Mr Gary Nairn
Member, Northern Territory Environment Protection Authority (NTEPA)
GPO Box 3675
Darwin NT 0801
20 May 2014

Dear Mr Nairn,

Re: Vista Gold Australia Pty Ltd – Mount Todd Gold Project EIS

Please find below our response to your request for additional information for your consideration. Your reference EN2011/0048 dated 4th February 2014.

The NT EPA advised that there are three substantial environmental risks that have not yet been satisfactorily documented to allow assessment of the Mt Todd EIS. For each of these we have prepared responses from experts in the respective fields;

1. Clearing critical habitat for Gouldian finches;

2. Dust levels in remaining Gouldian finch habitat; and

3. Contaminated drainage from waste rock dump.

We have engaged our experts to establish additional information for consideration. We have provided a summary below and appended to this document the detailed material

The information is proved in four parts;

Attachment 1 – GHD Gouldian Finch Survey Report, Alex Kutt & Alex Holmes (*14 02 GHD Mt Todd Gouldian Finch Survey Report_Rev0- EIS Response III.pdf*). This address the requested information on the following topics;

- 1.0 Introduction
  - 1.1 Background
  - 1.2 Yinberrie Hills Gouldian Finch population
  - 1.3 Gouldian Finch nesting
  - 1.4 Objectives of survey
- 2.0 Methods
- 3.0 Results and Discussion

Attachment 2 – GHD Memo - Mt Todd Vista Lab Testing (*14 02 Mt Todd Vista Lab Testing- EIS Response III.pdf*). This address the requested information on the following topics;

1. Discussion on the prospect of lab testing the Gouldian Finch for Dust exposure

Attachment 3 – GHD Mt Todd Gold Mine Draft EIS Additional Analysis for Air Quality Assessment (*14 02 GHD Mt Todd Dust Discussion_Rev0- EIS Response III.pdf*). This address the requested information on the following topics;

1. Objectives/Context
2. Background
    - 2.1 The Vista Gold Mount Todd Project and the Gouldian Finch
    - 2.2 Air Quality Assessment
    - 2.3 Mine Production
    - 2.4 Dust Emission Calculations
    - 2.5 Multi-year Assessments
    - 2.6 Blasting Emissions
    - 2.7 Haul Roads
    - 2.8 Previous Air Quality Assessment – 1991
    - 2.9 Dust suppression
3. Model Conservativeness
    - 3.1 US EPA Model Guidance on conservatism
    - 3.2 Pit Retention
    - 3.3 Modelled Vertical Pit Dispersion
    - 3.4 Modelled Surface Roughness
    - 3.5 Relative Humidity
    - 3.6 Artificial Humidity
4. Core Breeding Area Dust Levels
5. Updated Emissions and Modelling
6. Atmospheric Stability
7. Other Dust Sources
8. Concluding Comments
9. Limitations

Attachment 4 - Tetra Tech, Andrew Harley, Technical Memorandum (14 02 Tetra Tech Mt Todd WRD Drainage- EIS Response III.pdf). This address the requested information on the following topics;

- 1.0 Introduction
- 2.0 General Comments Regarding waste Rock Dump Design
- 3.0 Response to Specific Information Requirements
    - 3.1 Clarification of Gcl Bench Interlayer Width
    - 3.2 Justification of Rp1water Quality Data In Modelling
    - 3.3 Time Series Data For moisture Content of Fine, Covering Layer and GCL through Wetting and Drying Cycles, Including Modelling Outputs
    - 3.4 Quantification of Non Acid Forming (NAF) Material
    - 3.5 Generation of Acid Rock Drainage and Metalliferous Leacahte (ARD/Ml)

We have been able to respond to the request for additional information in full and look forward to the completion of this EIS process.

Staff from Vista Gold are available to discuss any questions that you may have.

Yours sincerely

Brent Murdoch
General Manager / Director

Attachment 1 - GHD Gouldian Finch Survey Report, Alex Kutt & Alex Holmes

Vista Gold Australia Pty Ltd

Mt Todd Gold Project Draft EIS

Gouldian Finch Nest Survey

May 2014

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Appendices

1. Introduction

1.1 Background

Vista Gold Australia Pty Ltd (Vista Gold) proposes to re-open and operate the Mt Todd Gold Mine (north of Katherine, Northern Territory). Vista Gold commissioned GHD Pty Ltd (GHD) to undertake a fauna assessment as part of a draft Environmental Impact Statement (EIS) required for the project. Following on from the submission of the draft Environmental Impact Statement (EIS), the Northern Territory Government and members of the public were able to make submissions on the draft EIS, requesting supplementary information. A supplementary EIS was reviewed by the Northern Territory Environmental Protection Agency (NT EPA), and it was requested that further information be provided on nesting activity in areas mapped as potential breeding habitat for the Gouldian Finch. The NT EPA requested specifically that Vista Gold undertake further field investigations in the 2014 breeding season (letter from NT EPA to Vista Gold 4th February 2014).

1.2 Yinberrie Hills Gouldian Finch population

The study area lies in the Yinberrie Hills (Pine Creek Bioregion), an area regarded by the Department of Land Resource Management (DLRM) as a Site of Conservation Significance. The listing is predominantly focused on the presence of the largest known breeding population of the nationally threatened Gouldian finch (*Erythrura gouldiae*) which is listed as endangered under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* and vulnerable under the *Territory Parks and Wildlife Conservation (TPWC) Act 2006*.

1.3 Gouldian Finch nesting

The Supplementary EIS reviewed ecological data with respect to the breeding ecology of the Gouldian Finch at the mine site. To reiterate this data in brief, Gouldian Finches can breed 2-3 times a year, produce clutches of 3-8 eggs and often juveniles can comprise up to 80% of the population (Garnett *et al.*, 2011, Tidemann *et al.*, 1999). At Yinberrie nesting occurs in hilly terrain and nests are built in hollows of salmon gum *Eucalyptus tintinnans* (Tidemann *et al.*, 1999). A cup shaped nest of grass is built in hollows created by termite activity, and eggs are laid between January and August, with a peak between April and June depending on local seasonal conditions (Tidemann *et al.*, 1999). Breeding coincides with peak resource availability (Dostine *et al.*, 2001) and up to three clutches can be produced per season, with an average annual recruitment of 2.5 birds per adult (Tidemann *et al.*, 1999).

The location of Gouldian Finch nests involves the physical inspection of potential nest trees (in this case *Eucalyptus tintinnans*) either along transects or in pre-determined quadrats that represent a subset of the available breeding habitat. Trees are inspected for potential nest cavities or hollows, and if present, inspection of the nest hollows requires the use of ladders or telescopic probes with burrow cameras. Additional data typically collected with respect to nest trees includes the morphometrics of the hollow (size, height, depth) and the tree (Brazill-Boast *et al.*, 2010).

There are a number of other factors to consider in monitoring for nests that are active, including:

- Gouldian Finches remain in the nests for long periods and leave the hollow infrequently; therefore physical searching of the tree hollows is preferred.
- Nesting areas may be spatially clustered and some may change annually, although there is evidence of reuse of trees and hollows over multiple years (Franklin and Dostine, 1996).

- Gouldian Finches may nest at multiple times over an extended breeding period.
- Observations of birds in nests represent breeding activity but not breeding success, and therefore multiple annual surveys, and other population estimates are needed to quantify success.

It is recommended that nest cavities, once identified, be sampled three times over the breeding season (Brazill-Boast *et al.*, 2010), and the area of searching for nesting sites be a sensible proportion of the total available area (i.e. 10-20% of the breeding area).

1.4 Objectives of survey

The purpose of this study is to examine a subset of the mapped potential breeding habitat that is proposed to be disturbed by the proposed mine activities, and survey individual trees on a systematic basis using typical nest survey methods. This would also involve recording the location and density of trees used for nesting or potential nesting trees (and current or past nesting activity) in the defined expansion area of approximately 160 hectares.

Thus the objectives of the field survey include the following:

- undertake a targeted survey to a standard that satisfies the requirements of the NT EPA and DLRM;
- record all Gouldian finch locations, nesting trees, nesting activity (active, inactive or retrospective) and any significant incidental observations of indigenous and introduced avifauna; and
- provide a report detailing the results of the survey, including mapping of nest locations.

2. Methods

Four experienced zoologists conducted a survey to detect nesting activity in the study area from the 11th to 16th April 2014.

The 160 ha study area was stratified via GIS into 1 ha grids, which were further delineated into 4 x 0.25 ha quarters. The 1 ha grid was positioned along cardinal points so they comprised NW, NE, SE, SW quarters. The grids for survey were selected on a semi random basis; in part governed by accessibility, in part by onsite inspection of the three main areas with respect to presence of *E. tintinnans*, and lastly in reference to previous records of Gouldian Finch on the site (Figure 1).

The zoologists worked in pairs, with one pair marking out the 100 x 100 m quadrat and recording the tree morphometric data, and one pair examining the hollows via a combination of video camera and direct inspection via ladder. The video camera used was a BurrowCam recordable video inspection tool with a 17mm lens and 2.5 inch LCD wireless display (supplied by FaunaTech, Bairnsdale), mounted on a 2.15m – 8.4m fibreglass/carbon fibre telescopic pole.

Every *E. tintinnans* in each quadrat was initially inspected from the ground, and data for each tree was recorded (Figure 2). If a tree contained no cavities (or unsuitable cavities), its height, diameter at breast height and location was still recorded. We classified a cavity as unsuitable if it was < 10 cm in depth. All other cavities were inspected. For each tree (and if there were suitable cavities) the following data was recorded (Brazill-Boast *et al.*, 2010):

- the height and width of the entrance;
- the height above ground of the entrance to the cavity;

