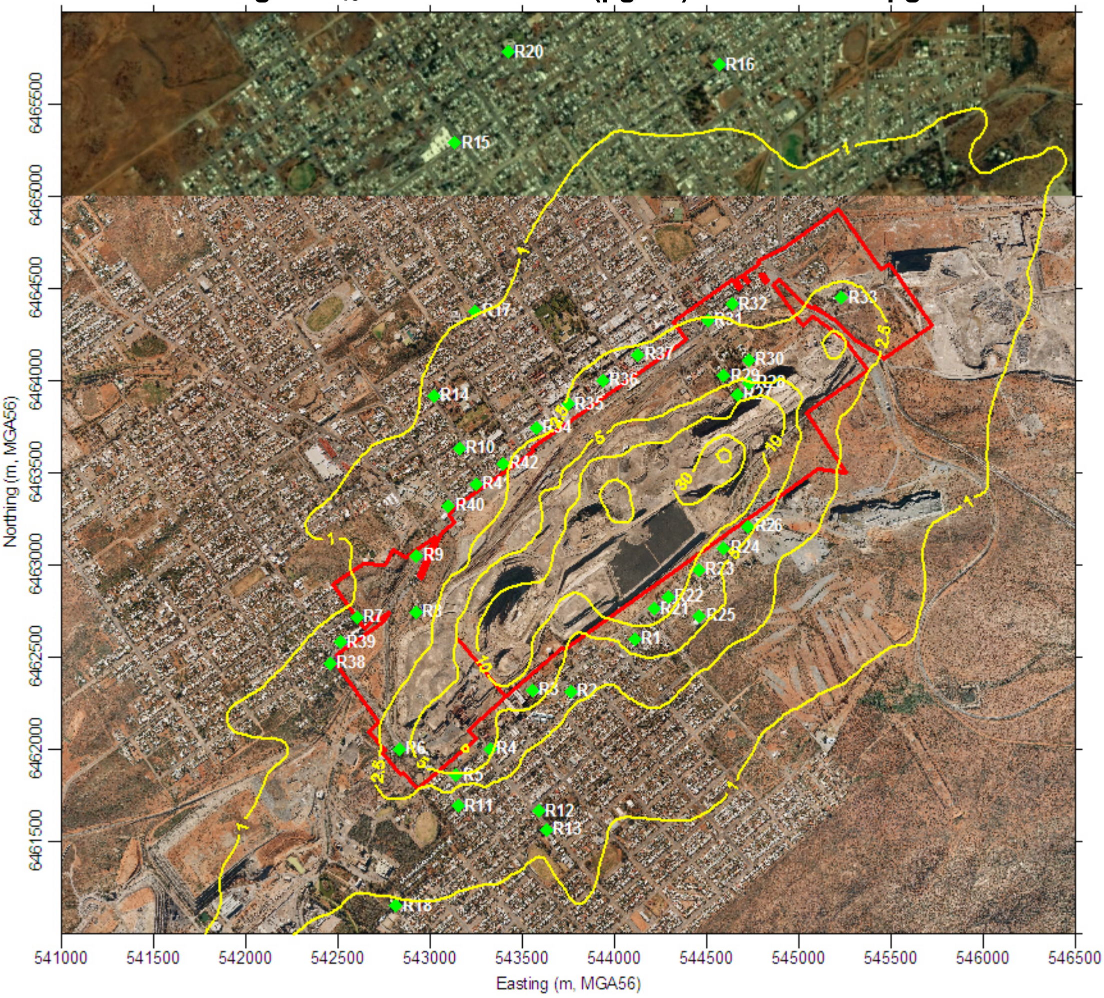
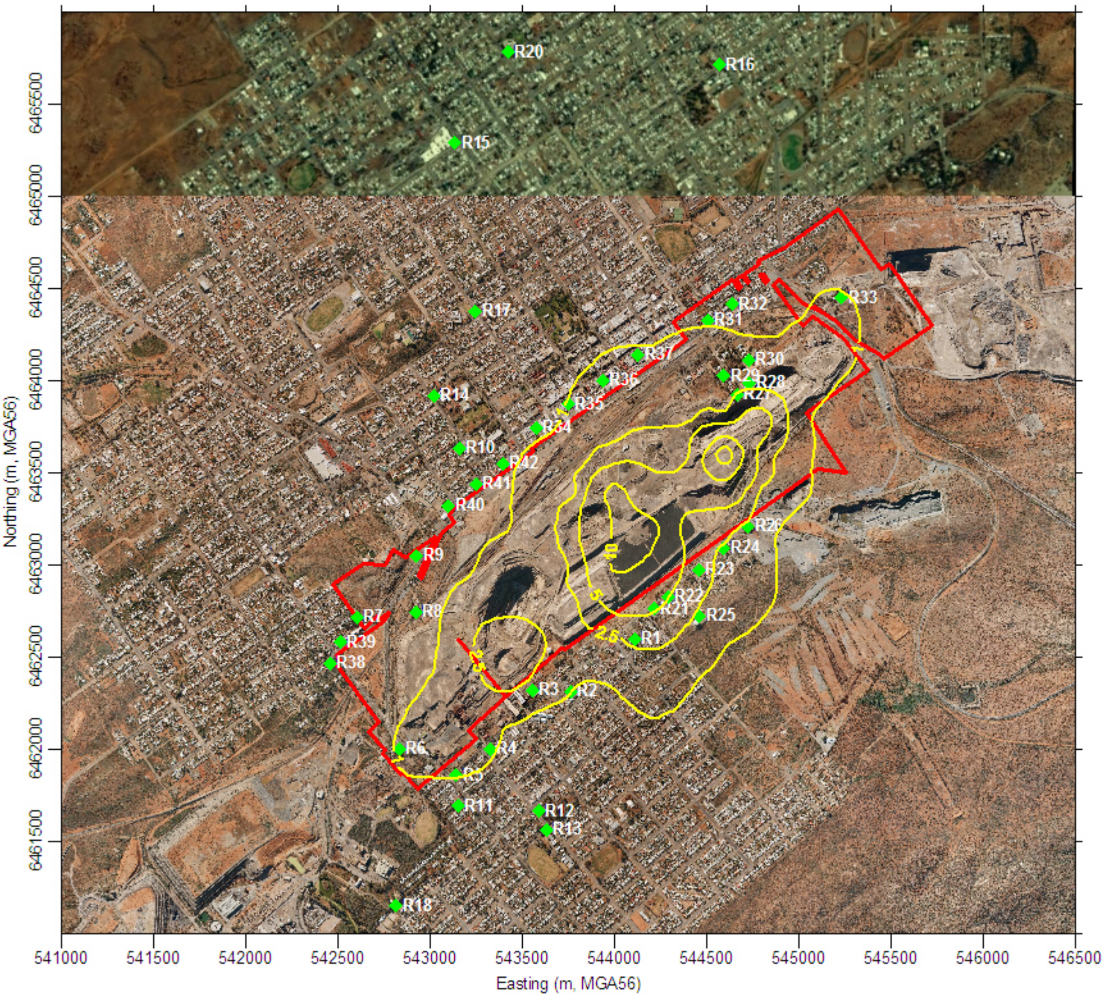