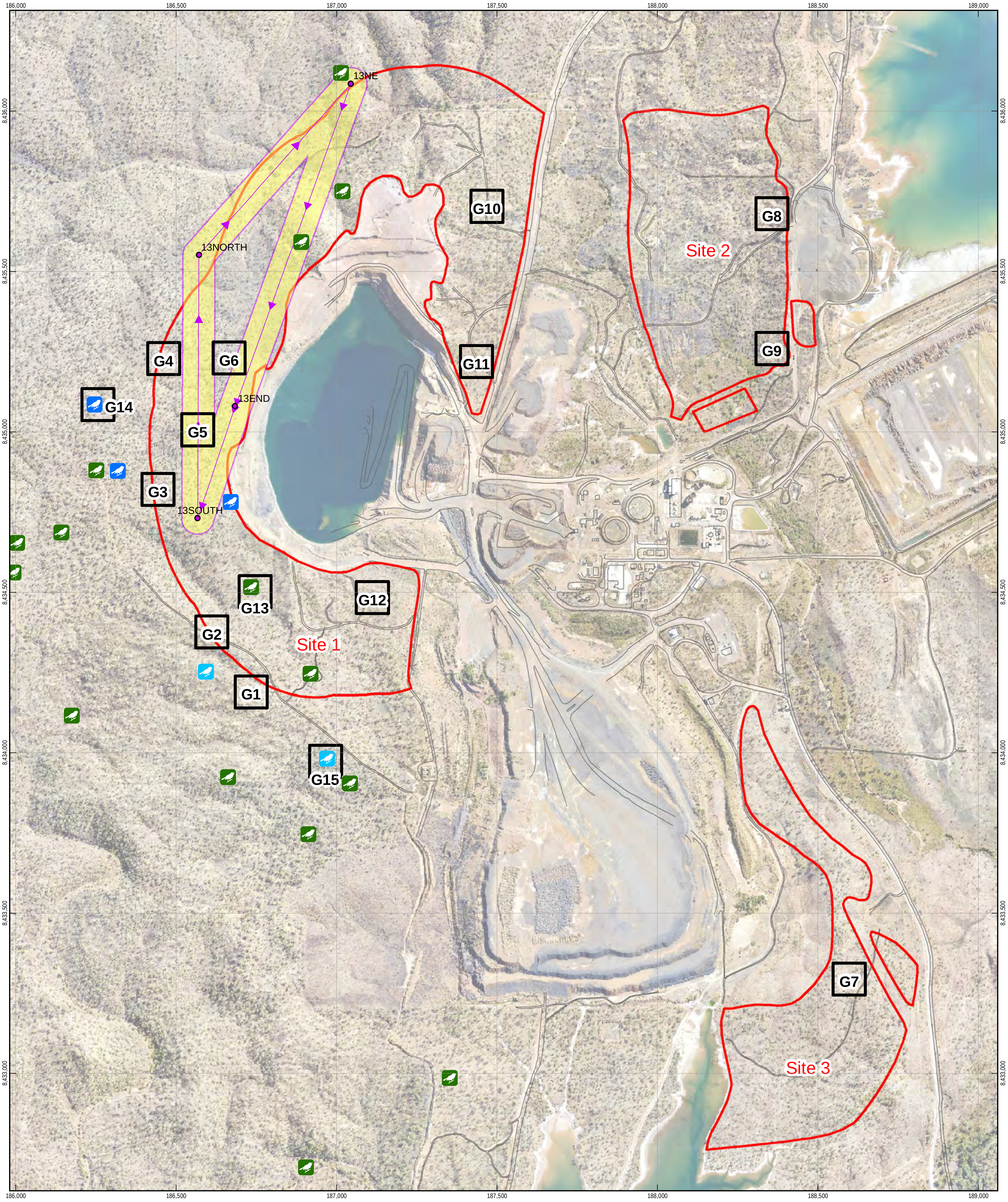
- the angle of the entrance (in relation to trunk: 90 = facing directly upward, 0 = facing horizontally);
- the height of tree (estimated to 1 m);
- the diameter at breast height;
- the compass bearing of entrance (4 quarters, NE, NW, SE, SW);
- the predominant type of the hollow (internal = intruding into the stem or hollow branch external = extruding from a stem);
- the state of the hollow (alive or dead);
- the fragility score (description of vulnerability to damage or collapse, with 1 = most robust, 5 = most fragile);
- nesting or other activity in the cavity.

Additionally, on one morning a walking transect was undertaken to facilitate the location of suitable nesting locations, and Gouldian Finch activity. Four predetermined locations were marked on GPS to create a transect of approximately 3.5 km that encompassed the north and west side of the Batman pit, where the best nesting habitat was considered to occur. The zoologists walked this transect to cover a 100 m width.

Incidental records of Gouldian Finch, other finches and other threatened bird species were recorded during all survey activities and the driving traverse within or adjacent to the Mt Todd mine site.

For each grid examined, we calculated totals and the mean and standard error for the number, height and diameter at breast height of trees (with and without hollows), and aspects of the hollow morphology. We also calculated the coefficient of variation for some of these measures for each grid (using the data derived for each grid quarter), because it represents the ratio of the standard deviation to the mean, and is a helpful standardised statistic in comparing the degree of variation from one data series to the other (i.e. from grid to grid).

An example of the Burrow Cam set up is presented in Plate 1and example images from this device presented in Plate 2.



LEGEND

Gouldian finch Records (GHD 2014)	Habitat Survey Quadrat	Survey Site Areas
Gouldian finch Records (GHD 2011)	Habitat Search Transect (100m wide coverage)	Infrastructure
Gouldian finch Records (NRETAS)		

0 100 200 300 400

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

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GHD

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Mt Todd Gold Mine Environmental Approvals

Job Number	43-22079
Revision	0
Date	01 May 2014

Gouldian Finch Habitat Survey Effort

Figure 1

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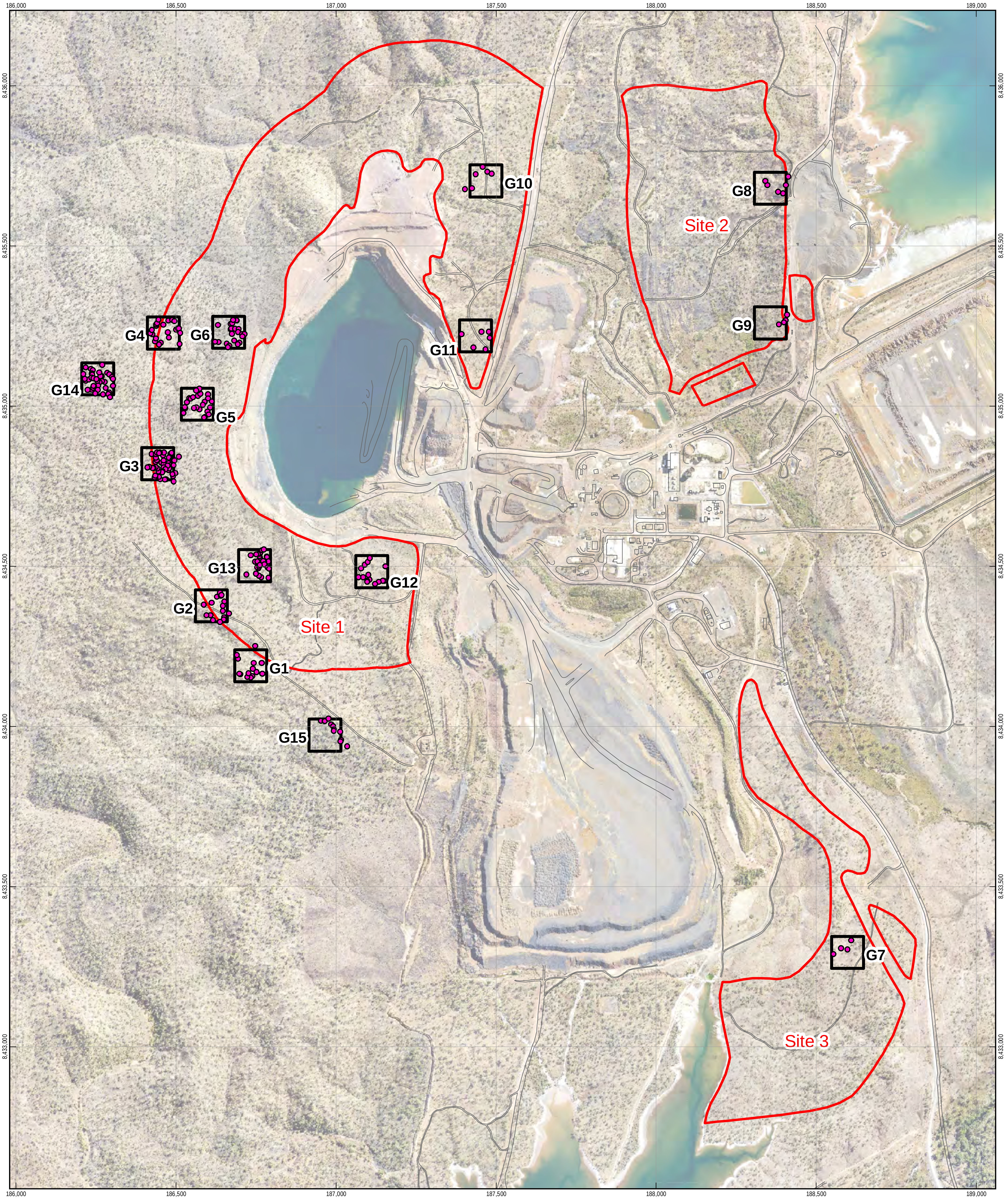
Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: Vista Gold - Mining Lease (2011). GHD - Vegetation, Proposed Future Vegetation Disturbance (2012), Gouldian Finch Habitat, Core Gouldian Finch Breeding Habitat. Created by: CM



LEGEND

- Trees Investigated
- Survey Site Areas
- Habitat Survey Quadrat
- Infrastructure

0 100 200 300 400

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

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Vista Gold Australia Pty Ltd
Mt Todd Gold Mine Environmental Approvals

Job Number	43-22079
Revision	0
Date	01 May 2014

Trees Investigated

Figure 2

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Level 5, 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: Vista Gold - Mining Lease (2011). GHD - Vegetation, Proposed Future Vegetation Disturbance (2012), Gouldian Finch Habitat, Core Gouldian Finch Breeding Habitat. Created by: CM

3. Results and Discussion

In this survey we examined 15 x 1 ha grids and recorded attributes of all *E. tintinnans* within these areas. We also examined a 100 m transect of approximately 3.5 km length, through known nesting habitat.

A total of 308 trees were examined, 190 of which had no hollows > 10 cm in depth and 118 trees that did contain hollows > 10 cm in depth. The mean number of trees per grid which had no hollows > 10 cm ranged from 1.5 to 12.5 trees and these were moderately variable in distribution in each grid (coefficient of variation 0.0 to 0.9). The mean number of trees per grid which had hollows > 10 cm ranged from 0 to 4.0, and were highly variable (coefficient of variation 0.0-2.0) (Table 1).

Tree height and diameter at breast height ranged from a mean of 6.5 to 12.2 m and 15.7 to 32.6 cm respectively, and in both cases were not very variable from grid to grid (coefficient of variation 0.09 to 0.33 for tree height, and 0.19 to 0.40 for diameter) (Table 2). Published records from the Yinberrie Hills and Newry in the Northern Territory, of mean tree height and diameter at breast height for trees containing Gouldian Finch nests, are 9.6 m and 0.30 cm respectively (Tidemann *et al.*, 1999). Our tree dimensions for each grid in this study encompass these scores.

In this study, for trees that contained hollows, the mean tree height ranged from 8.8 to 12.9 m and diameter at breast height from 26.1 to 33.7 cm; a range more tightly encompassing the dimensions of previously recorded nest trees. This indicates that trees that form hollows are generally of a certain size.

The dimensions of the trees and hollows we examined indicated that many of the trees across all the grids we surveyed contained trees and hollows of a size suitable for Gouldian Finches. The exception to this was in Grids 7 to 9 (sites 2 and 3) where the number, size and hollow distribution of *E. tintinnans* suggest that this area is sub-optimal breeding habitat. There is however a low abundance of *E. tintinnans* in these already disturbed areas.

The mean height of hollows off the ground ranged from 3.0 to 6.0 m, and the mean depth of the hollows ranged from 15 to 80 cm (Table 3). The hollows we examined were generally facing northwest or southwest (n=35 each), internal[1] (n=76), alive[2] (n=76) and were either of a low or high fragility score, which reflects that the internal hollows were generally alive whilst external hollows were dead and decaying (Table 4).

Published data on preferred architecture of Gouldian Finch hollows indicate that Gouldian Finches select hollows of a smaller internal diameter (compared to Long-tailed Finches) and hollows that are higher (3.7 m on average) on larger (9.6 m average height, diameter 30 cm), fewer stemmed (mean 1.7) trees. The hollows are generally inclined upwards, orientated NW and with a depth on average of 0.47 cm (Tidemann *et al.*, 1999). The complete data for all the trees and grids we examined is presented in Appendix A.

We did not record any evidence of Gouldian Finch nesting (current or inactive), nor Long-tailed Finches which build very similar nests. Only one nest was recorded and it was not a finch nest.

We revisited one location where previous survey conducted for the EIS noted the presence of Gouldian Finches investigating tree hollows (GHD, 2013), but no nest was found in this location. The reuse of tree hollows is not common, but there is some evidence of the spatial clustering of nest locations (Franklin and Dostine, 1996).

[1] Refers to a hollow contained within the trunk or branch of a tree.
[2] Refers to a hollow contained within the living trunk or branch of a tree (i.e. not within a dead hollow branch)

Generally the availability of suitable hollows is not a limiting factor for Gouldian Finch breeding in the Yinberrie Hills, i.e. many suitable sized trees and hollows are present, and our data reiterates this contention. In a recent study in the Wyndham district of Western Australia it was found that, of 503 hollows examined, 350 were unoccupied, 68 contained Gouldian Finch nests and 94 Long-tailed Finch nests (Brazill-Boast *et al.*, 2010).

During the course of this survey we located two small parties of Gouldian Finch, one at Grid 15 comprising 4 adults (two males [red and black face] and two females) and one comprising 6 adults comprising two males and three females (all black faced) (location directly south of Grid 2) (Figure 1).

We also observed Gouldian Finches on three occasions near the Edith River crossing prior to entering the Mt Todd mine site, in each instance consisting only of adult birds. All Finch locations were adjacent or in partly burnt habitat. This suggests that perhaps the Gouldian Finches were not yet breeding. We also located a small party of Long-tailed finches on the transect walk between Grid 5 and Grid 14, that included 2 adults and 2 fledged birds.

Plate 1 The burrow camera in operation examining a potential nest cavity

Plate 2 Typical views from the burrow camera

Table 1 The number and variation in trees with or without suitable cavities in each grid examined.

Grid	Trees with no hollows > 10 cm in depth				Trees with hollows > 10 cm in depth				All trees
	Total	**Mean**	**SD**	**CV**	**Total**	**Mean**	**SD**	**CV**	**Total**
G01	7	5.8	5.2	0.90	16	4.0	6.2	1.54	23
G02	10	5.0	3.2	0.63	10	2.5	1.7	0.69	20
G03	42	12.5	3.7	0.30	8	2.0	1.4	0.71	50
G04	15	6.3	2.2	0.35	10	2.5	3.1	1.24	25
G05	17	7.3	3.4	0.47	12	3.0	2.9	0.98	29
G06	15	6.0	3.8	0.64	9	2.3	2.1	0.92	24
G07	4	1.7	1.2	0.69	1	0.3	0.5	2.00	5
G08	5	2.0	0.0	0.00	1	0.3	0.5	2.00	6
G09	4	2.0	1.4	0.71	0	0.0	0.0	0.0	4
G10	3	2.7	1.2	0.43	5	1.3	1.5	1.20	8
G11	3	1.5	0.6	0.38	3	0.8	0.5	0.67	6
G12	9	4.8	0.5	0.11	10	2.5	1.0	0.40	19
G13	17	8.3	7.5	0.91	16	4.0	4.2	1.06	33
G14	32	10.5	2.1	0.20	10	2.5	2.1	0.83	42
G15	7	7.0	0.0	0.00	7	1.8	2.4	1.35	14
All trees	**190**				**118**				**308**

Note: Total is the total number of *E. tintinnans* in the grid, mean is the average number and SD the standard deviation, and CV the coefficient of variation measured for the four quarters within the grid.

Table 2 The variation in tree height and diameter at breast height for all trees examined.

Quadrat	Tree Height					Diameter at breast height				
	Max (m)	**Min (m)**	**Mean (m)**	**SD (m)**	**CV**	**Max (cm)**	**Min (cm)**	**Mean (cm)**	**SD (cm)**	**CV**
G01	15.0	4.5	12.2	3.2	0.26	43.2	13.0	32.6	8.0	0.25
G02	16.0	5.0	11.1	3.7	0.33	39.0	11.7	26.2	9.2	0.35
G03	15.0	8.0	12.0	1.7	0.14	34.2	11.1	23.5	4.8	0.20
G04	15.0	7.0	11.5	2.1	0.18	33.9	16.2	24.7	5.5	0.22
G05	15.0	5.0	11.2	2.6	0.23	46.0	14.8	29.5	7.7	0.26
G06	16.0	7.0	11.0	1.9	0.17	37.4	10.0	21.1	6.7	0.32
G07	11.0	7.0	9.0	1.6	0.18	29.5	10.6	19.6	7.8	0.40
G08	12.0	8.0	9.3	1.6	0.17	30.0	14.1	22.9	6.0	0.26
G09	7.0	6.0	6.5	0.6	0.09	21.6	9.6	15.7	5.9	0.38
G10	14.0	6.0	9.4	2.3	0.24	34.4	11.3	25.9	6.6	0.25
G11	14.0	8.0	10.2	2.3	0.23	33.9	17.3	25.1	6.5	0.26
G12	14.0	8.0	11.4	1.5	0.13	32.7	10.8	24.8	4.8	0.19
G13	14.0	6.0	11.0	1.9	0.17	43.0	18.0	26.6	5.5	0.21
G14	16.0	5.0	10.8	2.6	0.24	42.2	13.3	24.7	6.5	0.26
G15	16.0	7.0	10.9	2.8	0.26	47.2	20.5	30.3	9.2	0.30
All grids			**11.1**	**2.4**				**25.6**	**7.2**	

Note: Max is the maximum height / DBH in that grid and min the minimum, mean is the average height / DBH and SD the standard deviation, and CV the coefficient of variation measured for the four quarters within the grid.

Table 3 The variation in tree and hollow morphometric data for the trees with hollows > 10 cm in depth.

Grids	Tree Height			Diameter at breast height			Hollows									
	Mean	**SD**	**CV**	**Mean**	**SD**	**CV**	**Mean H (cm)**	**SD H (cm)**	**Mean W (cm)**	**SD W (cm)**	**Mean EH (m)**	**SD EH (m)**	**CV EH (m)**	**Mean D (cm)**	**SD D (cm)**	**CV D**
G01	13.1	2.4	0.18	36.2	4.8	0.13	8.8	5.2	5.5	5.2	5.9	2.5	0.42	35.6	19.1	0.54
G02	11.5	3.5	0.30	31.5	5.3	0.17	9.7	3.5	4.5	4.9	5.0	1.3	0.26	57.0	27.9	0.49
G03	12.5	1.8	0.14	26.1	5.3	0.20	11.5	5.6	1.5	4.1	6.0	2.1	0.35	70.0	28.9	0.41
G04	11.7	2.0	0.17	27.0	4.6	0.17	6.1	2.2	2.3	3.3	4.7	1.3	0.28	64.0	36.3	0.57
G05	11.7	2.8	0.24	33.7	5.5	0.16	7.1	2.9	4.3	6.5	5.8	1.4	0.24	57.9	26.8	0.46
G06	12.1	1.8	0.15	26.1	7.0	0.27	8.1	3.3	3.0	4.2	5.8	2.1	0.36	64.4	28.0	0.43
G07	11.0	0.0	0.0	29.5	0.0	0.0	8.0	0.0	1.6	3.6	3.0	0.0	0.0	30.0	0.0	0.0
G08	10.0	0.0	0.0	30.0	0.0	0.0	5.0	0.0	1.2	2.9	6.0	0.0	0.0	15.0	0.0	0.0
G09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G10	8.8	0.4	0.05	26.8	1.8	0.07	8.4	2.3	6.5	6.4	4.2	1.6	0.38	86.0	28.9	0.34
G11	11.7	2.5	0.21	30.6	2.9	0.09	16.7	7.6	9.2	11.1	3.7	1.2	0.32	93.3	8.7	0.09
G12	11.7	1.3	0.11	25.8	2.7	0.10	6.5	2.4	3.4	3.7	4.7	2.2	0.47	76.5	36.4	0.48
G13	11.2	2.0	0.18	28.7	4.5	0.16	8.6	4.7	4.2	5.3	5.9	1.3	0.22	63.8	24.4	0.38
G14	12.3	3.0	0.24	27.1	8.7	0.32	7.7	4.7	2.0	4.3	5.8	2.1	0.36	80.0	19.3	0.24
G15	12.9	2.6	0.20	34.0	10.2	0.30	8.7	5.5	4.4	5.9	3.9	0.9	0.23	77.1	21.9	0.28
Total	**11.9**	**2.4**		**29.9**	**6.5**		**8.4**	**4.4**	**3.3**	**5.1**	**6.5**	**9.8**		**63.5**	**27.5**	

Note: Mean, SD and CV are the mean, standard deviation and coefficient of variation. H and W are the dimensions of the hollow entrance, and EH is the height of the hollow above the ground and D is the depth of the hollow.

Table 4 The aspect, type, state and fragility of the hollows of each tree.

Grid	Aspect				Type		State		Fragility				
	NE	**NW**	**SE**	**SW**	**External**	**Internal**	**Alive**	**Dead**	**1**	**2**	**3**	**4**	**5**
G1	3	7	1	5	9	7	7	9	7	2	21	4	0
G2	2	1	3	4	3	7	7	3	7	0	6	0	5
G3	1	2	3	2	5	3	3	5	2		6	4	15
G4	2	3	3	2	1	9	9	1	7	4	0	4	0
G5	3	5	1	3	6	6	6	6	2	8	3	20	0
G6	4	3	0	2	3	6	6	3	6	0	0	12	0
G7	1	0	0	0	1	0	0	1	0	0	0	4	0
G8	0	1	0	0	0	1	1	0	1	0	0	0	0
G9	0	0	0	0	0	0	0	0	0	0	0	0	0
G10	0	1	2	2	3	2	2	3	2	0	0	4	10
G11	0	2	0	1	1	2	2	1	2	0	0	4	0
G12	1	2	3	4	2	8	8	2	8	0	6	0	0
G13	2	5	3	6	7	9	9	7	8	4	12	4	5
G14	3	3	1	3	1	9	9	1	9	0	0	0	5
G15	1	0	5	1	0	7	7	0	5	4	0	0	0
Total	**23**	**35**	**25**	**35**	**42**	**76**	**76**	**42**	**66**	**22**	**54**	**60**	**40**

Note: The fragility score (description of vulnerability to damage or collapse, with 1 = most robust, 5 = most fragile).

4. References

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Appendices

Appendix A – Hollow and tree data collected during the field survey

Quad is the grid number, Tree is the tree number in each quarter, DBH is diameter at breast height, Hollow height and width is the dimensions of the hollow entrance, Entrance height is the height of the hollow above the ground, Depth is the depth of the hollow Angle is the angle of the entrance (in relation to trunk: 90 = facing directly upward, 0 = facing horizontally), Bearing is the compass bearing of entrance (4 quarters, NE, NW, SE, SW), type is whether the hollow is predominantly internal (intruding into the stem or hollow branch) or external (extruding from a stem), State is the state of the hollow (alive or dead), Fragility is the fragility score (description of vulnerability to damage or collapse, with 1 = most robust, 5 = most fragile) and Activity is if there was nesting or other activity in the cavity.