Figure B2 Operation Scenario 4 (Project Increment) – Maximum Predicted 24 Hour Average $PM_{2.5}$ Concentrations (µg/m³) Criterion = 25µg/m³ (cumulative)



Appendix C
Incremental Metal Contour Plots (Maximum Production Operation and TSF 'Upset' Scenario)

Figure C1 Operation Scenario 2 and Operation Scenario 4 (TSF 'Upset') - 99.9th Percentile Predicted Incremental 1-Hour Average Cadmium Concentrations (µg/m³) Criterion = 0.018µg/m³ (incremental)

Note 1: Modelled concentrations of Antimony and Arsenic display similar spatial distributions. Predicted concentrations are 4.2E-01 and 2.4 times those displayed respectively. Criteria are 9.0µg/m³ and 0.09µg/m³ respectively

Note 2: Scenario 2 (noise cladding enclosure and hooded extraction to crusher) and Scenario 4 (TSF 'Upset') predict equivalent contours. This is due to Cadmium concentrations in the tailings being low compared to other sources.

Figure C2 Operation Scenario 2 and Operation Scenario 4 (TSF 'Upset') - 99.9th Percentile Predicted Incremental 1-Hour Average Beryllium Concentrations (µg/m^3) Criterion = 0.004µg/m^3 (incremental)

Note 1: Modelled concentrations of Barium display similar spatial distribution. Predicted concentrations are 4.0E+01 times those displayed. Criterion = 9.0µg/m^3.

Note 2: Scenario 2 (noise cladding enclosure and hooded extraction to crusher) shown in yellow. Scenario 4 (TSF 'Upset') shown in white.

Figure C3 Operation Scenario 2 and Operation Scenario 4 (TSF 'Upset') - 99.9th Percentile Predicted Incremental 1-Hour Average Chromium Concentrations (µg/m^3) Cr VI Criterion = 0.09µg/m^3

Note 1: Modelled concentrations of Manganese, Mercury and Nickel display similar spatial distributions. Predicted concentrations are 7.3E+01, 1.2E-01 and 7.2E-01 times those displayed respectively. Criteria are 18µg/m^3, 0.18µg/m^3 (organic Hg) and 0.18µg/m^3 respectively

Note 2: Scenario 2 (noise cladding enclosure and hooded extraction to crusher) shown in yellow. Scenario 4 (TSF 'Upset') shown in white.