Quad	Tree	Latitude	Longitude	Tree Height (m)	DBH (cm)	Hollow present	Hollow Height (cm)	Hollow Width (cm)	Entrance Height (m)	Depth (cm)	Angle (deg)	Bearing	Type	State	Fragility	Activity
G1	A1	-14.14591	132.09849	4.5	16.5	N										
G1	A2	-14.14543	132.09854	7	13	N										
G1	B1	-14.14591	132.09872	15	34.3	Y	20	5	3	20	70	NE	Int	A	1	N
G1	B1	-14.14591	132.09872	15	34.3	Y	3	3	7.5	20	10	SW	Int	A	1	N
G1	B1	-14.14591	132.09872	15	34.3	Y	5	5	12	15	20	SW	Int	A	1	N
G1	B1	-14.14591	132.09872	15	34.3	Y	3	3	10	25	10	NE	Ext	D	3	N
G1	B2	-14.14622	132.09873	13	43.2	Y	15	15	3	15	45	NW	Ext	D	3	N
G1	B2	-14.14622	132.09873	13	43.2	Y	10	10	5	10	45	NW	Int	A	1	N
G1	B2	-14.14622	132.09873	13	43.2	Y	5	5	6	10	45	NW	Ext	D	3	N
G1	B2	-14.14622	132.09873	13	43.2	Y	5	5	7	5	10	NW	Ext	D	3	N
G1	B3	-14.14616	132.09857	15	37.6	Y	10	10	5	15	45	SW	Int	A	1	N
G1	B3	-14.14616	132.09857	15	37.6	Y	10	10	5.5	100	30	NW	Ext	D	2	N
G1	B3	-14.14616	132.09857	15	37.6	Y	10	10	6.5	20	20	NW	Int	A	1	N
G1	B4	-14.14607	132.09846	10	30.9	Y	15	15	4.5	40	45	SE	Ext	D	3	N
G1	B4	-14.14607	132.09846	10	30.9	Y	15	15	5	100	30	NE	Ext	D	3	N
G1	C1	-14.14628	132.09844	12	31.8	N										
G1	C2	-14.14632	132.09840	6	18.5	N										

Quad	Tree	Latitude	Longitude	Tree Height (m)	DBH (cm)	Hollow present	Hollow Height (cm)	Hollow Width (cm)	Entrance Height (m)	Depth (cm)	Angle (deg)	Bearing	Type	State	Fragility	Activity
G1	C3	-14.14631	132.09830	7	29.7	N		3	3	100	20	NW	Int	A	1	N
G1	C4	-14.14620	132.09834	14	32	N										
G1	C5	-14.14623	132.09810	12	33.2	Y	7	8	4	50	10	SW	Ext	D	4	N
G1	C6	-14.14621	132.09807	14	30.9	Y	5	4	8	25	60	SW	Ext	D	3	N
G1	D1	-14.14579	132.09804	14	29.5	N										
G1	D2	-14.14568	132.09800	12	30	N										
G2	A1	-14.14420	132.09729	9	33.1	N										
G2	A2	-14.14403	132.09745	9	30.5	Y	8	8	3	100	75	NE	Int	A	1	N
G2	A3	-14.14400	132.09756	8	14.8	N										
G2	A4	-14.14391	132.09754	12	22.8	N										
G2	A5	-14.14398	132.09758	16	14.5	N										
G2	A6	-14.14417	132.09766	16	36.3	Y	10	12	5	100	45	NE	Int	A	1	N
G2	A6	-14.14417	132.09766	16	36.3	Y	8	8	6	100	75	SE	Int	A	1	N
G2	A6	-14.14417	132.09766	16	36.3	Y	8	8	6	100	75	SE	Int	A	1	N
G2	B1	-14.14428	132.09762	9	16.1	N										
G2	B2	-14.14443	132.09762	7	11.8	N										
G2	B3	-14.14451	132.09779	12	35.5	Y	15	10	5	30	45	SW	Int	A	1	N
G2	B3	-14.14451	132.09779	12	35.5	Y	15	8	5	30	45	SW	Int	A	1	N
G2	B4	-14.14462	132.09765	5	11.7	N										
G2	B5	-14.14467	132.09764	9	18.7	N										
G2	B6	-14.14474	132.09753	10	30.4	Y	10	12	3	20	0	SW	Ext	D	3	N
G2	C1	-14.14468	132.09733	6	22.4	Y	3	3	4	50	10	SE	Ext	D	3	N
G2	C2	-14.14455	132.09725	9	25.9	Y	10	10	6	20	75	SW	Int	A	1	N
G2	C2	-14.14455	132.09725	9	25.9	Y	10	10	7	20	30	NW	Ext	D	5	N
G2	C3	-14.14455	132.09714	16	26.8	N										
G2	D1	-14.14425	132.09707	15	39	N										

Quad	Tree	Latitude	Longitude	Tree Height (m)	DBH (cm)	Hollow present	Hollow Height (cm)	Hollow Width (cm)	Entrance Height (m)	Depth (cm)	Angle (deg)	Bearing	Type	State	Fragility	Activity
G3	A1	-14.14023	132.09590	13	30.3	N										
G3	A2	-14.14027	132.09596	10	24.1	N										
G3	A3	-14.14017	132.09596	11	20.9	N										
G3	A4	-14.14002	132.09594	10	19.1	N										
G3	A5	-14.13995	132.09597	11	18	N										
G3	A6	-14.13998	132.09616	12	23.7	N										
G3	A7	-14.13996	132.09619	11	17.8	N										
G3	A8	-14.14007	132.09613	12	19.8	N										
G3	A9	-14.14008	132.09611	11	27.7	Y	15	10	6	30	45	SE	Ext	D	5	N
G3	A10	-14.14025	132.09610	14	27	Y	20	5	7	100	90	SW	Ext	D	4	N
G3	A11	-14.14031	132.09616	11	17.5	Y	10	8	3	100	45	SE	Int	A	1	N
G3	A12	-14.14031	132.09624	11	23.8	N										
G3	A13	-14.14031	132.09625	14	28.4	N										
G3	A14	-14.14016	132.09622	12	26.5	N										
G3	A15	-14.14015	132.09625	14	33.8	N										
G3	A16	-14.14018	132.09627	12	27.5	N										
G3	A17	-14.14007	132.09640	14	34.2	Y	4	4	10	20	30	NE	Int	A	1	N
G3	B1	-14.14053	132.09629	14	30.8	N										
G3	B2	-14.14076	132.09624	11	25	N										
G3	B3	-14.14062	132.09623	14	31.1	N										
G3	B4	-14.14056	132.09621	12	24.4	Y	15	20	4	80	80	NW	Ext	D	5	N
G3	B5	-14.14044	132.09610	10	20.1	N										
G3	B6	-14.14039	132.09612	11	21.6	N										
G3	B7	-14.14032	132.09607	10	17.5	N										
G3	B8	-14.14036	132.09595	9	19.9	N										
G3	B9	-14.14042	132.09601	11	17.4	N										

Quad	Tree	Latitude	Longitude	Tree Height (m)	DBH (cm)	Hollow present	Hollow Height (cm)	Hollow Width (cm)	Entrance Height (m)	Depth (cm)	Angle (deg)	Bearing	Type	State	Fragility	Activity
G3	B10	-14.14047	132.09592	12	22.5	N										
G3	B11	-14.14050	132.09591	8	16	N										
G3	B12	-14.14070	132.09602	15	30.9	N										
G3	B13	-14.14070	132.09599	14	18.2	N										
G3	C1	-14.14069	132.09586	12	21.4	N										
G3	C2	-14.14063	132.09582	13	25.2	N										
G3	C3	-14.14067	132.09571	14	25.5	N										
G3	C4	-14.14065	132.09569	9	11.1	N										
G3	C5	-14.14059	132.09571	15	29.3	Y	15	15	5	100	80	SE	Int	A	3	N
G3	C6	-14.14047	132.09580	12	25.5	N										
G3	C7	-14.14039	132.09578	10	21.5	N										
G3	C8	-14.14035	132.09572	12	19.2	N										
G3	C9	-14.14038	132.09567	13	24.9	N										
G3	C10	-14.14038	132.09564	14	24.7	N										
G3	C11	-14.14034	132.09555	10	19.6	N										
G3	C12	-14.14035	132.09549	10	24.2	N										
G3	D1	-14.14020	132.09572	12	24.2	N										
G3	D2	-14.14016	132.09576	12	23	N										
G3	D3	-14.14009	132.09574	10	20.2	Y	5	5	6	100	30	NW	Ext	D	5	N
G3	D4	-14.13998	132.09562	13	28.7	Y	8	8	7	30	10	SW	Ext	D	3	N
G3	D5	-14.13998	132.09574	12	22.2	N										
G3	D6	-14.13994	132.09577	14	25.9	N										
G3	D7	-14.13994	132.09586	14	20.4	N										
G3	D8	-14.13995	132.09583	14	20.4	N										
G4	A1	-14.13634	132.09600	12	29.8	N										
G4	A2	-14.13623	132.09614	12	22.6	Y	5	5	6	30	30	NE	Int	A	1	N

Quad	Tree	Latitude	Longitude	Tree Height (m)	DBH (cm)	Hollow present	Hollow Height (cm)	Hollow Width (cm)	Entrance Height (m)	Depth (cm)	Angle (deg)	Bearing	Type	State	Fragility	Activity
G4	A3	-14.13619	132.09626	13	27	Y	6	6	7	30	30	SE	Int	A	1	N
G4	A4	-14.13621	132.09626	10	27.6	N										
G4	A5	-14.13625	132.09632	10	16.8	N										
G4	A6	-14.13648	132.09636	14	29.7	N										
G4	A7	-14.13645	132.09642	8	16.2	N										
G4	B1	-14.13645	132.09645	12	22.3	N										
G4	B2	-14.13657	132.09648	12	25.6	N										
G4	B3	-14.13689	132.09646	15	26.7	N										
G4	B4	-14.13670	132.09616	7	29.3	Y	3	3	5	30	0	NE	Ext	D	4	N
G4	B5	-14.13655	132.09612	13	23.5	N										
G4	C1	-14.13685	132.09592	11	22.1	N										
G4	C2	-14.13689	132.09587	12	17.9	N										
G4	C3	-14.13681	132.09575	14	33.9	N										
G4	C4	-14.13673	132.09578	9	17.5	N										
G4	D1	-14.13661	132.09568	7	16.8	N										
G4	D2	-14.13657	132.09562	12	31.9	Y	8	3	3	100	90	SE	Int	A	1	N
G4	D2	-14.13657	132.09562	12	31.9	Y	8	7	5	100	90	SE	Int	A	1	N
G4	D3	-14.13648	132.09567	11	31.1	Y	10	10	4	100	90	SW	Int	A	2	N
G4	D3	-14.13648	132.09567	11	31.1	Y	5	10	5	50	75	NW	Int	A	2	Y
G4	D4	-14.13638	132.09579	14	20.5	Y	3	3	5	20	10	NW	Int	A	1	Y
G4	D5	-14.13633	132.09579	14	23.9	Y	7	5	4	100	10	SW	Int	A	1	N
G4	D6	-14.13630	132.09582	12	21	N										
G4	D7	-14.13620	132.09586	11	21.1	Y	6	6	3	80	45	NW	Int	A	1	N
G5	A1	-14.13836	132.09697	14	32.8	Y	5	10	5	20	10	NW	Int	A	2	N
G5	A1	-14.13836	132.09697	14	32.8	Y	6	8	8	25	10	NE	Int	A	2	N
G5	A2	-14.13830	132.09704	10	18.6	N										

Quad	Tree	Latitude	Longitude	Tree Height (m)	DBH (cm)	Hollow present	Hollow Height (cm)	Hollow Width (cm)	Entrance Height (m)	Depth (cm)	Angle (deg)	Bearing	Type	State	Fragility	Activity
G5	A3	-14.13820	132.09698	11	18.1	N										
G5	A4	-14.13815	132.09702	12	34.8	Y	10	10	6	20	45	NW	Int	A	2	N
G5	A4	-14.13815	132.09702	12	34.8	Y	10	20	4	25	20	NE	Ext	D	3	N
G5	A5	-14.13832	132.09727	13	37.2	Y	5	5	7	20	45	NW	Int	A	1	N
G5	A5	-14.13832	132.09727	13	37.2	Y	8	8	6	100	45	SW	Int	A	2	N
G5	A6	-14.13844	132.09726	12	27.5	N										
G5	A7	-14.13852	132.09737	9	39.6	N										
G5	A8	-14.13853	132.09717	7	26.4	Y	3	3	6	35	40	SW	Ext	D	4	N
G5	A9	-14.13852	132.09717	11	21.6	N										
G5	B1	-14.13861	132.09711	6	26	Y	3	25	3	50	75	SE	Ext	D	4	N
G5	B2	-14.13869	132.09732	14	44.8	Y	5	5	5	100	75	SW	Int	A	1	N
G5	B3	-14.13880	132.09724	15	28.4	N										
G5	B4	-14.13889	132.09728	15	24.4	N										
G5	B5	-14.13896	132.09717	12	26.9	Y	10	10	6	100	75	NE	Ext	D	4	N
G5	B6	-14.13897	132.09715	12	31	N										
G5	B7	-14.13874	132.09701	10	26.4	N										
G5	C1	-14.13868	132.09693	14	38.5	Y	10	10	7	100	75	NW	Ext	D	4	N
G5	C2	-14.13870	132.09685	12	21.5	N										
G5	C3	-14.13884	132.09656	5	46	N										
G5	C4	-14.13870	132.09659	12	26.8	N										
G5	C5	-14.13867	132.09659	7	14.8	N										
G5	C6	-14.13854	132.09665	9	32.3	Y	10	10	6	100	10	NW	Ext	D	4	N
G5	D1	-14.13842	132.09672	10	27	N										
G5	D2	-14.13844	132.09676	12	31.7	N										
G5	D3	-14.13839	132.09683	12	25.2	N										
G5	D4	-14.13821	132.09692	11	22.2	N										

Quad	Tree	Latitude	Longitude	Tree Height (m)	DBH (cm)	Hollow present	Hollow Height (cm)	Hollow Width (cm)	Entrance Height (m)	Depth (cm)	Angle (deg)	Bearing	Type	State	Fragility	Activity
G6	A1	-14.13649	132.09795	10	14.5	N										
G6	A2	-14.13647	132.09797	12	14	N										
G6	A3	-14.13634	132.09795	9	12.1	N										
G6	A4	-14.13632	132.09798	8	10	N										
G6	A5	-14.13625	132.09813	10	13.6	Y	8	8	4	30	75	SW	Int	A	1	N
G6	A6	-14.13624	132.09812	11	29.9	Y	10	10	5	100	30	NE	Int	A	1	N
G6	A7	-14.13623	132.09801	9	25.7	N										
G6	A8	-14.13648	132.09808	14	22.5	N										
G6	A9	-14.13649	132.09818	12	17.5	N										
G6	B1	-14.13657	132.09816	11	16.4	N										
G6	B2	-14.13663	132.09827	12	28.4	Y	5	5	5	100	90	NE	Int	A	1	N
G6	B3	-14.13663	132.09834	11	21.3	Y	8	8	6	100	75	NW	Ext	D	4	N
G6	B3	-14.13663	132.09834	11	21.3	Y	10	10	5	50	75	NW	Ext	D	4	N
G6	B4	-14.13670	132.09828	13	25.1	Y	6	6	8	30	30	NE	Int	A	1	N
G6	B5	-14.13687	132.09819	16	37.4	Y	7	8	10	30	30	NE	Int	A	1	Y
G6	B6	-14.13692	132.09814	12	19.3	N										
G6	B7	-14.13681	132.09804	12	21	N										
G6	B8	-14.13662	132.09798	7	18.5	N										
G6	C1	-14.13690	132.09783	10	21.4	N										
G6	C2	-14.13695	132.09789	10	18.1	N										
G6	C3	-14.13700	132.09786	13	25.7	Y	4	4	6	40	45	SW	Int	A	1	N
G6	C4	-14.13685	132.09759	12	32.6	Y	15	12	3	100	10	NW	Ext	D	4	N
G6	C5	-14.13684	132.09749	10	24	N										
G6	D1	-14.13637	132.09758	10	15	N										
G7	B1	-14.15439	-167.88411	7	13.2	N										
G7	C1	-14.15432	132.11515	8	10.6	N										

Quad	Tree	Latitude	Longitude	Tree Height (m)	DBH (cm)	Hollow present	Hollow Height (cm)	Hollow Width (cm)	Entrance Height (m)	Depth (cm)	Angle (deg)	Bearing	Type	State	Fragility	Activity
G7	D1	-14.15416	132.11536	11	29.5	Y	8	8	3	30	30	NE	Ext	D	4	N
G7	D2	-14.15419	132.11556	10	24.1	N										
G7	D3	-14.15394	132.11566	9	20.7	N										
G8	A1	-14.13262	132.11404	12	29.3	N										
G8	A2	-14.13238	132.11412	8	21.2	N										
G8	B1	-14.13285	132.11396	10	30	Y	5	7	6	15	30	NW	Int	A	1	N
G8	B2	-14.13281	132.11382	8	14.1	N										
G8	D1	-14.13262	132.11351	8	22.5	N										
G8	D2	-14.13250	132.11345	10	20	N										
G9	A1	-14.13627	132.11403	7	21.6	N										
G9	B1	-14.13644	132.11399	6	19.8	N										
G9	B2	-14.13649	132.11394	6	9.6	N										
G9	B3	-14.13655	132.11379	7	11.6	N										
G10	A1	-14.13219	132.10554	11	34.4	N										
G10	A2	-14.13214	132.10542	9	27.8	Y	10	15	3	100	75	NW	Ext	D	5	N
G10	A2	-14.13214	132.10542	9	27.8	Y	5	5	5	100	60	SE	Int	A	1	N
G10	A2	-14.13214	132.10542	9	27.8	Y	7	7	6	100	60	SE	Int	A	1	N
G10	C1	-14.13260	132.10497	8	23.6	Y	10	15	5	30	0	SW	Ext	D	4	Y
G10	C2	-14.13262	132.10477	9	27	Y	10	10	2	100	45	SW	Ext	d	5	N
G10	D1	-14.13200	132.10528	14	27.7	N										
G10	D2	-14.13220	132.10508	6	11.3	N										
G11	A1	-14.13664	132.10519	9	19.3	N										
G11	A2	-14.13665	132.10541	12	28.4	Y	10	10	3	80	60	NW	Ext	D	4	N
G11	B1	-14.13682	132.10543	8	17.3	N										
G11	B2	-14.13715	132.10531	9	29.5	Y	15	20	3	100	75	NW	Int	A	1	N
G11	C1	-14.13709	132.10495	9	22.3	N										

Quad	Tree	Latitude	Longitude	Tree Height (m)	DBH (cm)	Hollow present	Hollow Height (cm)	Hollow Width (cm)	Entrance Height (m)	Depth (cm)	Angle (deg)	Bearing	Type	State	Fragility	Activity
G11	D1	-14.13671	132.10461	14	33.9	Y	25	25	5	100	75	SW	Int	A	1	Y
G12	A1	-14.14323	132.10233	12	26.3	Y	10	10	3	100	90	NE	Int	A	1	N
G12	A1	-14.14323	132.10233	12	26.3	Y	10	10	4	100	80	SW	Int	A	1	N
G12	A1	-14.14323	132.10233	12	26.3	Y	8	8	4	100	0	SW	Int	A	1	N
G12	A1	-14.14323	132.10233	12	26.3	Y	5	5	10	100	45	SE	Int	A	1	N
G12	B1	-14.14364	132.10230	11	30.4	Y	5	5	6	55	30	SE	Int	A	1	Y
G12	B2	-14.14364	132.10225	13	23.4	N										
G12	B3	-14.14367	132.10214	9	26.8	Y	5	5	5	50	20	NW	Ext	D	3	Y
G12	B4	-14.14372	132.10203	12	10.8	N										
G12	B5	-14.14360	132.10187	14	26.5	N										
G12	C1	-14.14346	132.10184	10	32.7	N										
G12	C2	-14.14363	132.10181	11	22	Y	3	3	5	30	0	SE	Int	A	1	N
G12	C3	-14.14367	132.10180	14	28.6	Y	5	5	4	30	0	SW	Ext	D	3	N
G12	C4	-14.14353	132.10168	11	25.3	N										
G12	C5	-14.14352	132.10155	12	22.8	N										
G12	D1	-14.14328	132.10162	12	22.5	Y	6	6	4	100	45	NW	Int	A	1	N
G12	D1	-14.14328	132.10162	12	22.5	Y	8	7	2	100	90	SW	Int	A	1	N
G12	D2	-14.14318	132.10174	8	24.4	N										
G12	D3	-14.14310	132.10182	10	29.1	N										
G12	D4	-14.14299	132.10188	10	17.4	N										
G13	A1	-14.14306	132.09856	12	28.6	Y	8	7	6	45	90	NW	Ext	D	2	N
G13	A1	-14.14306	132.09856	12	28.6	Y	10	10	8	50	75	NW	Ext	D	5	N
G13	A2	-14.14304	132.09863	14	34.9	Y	3	3	6	30	30	NW	Int	A	1	N
G13	A2	-14.14304	132.09863	14	34.9	Y	5	5	8	100	80	NE	Int	A	1	N
G13	A3	-14.14294	132.09872	14	30.3	Y	10	15	6	100	90	SW	Ext	D	3	N
G13	A4	-14.14290	132.09870	6	23.4	Y	15	20	5	50	75	SW	Ext	D	3	N

Quad	Tree	Latitude	Longitude	Tree Height (m)	DBH (cm)	Hollow present	Hollow Height (cm)	Hollow Width (cm)	Entrance Height (m)	Depth (cm)	Angle (deg)	Bearing	Type	State	Fragility	Activity
G13	A5	-14.14283	132.09870	12	22.7	Y	10	10	4	100	90	SE	Ext	D	3	N
G13	A5	-14.14283	132.09870	12	22.7	Y	10	10	6	60	45	NW	Ext	D	4	N
G13	A6	-14.14280	132.09872	11	29.9	Y	15	10	6	100	90	SW	Int	A	1	N
G13	A7	-14.14273	132.09877	13	43	N										
G13	A8	-14.14271	132.09882	11	26.6	N										
G13	A9	-14.14284	132.09865	10	21.8	N										
G13	A10	-14.14285	132.09860	10	27	N										
G13	A11	-14.14291	132.09890	10	35.1	Y	5	5	5	40	90	SW	Int	A	1	N
G13	A12	-14.14293	132.09891	8	20.5	N										
G13	A13	-14.14305	132.09895	12	28	N										
G13	A14	-14.14305	132.09882	13	23	N										
G13	A15	-14.14304	132.09880	14	25.9	N										
G13	B1	-14.14313	132.09883	12	28.6	N										
G13	B2	-14.14322	132.09893	10	25.5	Y	5	5	6	35	45	SE	Int	A	1	N
G13	B3	-14.14326	132.09897	10	31.8	Y	7	8	5	100	30	SW	Int	A	1	N
G13	B4	-14.14351	132.09895	12	34.2	Y	5	10	7	30	30	SW	Ext	D	2	N
G13	B5	-14.14349	132.09873	10	26.9	N										
G13	B6	-14.14345	132.09867	9	20	N										
G13	B7	-14.14325	132.09866	12	18.7	N										
G13	B8	-14.14321	132.09863	10	20.3	N										
G13	B9	-14.14319	132.09869	10	26	N										
G13	B10	-14.14315	132.09870	7	18	N										
G13	C1	-14.14339	132.09859	10	25.7	Y	20	10	3	100	75	SE	Int	A	3	N
G13	C1	-14.14339	132.09859	10	25.7	Y	5	5	7	30	45	NE	Int	A	1	N
G13	C1	-14.14339	132.09859	10	25.7	Y	5	5	6	50	45	NW	Int	A	1	N
G13	C2	-14.14341	132.09831	10	21.5	N										