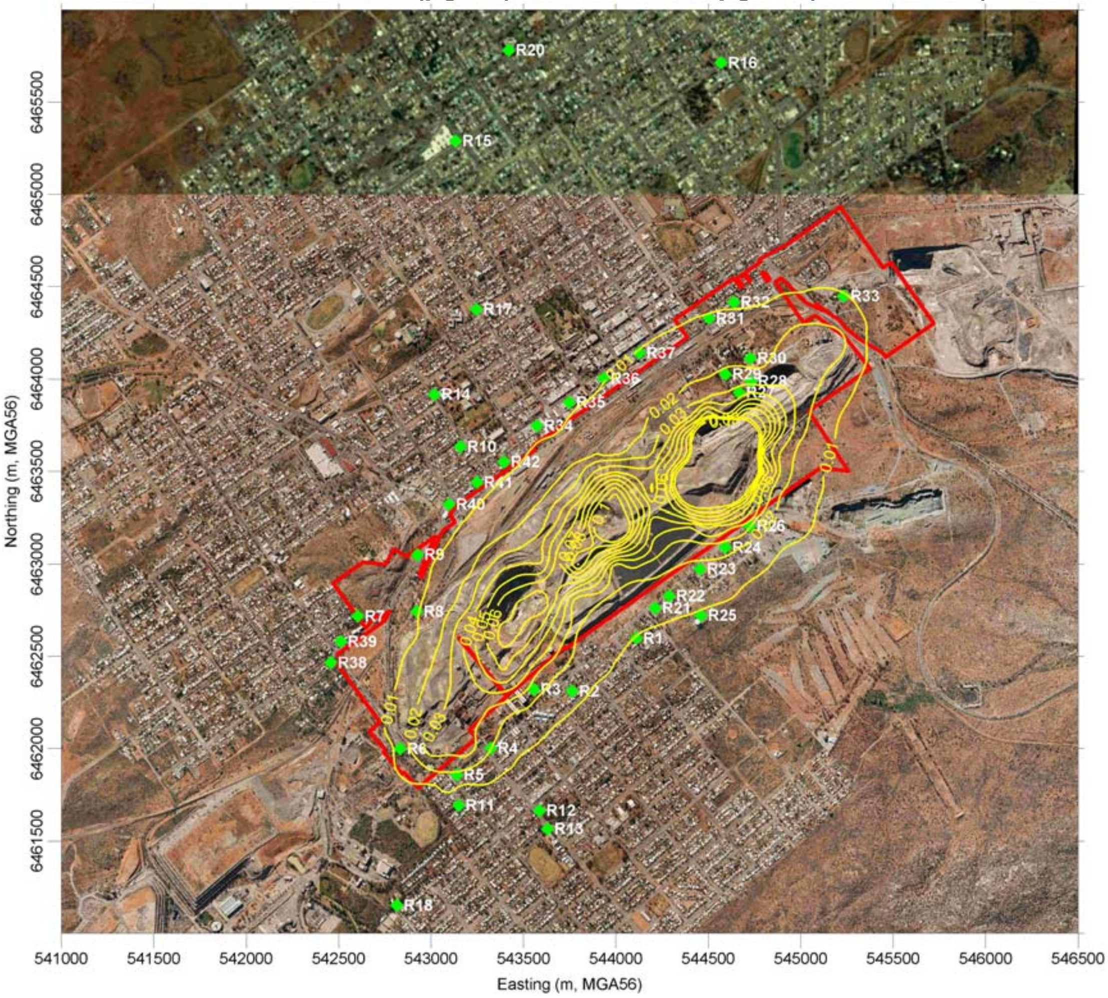
Figure C4 Operation Scenario 2 and Operation Scenario 4 (TSF 'Upset') - 99.9th Percentile Predicted Incremental 1-Hour Average Copper Concentrations (µg/m^3) Criterion = 18µg/m^3 (incremental)

Note 1: Scenario 2 (noise cladding enclosure and hooded extraction to crusher) and Scenario 4 (TSF 'Upset') predict equivalent contours. This is since Copper is not detected within the tailings.

Figure C5 Operation Scenario 2 and Operation Scenario 4 (TSF 'Upset') - 99.9th Percentile Predicted Incremental 1-Hour Average Silver Concentrations (µg/m³) Criterion = 0.18µg/m³ (incremental)

Note 1: Scenario 2 (noise cladding enclosure and hooded extraction to crusher) and Scenario 4 (TSF 'Upset') predict equivalent contours. This is since Silver is not detected within the tailings.

Figure C6 Operation Scenario 2 - Predicted Incremental Annual Average Lead Concentrations (µg/m^3) Criterion = 0.5µg/m^3 (incremental)



Note 1: Scenario 4 (TSF 'Upset') is not an applicable scenario for annual average criteria due to any 'upset' at the TSF being a short-term phenomenon.