Quad	Tree	Latitude	Longitude	Tree Height (m)	DBH (cm)	Hollow present	Hollow Height (cm)	Hollow Width (cm)	Entrance Height (m)	Depth (cm)	Angle (deg)	Bearing	Type	State	Fragility	Activity
G13	D1	-14.14287	132.09844	12	23.3	N										
G14	A1	-14.13787	132.09418	11	25.4	N										
G14	A2	-14.13777	132.09419	7	13.3	N										
G14	A3	-14.13777	132.09416	9	23.2	N										
G14	A4	-14.13766	132.09413	10	20.9	N										
G14	A5	-14.13745	132.09421	12	21	N										
G14	A6	-14.13768	132.09436	11	22.6	N										
G14	A7	-14.13772	132.09442	14	28.8	Y	8	6	7	100	75	SW	Int	A	1	N
G14	A7	-14.13772	132.09442	14	28.8	Y	5	5	8	50	75	SE	Int	A	1	N
G14	A8	-14.13779	132.09450	12	28.3	N										
G14	A9	-14.13785	132.09453	10	23.4	Y	5	5	4	20	45	NW	Int	A	1	N
G14	B1	-14.13805	132.09452	14	23.6	N										
G14	B2	-14.13824	132.09440	12	24	Y	10	20	6	100	90	SW	Int	A	1	N
G14	B3	-14.13828	132.09439	5	18.8	N										
G14	B4	-14.13837	132.09443	6	15.5	Y	5	5	3	100	45	SW	Int	A	1	N
G14	B5	-14.13828	132.09423	11	21.3	Y	N									
G14	B6	-14.13811	132.09431	14	18.3	Y	5	5	4	100	75	NE	Int	A	1	N
G14	B7	-14.13793	132.09429	14	20.7	Y	6	8	4	100	75	NE	Int	A	1	N
G14	B8	-14.13791	132.09420	12	19	N										
G14	B9	-14.13794	132.09413	10	22.1	N										
G14	B10	-14.13791	132.09408	9	19.3	N										
G14	B11	-14.13804	132.09409	9	18.1	N										
G14	B12	-14.13815	132.09408	9	29.1	Y	8	8	6	50	60	NW	Int	A	1	N
G14	B13	-14.13825	132.09401	8	23.7	N										
G14	C1	-14.13814	132.09390	8	22.5	N										
G14	C2	-14.13810	132.09394	9	22.6	N										

Quad	Tree	Latitude	Longitude	Tree Height (m)	DBH (cm)	Hollow present	Hollow Height (cm)	Hollow Width (cm)	Entrance Height (m)	Depth (cm)	Angle (deg)	Bearing	Type	State	Fragility	Activity
G14	C3	-14.13810	132.09395	9	21.5	N										
G14	C4	-14.13805	132.09397	9	21.2	N										
G14	C5	-14.13804	132.09396	9	23.9	N										
G14	C6	-14.13815	132.09378	12	32.5	N										
G14	C7	-14.13790	132.09374	14	42.2	N										
G14	C8	-14.13785	132.09382	16	28.2	N										
G14	D1	-14.13784	132.09372	12	26.4	N										
G14	D2	-14.13770	132.09367	9	24	N										
G14	D3	-14.13752	132.09374	11	27.7	N										
G14	D4	-14.13756	132.09388	11	22.6	N										
G14	D5	-14.13760	132.09395	13	26.3	N										
G14	D6	-14.13768	132.09391	9	38.9	N										
G14	D7	-14.13772	132.09393	8	21	N										
G14	D8	-14.13781	132.09391	12	21.1	N										
G14	D9	-14.13783	132.09396	10	24.2	N										
G14	D10	-14.13785	132.09404	15	41.1	Y	20	15	6	80	45	NW	Ext	D	5	N
G14	D10	-14.13785	132.09404	15	41.1	Y	5	5	10	100	30	NE	Int	A	1	N
G15	A1	-14.14756	132.10042	11	37.7	N										
G15	A2	-14.14758	132.10052	8	23	N										
G15	A3	-14.14757	132.10053	9	24.2	N										
G15	A4	-14.14750	132.10063	10	34.5	N										
G15	A5	-14.14767	132.10071	7	20.5	N										
G15	A6	-14.14773	132.10077	12	29.5	Y	5	5	4	100	75	SE	Int	A	1	N
G15	A6	-14.14773	132.10077	12	29.5	Y	6	7	4	100	75	SE	Int	A	1	N
G15	B1	-14.14780	132.10079	11	23.4	Y	5	5	3	50	30	SE	Int	A	2	N
G15	B2	-14.14785	132.10078	14	37.7	Y	20	20	3	100	80	SW	Int	A	2	N

Quad	Tree	Latitude	Longitude	Tree Height (m)	DBH (cm)	Hollow present	Hollow Height (cm)	Hollow Width (cm)	Entrance Height (m)	Depth (cm)	Angle (deg)	Bearing	Type	State	Fragility	Activity
G15	B3	-14.14788	132.10096	9	23.5	Y	5	5	5	40	30	NE	Int	A	1	N
G15	B4	-14.14811	132.10098	10	20.9	N										
G15	B5	-14.14816	132.10097	8	25	N										
G15	B6	-14.14829	132.10116	16	47.2	Y	10	10	100	100	45	SE	Int	A	1	N
G15	B6	-14.14829	132.10116	16	47.2	Y	10	10	50	50	45	SE	Int	A	1	N

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	Alex Kutt	Alex Holmes	*A. Holmes*	Nicole Conroy	[signature]	07/05/14

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Attachment 2 – GHD Memo - Mt Todd Vista Lab Testing

Memorandum

20 May 2014

To	Rod Johnson, Northern Territory Environment Protection Authority		
Copy to	Brent Murdoch, General Manager, Vista Gold Australia Pty Ltd		
From	Nicole Conroy	Tel	(08) 8982 0109
Subject	MT Todd Gold Mine EIS Supplementary information - Air Quality	Job no.	43/22079

Given the proximity of known Gouldian Finch breeding habitat to the existing mine pit and the mineral resource at Mount Todd, dust generated from the proposed mine operation recommissioning may impact on the Gouldian Finch and it's habitat.

A workshop was held at the NT EPA on 13 January 2014 between the NT EPA represented by Rodney Johnson, and Vista Gold Australia Pty Ltd represented by Brent Murdoch; in order to discuss issues contained in the Mt Todd Gold Mine EIS request for further information. Also present at the workshop was Dr John Woinarski, the NT EPA appointed biodiversity specialist.

Given the lack of data related to trigger values for dust in small bird populations, John Woinarski suggested that Vista Gold may want to consider conducting laboratory tests in order to understand what small bird trigger levels might look like.

Brent Murdoch queried whether the results of such testing would have any scientific validity, and whether in fact the Regulators would accept such results being adopted as legitimate trigger values for operational mining at Mt Todd.

GHD have since completed additional dust modelling as a result of the workshop discussions, and have documented this as part of the "Mt Todd EIS Response III" submitted by Vista Gold , dated 20th May 2014.

Given the proximity of known Gouldian Finch breeding habitat to the existing mine pit, and the extent of the mineral resource at Mount Todd, dust generated from the proposed mine operation recommissioning may impact on the Gouldian Finch and it's habitat. The extent and severity of the potential impact will be reduced through avoidance and mitigation, but given the proposed mine operation and the lack of scientific information about dust effects on small birds, it is unlikely that the impact can be completely mitigated.

The Mt Todd Project is relying on 'best practice' industry methodology to protect the Gouldian finch, comprising:

1. Mitigation by reducing the amount of dust produced
2. Monitoring of the Gouldian Finch population
3. Adaptive changes to operations if monitoring indicates distresses

Vista Gold is committed to building on and improving best practice methodology for the management of the Gouldian Finch in Australia, and have indicated a willingness to conduct experimental laboratory testing once construction is underway.

Vista Gold has not been able to identify anywhere in the world where this kind of experimental testing has been carried out, but is committed to proceeding; with caution, and in cooperation with other stakeholders who have an interest in Gouldian Finch conservation into the future.

This commitment is in addition to the extensive undertakings made by Vista Gold, as described in the EIS and the 3 supplementary reports.

Attachment 3 – GHD Mt Todd Gold Mine Draft EIS Additional Analysis for Air Quality Assessment

GHD

Vista Gold Australia Pty Ltd

Mt Todd Gold Mine Draft EIS

Additional Analysis for Air Quality Assessment

May 2014

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1. Objectives/Context

The Northern Territory EPA has advised that the dust levels in finch habitat appear to be excessive and more information has been requested from the modelling regarding the predicted dust levels. This document details an investigation and its findings, with regard to the following:

- a review of overall model uncertainty that could result in concentrations being over predicted by 50 per cent or more
- a detailed review of modelled pit emissions, particularly in relation to staged depths of the Mt Todd proposed operations
- a more critical assessment of the model settings used for the original EIS air quality assessment
- a multi- year assessment that allows for understanding of, not only worst case year but also variability around the worst case across other years.

2. Background

2.1 The Vista Gold Mount Todd Project and the Gouldian Finch

Vista Gold proposes to re-open and expand the existing mine at Mount Todd, Northern Territory. The mine is located in the south-western part of the Yinberrie Hills, approximately 50 km north of Katherine. The Yinberrie Hills is a Site of Conservation Significance (SOCS). The SOCS was declared partly on the basis of the breeding habitat it provides for the Gouldian Finch.

The Gouldian Finch is listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*, and as *Vulnerable* under the *Territory Parks and Wildlife Conservation Act 2000* (Northern Territory).

Given the proximity of known Gouldian Finch breeding habitat to the existing mine pit, and the extent of the mineral resource at Mount Todd, dust generated from the proposed mine operation recommissioning may impact on the Gouldian Finch and it's habitat. The extent and severity of the potential impact will be reduced through avoidance and mitigation, but given the proposed mine operation and the lack of scientific information about dust effects on small birds, it is unlikely that the impact can be completely dispelled.

2.2 Air Quality Assessment

A detailed air quality assessment was undertaken as part of the EIS to determine if levels of dust from the mining activities could be potentially harmful.

Australian guidelines for acceptable exposure for human populations are provided in the National Environment (Ambient Air Quality) Protection Measure (NEPM). The assessment criterion used for the Mt Todd project is 50 µg/m³ of dust as measured as PM_{10} averaged over a 24 hour period, with no more than five exceedances in any 12 month period, which is consistent with Australian guidelines.

The World Health Organisation (WHO 2000) indicates that no study has found a level of dust that does not have health implications for human populations. Other jurisdictions around the world have different criteria. For example, the United States has National Ambient Air Quality Standards (NAAQS) for PM_{10} of 150 µg/m³.

There is no clearly defined dust exposure limit for the health of small bird species, including Gouldian Finches. Victorian, New South Wales and Queensland air quality guidelines do protect a variety of 'beneficial uses' of the environment including human health (and wellbeing), aesthetic environment, agriculture and health and biodiversity of ecosystems. Biodiversity of ecosystems is the closest matter that could apply to potential impacts on the Gouldian Finch, but currently does not address dust; only vegetation impacting pollutants/indicators such as fluoride, ozone and sulphur dioxide.

The Queensland Guideline on 'Application requirements for activities with impacts to air' (EM960, Department of Environment and Heritage Protection) addresses impacts on the health and biodiversity of ecosystems by suggesting that if "…*contaminates are not listed in the* [Environment Protection Policy] *EPP (Air), a literature search may be required to determine potential risks*" (DERM, n.d. p.10).

2.3 Mine Production

With regard to dust emissions, as a general rule, the more earth mined and moved, the more dust generated. The mine production levels that were used and presented in the EIS air quality assessment are summarised in Table 1.

Standard practice with regards to air quality assessment is to consider a reasonable 'worst case' situation. Usually the daily, weekly or even monthly production schedule is not fully formed at the EIS stage of a mining project; and even if considered, it is unlikely to remain unchanged. Furthermore, it is difficult to predict what the weather conditions will be during a particular day in three years' time when production is predicted to be at certain volume. As such, it is considered reasonable that annual emissions are evenly distributed across all days of the year and that applied control measures are evenly controlled.

In reality, the site dust management plan in the context of an operating mine may contain measures that increase the focus of controls during known times of high dust emissions, such as seasonally in high wind periods during the dry season. Such situations are, conservatively, not reasonably modelled at the EIS stage of a project.

Table 1 Annual mine production schedule ('000 tonnes)

Mining year	Total ore mined	Total waste mined	Total tonnes mined	Strip ratio	Total rehandle	Total ore processed
Pre-production	11,764	24,761	36,525	2.10	-	-
1	28,101	33,803	61,905	1.20	316	17,799
2	20,983	55,290	76,273	2.64	5,085	17,750
3	23,941	78,227	102,169	3.27	1,108	17,750
4	18,285	71,608	89,893	3.92	6,061	17,750
5	29,066	58,329	87,395	2.01	-	17,799
6	7,561	71,279	78,840	9.43	10,770	17,750
7	4,777	54,405	59,182	11.39	12,973	17,750
8	7,078	45,482	52,560	6.43	10,672	17,750
9	10,700	38,710	49,410	3.62	7,099	17,799
10	24,331	27,864	52,195	1.15	-	17,750
11	22,861	2,592	25,454	0.11	-	17,750
12	Heap Leach & Stockpile			-	17,750	17,750
13	Heap Leach Only			-	9,505	9,505
Total	209,451	562,349	771,800	2.68	81,339	222,651

Note: Rehandle includes 13,200 t from the existing Heap Leach Pad

2.4 Dust Emission Calculations

Dust emissions were calculated using standard accepted practice contained within National Pollution Inventory (NPI) estimation techniques. For the mining industry, the estimation techniques are clearly specified in the NPI Mining Manual Version 3.1 (January 2012). Most of the supplied emission factor values and methods are consistent with those adopted by the US EPA.

Dust emitting processes are usually very process specific. For example, factors for dust emissions from blasting have been derived from measurements of a variety of different blasts, compiled into a single expression that is representative of the data set. For blasting emissions then, using two different types of explosives, say ANFO or emulsion, will generate different levels of dust. Site specific factors such as rock hardness are not considered in the emissions estimation techniques.

All years of mine production were examined. Annual dust (PM_{10}) emissions were predicted (assuming standard dust emission factors and reduction measures are adopted at the operating mine) for the first 10 years of operation (Table 2). The most earth mined and moved, and the most dust generated will be in Year 3. Hence Year 3 was assessed in terms of air quality as the reasonable worst case situation.

There was found to be an inter-annual variability of up to 33 per cent from the maximum emissions year. On average, emissions over the modelled ten year period are 22 per cent lower than the year 3 emissions (Table 2).

Vista Gold anticipates that mining in Year 1 and Year 2, when the estimated annual emissions are expected to vary 26 per cent and 17 per cent from the worst case respectively (Table 2), will provide the opportunity to calibrate modelled dust emissions so that by Year 3 targeted controls are in place.

Table 2 Estimated PM_{10} annual emissions for the first ten years.

Production Year	Total Mined Earth Mined (Mtpa)	Total Ore Processed (Mtpa)	Estimated Annual PM10 Emissions (tonnes per year)	Variation from Year 3 (max.) (%)
1	61.9	17.80	1,893	-26
2	76.3	17.75	2,144	-17
3	102.2	17.75	2,569	0
4	89.9	17.75	2,376	-8
5	87.4	17.80	2,315	-10
6	78.8	17.75	2,212	-14
7	59.2	17.75	1,891	-26
8	52.6	17.75	1,776	-31
9	49.4	17.80	1,718	-33
10	52.2	17.75	1,738	-32
Average	71.0	17.76	2,063	-22

2.5 Multi-year Assessments

Air quality assessments are normally based on 12 months of meteorology and emissions. Averaging over multiple years is generally not accepted by regulators because it could be perceived as allowing a company to have uncontrolled emissions for a short duration, for example excessively high pollution output for year one, but low pollution output in future years. As an example of this thinking, EPA Victoria has indicated in new draft modelling guidelines (Publication 1550) that emissions have to be assessed over five years of meteorology, and compliance must be obtained with all five years audited individually, not as a whole block.

Predicted dust emissions for Year 3 at Mt Todd have been further delineated per source (still assuming application of standard emission factors and reduction measures) and this is depicted in Table 3 below.

As a rule of thumb from such a large mining operation, a reduction in total emissions equates to an equal reduction in predicted ground level concentrations of dust. In other words, it is best to focus on model accuracy, and the controls applied to the largest dust contributors. The three sources of the largest percentage of dust emissions/ PM_{10} in Year 3 are:

- wheel generated dust from haul roads (49.7%)
- the screening process at the Process Plant (12.9%)
- loading trucks on the WRD (10.9%).

Table 3 Estimated Maximum Annual Controlled Dust Emissions for Mt Todd Mine Site Operations of PM_{10}.

Location of dust source	Dust emitting process	Estimated Emissions (tonnes/year) PM10	% of Total
Mine Pit	Blasting	3.5	0.1
	Loading mined material to trucks	62.5	2.4
	Wind erosion from mine pit	149.1	5.8
ROM (Run on Mine) pad	Loading Stockpile (50% water sprays)	37.3	1.5
	Wind erosion of ROM stockpile (50% reduction)	4.9	0.2
Low Grade Ore (LGO) Stockpile	Loading LGO Stockpile (50% water sprays)	13.0	0.5
	Wind Erosion Of LGO stockpile (50% reduction)	25.5	1.0
Waste Rock Dump (WRD)	Wind Erosion of WRD (30% reduction – rock armour)	174.3	6.8
	Loading WRD	281.2	10.9
Haul Roads	Wheel Generated Dust (90% reduction via chemical stabilisation)	1,277.7	49.7
	Wind Erosion of Haul Roads (50% reduction)	2.8	0.1
Processing Plant	Loading Primary Crusher (70% reduction as enclosed)	3.4	0.1
	Conveyor transfer points(1) (70% reduction for enclosure)	20.4	0.8
	Primary Crusher (75% reduction due to scrubbers)	17.8	0.7
	Secondary Crusher (3) (75% reduction due to scrubbers)	63.9	2.5
	Screening (75% reduction due to scrubbers)	332.3	12.9
	Wind Erosion of Coarse Ore Stockpile	1.2	0.0
	High Pressure Grinding Roll (HPGR)(1) (99% reduction as enclosed)	33.2	1.3
Tailings Storage Facility 1	Bulldozer Operation	17.9	0.7
	Waste Rock Unloading for Construction	47.3	1.8
Total		**2,569**	**100.0**

(1) Includes total values for material which is oversized and reprocessed.

2.6 Blasting Emissions

Dust, as PM_{10}, emitted from blasting activities was calculated to be approximately 3.5 tonnes per year. This is approximately 0.14 per cent of total emissions, significantly less than many wind erosion sources.

Even though blasting sources may be close to the Finch habitat, the relative magnitude of other dust sources at a greater distance mean that emissions from blasting is considered as insignificant in comparison to other sources.

2.7 Haul Roads

Dust emissions from haul roads due to trucks moving material out of the pit to either the ore processing centre or the waste rock dump comprises almost half of all the dust emissions from the site. This is with a 90 per cent reduction being applied to the modelling due to chemical stabilisation of haul road dust.

Of the estimated 1278 tonnes of haul road dust, almost 87 per cent of this was assumed to be generated inside the pit. The pit generated haul road dust emission estimation has had an additional 5 per cent reduction applied due to passive pit retention (in addition to the 90 per cent from chemical stabilisation). This 5 per cent value is the default pit retention factor for PM_{10} and standard practice in air quality modelling of mining operations, as defined in the NPI Mining Manual, but with no allowance for pit depth.

2.8 Previous Air Quality Assessment – 1991

In 1991, Nigel Holmes & Associates (Holmes 1991) conducted an air quality assessment for the original Mt Todd gold mine. This assessment was detailed in Appendix 14 of the EIS report authored by NSR. The 1991 assessment was based on a 15 Mtpa total earth mined operation. This was a significantly smaller operation than the approximate 100 Mtpa operation currently being proposed, however still useful as a point of comparison. The 1991 air quality assessment predicted dust impacts approximately half of those predicted for this proposed re-opening of the mine. The fact that the current predictions are only double (and not six-fold as would be expected based on the throughput ratio of the current mine from the earlier mine) is due largely to chemical suppressants being specified on the haul roads.

2.9 Dust suppression

The 90 per cent dust suppression value is based on information supplied in Buonicore and Davis (1992). It is likely that technological improvements have been made since the late 1980's and early 1990's in mine site dust suppression and haul road stabilisation; and this could be considered as a conservative value for this type of dust control technique.

Without more recent studies however, the amount of extra dust suppression is unknown. Using a value of 100 per cent suppression is not acceptable because even sealed roads have some dust emissions due to entrained spillage. As a compromise, a 95 per cent reduction, instead of 90 per cent, could be reasonably applied to model predictions.

3. Model Conservativeness

Model predictions for regulatory purposes are **always** conservative (i.e. model predictions err on the side of caution and therefore predictions may be greater than in reality). If there is any doubt regarding a model output or emission factor, standard practise is always to lean to the more conservative side. The precautionary principle is always applied to regulatory modelling.

3.1 US EPA Model Guidance on conservatism

The United States Environmental Protection Agency (US EPA) has detailed guidance documentation with regards to the application of air quality models. Section 9 of Appendix W (US EPA 2005 p.68246) discusses the accuracy and uncertainty of air dispersion models.

"*Even with a perfect model that predicts the correct ensemble average, there are likely to be deviations from the observed concentrations in individual repetitions of the event, due to variations in the unknown conditions. The statistics of these concentration residuals are termed*

''inherent'' uncertainty. Available evidence suggests that this source of uncertainty alone may be responsible for a typical range of variation in concentrations of as much as ±50 percent."

Studies of dispersion model accuracy have clearly found that (US EPA 2005, p.68246):

1. Models are more reliable for estimating longer time-averaged concentrations than for estimating short-term concentrations at specific locations.
2. Models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area.

It has long been recognised in industry that air dispersion models have a factor-of-2 accuracy (US EPA 2005), however a number of studies have found accuracy in the predicted highest concentrations occurs at between ±10 to 40 per cent.

To improve the basis for decision-making, the US EPA continues to study procedures for determining the accuracy of models, quantifying the uncertainty, and expressing confidence levels in decisions that are made regarding emissions. However work in this area appears to move forward slowly and sporadically.

The US EPA (2005 p.68247) clearly concludes that:

"…*no specific guidance on the quantification of model uncertainty for use in decision-making is being given at this time. As procedures for considering uncertainty develop and become implementable, this guidance will be changed and expanded. For the present, continued use of the ''best estimate'' is acceptable.*"

3.2 Pit Retention

Pit retention factors are fixed irrespective of the size, shape or depth of a mining operation. This is an example of the precautionary approach adopted within NP estimation techniques. Pit retention is a passive control applied to emission estimations from an open cut mine or quarry that reduces the amount of dust that escapes over the top of the mine to the surrounding environment.

The air patterns inside an open cut pit consist of complex three dimensional structures. An example of the vortex nature of air patterns within a pit is shown in Figure 1. Factors affecting the air patterns include, but are not limited to, the wind speed, the pit side slope and benching size, the planar shape, atmospheric turbulence conditions and pit depth. Chinthala and Khare (2011) provide a good description of factors affecting particle dispersion inside a deep open cast mine.

Pit retention control factors specified by NPI for dust are 50 per cent for Total Suspended Particulate (TSP) and 5 per cent for PM_{10}. TSP is defined as all dust, normally less than 50 or 80 µm diameter. In other words, 95 per cent of all PM_{10} generated at the bottom of a 4 m, 40 m or a 400 m deep mine is modelled as escaping. This is an example of the conservativeness applied to standard air quality modelling accepted by Australian regulators, and yet this is unlikely to represent all realities. Therefore the pit retention factor model assumptions have been investigated further.

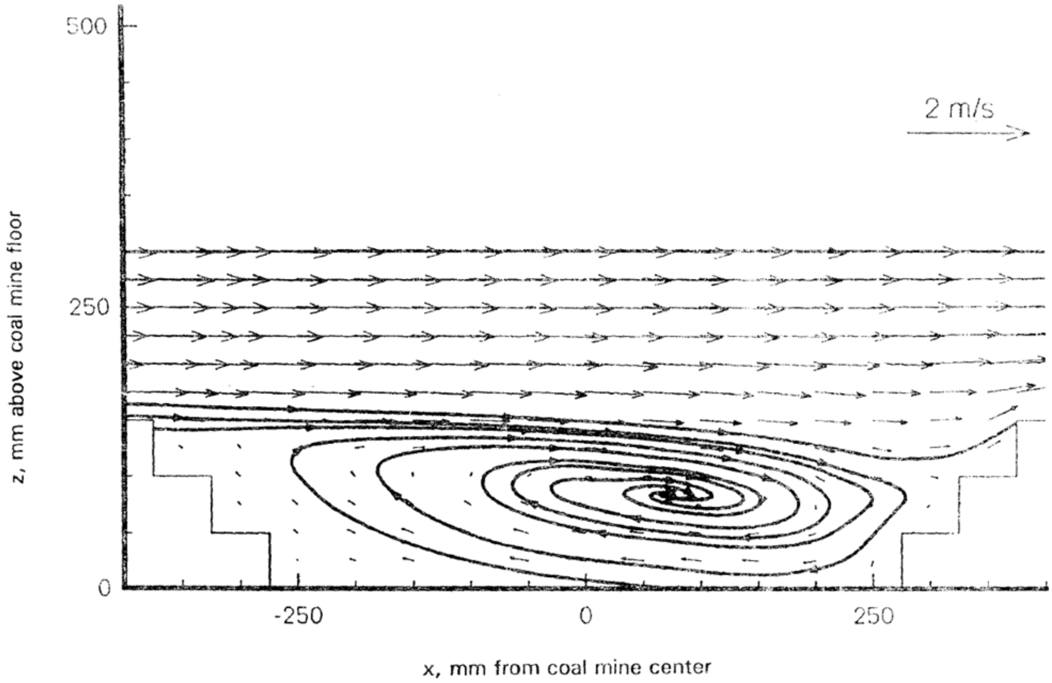


Figure 1 Centre plane velocity vectors and streamlines for an open cut mine as computed from pulsed-wire anemometer measurements in a wind tunnel, from Thompson (1994).

3.2.1 Gas Tracer Study

The source of the pit retention values in air quality models relates back to a US EPA study by Thompson (1994). This study examined a series of 20 different rectangular shapes in a scaled wind tunnel experiment using gas as a tracer. The 1/300th scale models, which equated to mines no deeper than 75 m full scale (the majority of the tests were done on equivalent full scale mine pits of 45 m), used the residence time of a gas as a measure of the amount of pit retention. The longer the gas stayed in the wind tunnel cavity, the more dust is likely to be retained in the pit. The wind tunnel modelling used a nominal neutral boundary layer (D class) with an equivalent full scale roughness length of 0.03 m.

The residence time was found for rectangular mines to be proportional to:

$$Residence\ Time = 33.8\frac{Mine\ Volume}{Wind\ speed\ x\ Mine\ Length\ x\ Mine\ Width}$$

It was shown that the proportionality constant for a triangular cross section was 29, close to the 33.8 constant found for rectangular pit cross-sections.

The Thompson (1994) study is cited as the basis of the US EPA air dispersion model ISC3 pit retention model.

A detailed study by Holmes Air Sciences (now PEL) for the Minerals Council of NSW (19 July 2000) examining particular matter and mining cites the Thompson (1994) study. This Holmes (2000, p.7-4) report states that "*under light wind conditions (say 1 m/s) only 5 percent of the particles escape*." There are emission control factors stated in Appendix A of the Holmes (2000) report that are identical to those stated in the NPI Mining emissions estimation manual (2012). It is highly likely that the 5 per cent pit retention factor stated in NPI Mining (2012) is sourced from these references, without consideration of more details.

In general, mining emission factors and controls are based on emissions modelling and monitoring from coal mines, in particular coal mines from the Hunter Valley NSW. However,

Hunter Valley open cut coal mines are not hundreds of metres deep and therefore differ considerably from that at the proposed Mt Todd mine site.

3.2.2 Pit Retention for Particles

Cole and Fabrick (1984) produced a relationship that related pit dust escape fraction to pit depth, taking into account particle deposition velocity (Vd) and vertical diffusivity (Kz). This model has been applied to the dust fractions as modelled for Mt Todd, with a vertical diffusivity value of 7 m²/s and particle deposition velocity based on mean particle diameter (both as suggested by Cole and Fabrick 1984). A plot of this function, along with the NPI default value and the Thompson (1994) gas tracer study, derived for the Mt Todd mine are shown in Figure 2. The Cole and Fabrick relationship approaches the NPI default value for a mine depth of 30 m. The Thompson curve was scaled assuming 30 m corresponded to 5 per cent pit retention. The applicable pit retention factor for Year 3 of mine operations is shown in Figure 2 by the ellipse.

This review of the model shows that applying the default pit retention value for PM_{10} for the Mt Todd mine is overly conservative; especially because the existing mine is already (nominally) 100 m deep and new operations have not yet started. It is more likely that the actual pit retention factor for PM_{10} resides somewhere between the Thompson gas tracer study curve and the Cole and Fabrick derived value, i.e. between 20 and 40 per cent, as opposed to a flat 5 per cent as directed by NPI emission control factors.

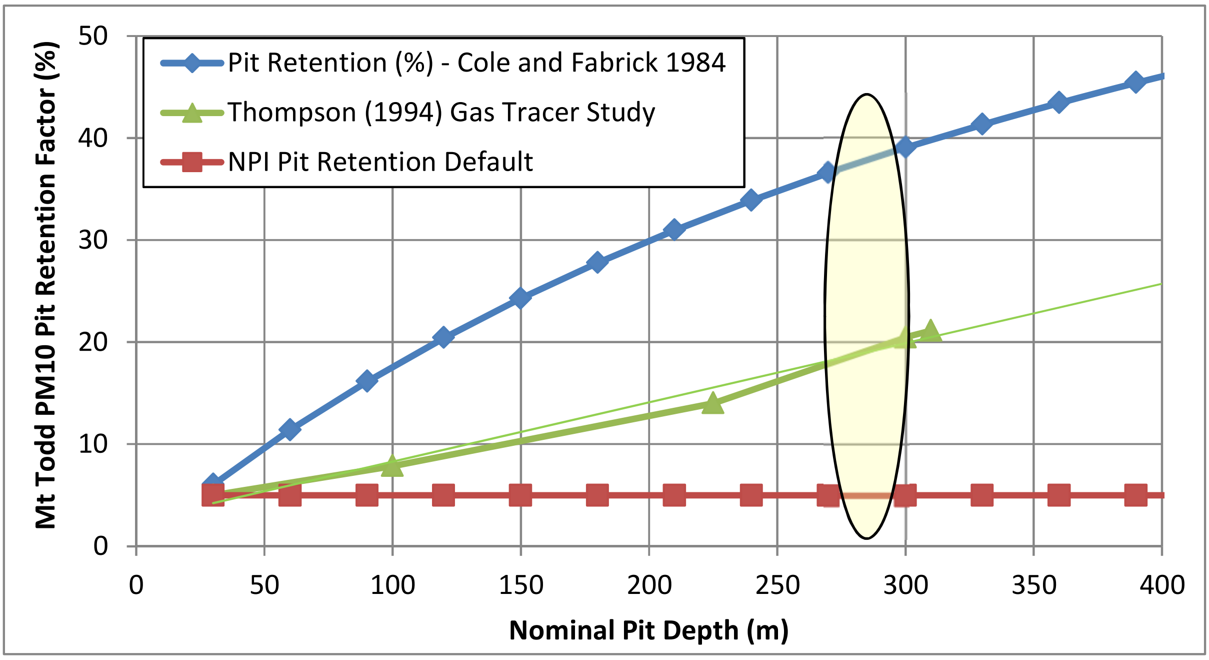


Figure 2 Pit Retention Scale Factor for Mt Todd Mine based on Thompson (1994) Gas Tracer Study - applicable Year 3 pit retention factor shown by ellipse.

It is possible to adjust the source mass emissions by the Cole and Fabrick pit retention factor of 40 per cent for Year 3, and also apply a 95 per cent haul road dust control factor instead of a 90 per cent value (as discussed above in Section 2.7). For this scenario, it can be calculated that the total PM_{10} dust emissions are estimated to reduce by 33 per cent from 2569 tonnes per year to 1720 tonne per year.

3.3 Modelled Vertical Pit Dispersion

The air quality dispersion model used to predict dust dispersion was AUSPLUME. This is the standard air quality model in Australia.

The mine pit sources were modelled with an initial vertical spread of only 1 m, i.e. just escaping from the surface plane of the pit. A review of modelling approaches has found that this conservation approach can be revised to better simulate the real-world situation of a deep open pit mine.

Modelling guidance for the US EPA equivalent model for AUSPLUME, ISC3, indicates that for an open pit the initial vertical dispersion should be set to a value of the effective pit depth, d_e, divided by 4.3[1]. The effective pit depth, d_e, is defined as the pit volume divided by the product of its length and width. For the Year 3 pit, the effective depth for modelling purposes, d_e, is approximately 270 m assuming a frustum shape; and the effective pit diameter is the average of the top and bottom average distance/diameters. Therefore an initial vertical dispersion value of approximately 63 m should be applied to the modelling. This is a significant change from the 1 m adopted in the EIS modelling.

The physical explanation of this is that if there is enough wind energy to cause dust to be expelled from the deep pit, then it will be mixed through some depth of the atmosphere rather than be restricted close to the ground surface surrounding the pit.

3.4 Modelled Surface Roughness

Surface roughness in the original EIS study was modelled as 0.1 m for the region. AUSPLUME only allows for a single surface roughness value to be applied for the entire region.

A surface roughness value of 0.1 m corresponds to a flat rural terrain. Upon review, it is felt that this characterisation for the entire area was too conservative, given the deep pit and a high waste rock dump that could have a large impact on local atmospheric turbulence. Therefore, an increased surface roughness value to 0.4 m is suggested as more representative of real world conditions during the operation of the mine. A surface roughness value of 0.4 m corresponds to a rolling rural terrain and landscape characterisation.

3.5 Relative Humidity

Current air quality modelling practise does not take into account relative humidity effects on dust. High humidity levels in the wet season are likely to result in water condensation on particulates, thereby increasing their mass and enhancing depletion. There are few studies that have examined this and therefore it is difficult to place a quantitative value to its effect. However, as will be shown in subsequent sections of this document, this phenomenon is unlikely to have a significant impact on the peak dust levels as they mostly occur during the dry season months, where humidity levels are considerably lower than those in the wet season. The exclusion of wet deposition processes in the modelling reflects the conservative assumption that every model hour has no rain or ambient temperatures exactly at the dew point causing condensation on particulate matter (fog is rare in the tropics although mist can occur during monsoonal rains).

[1] http://www.weblakes.com/guides/iscst3/section6/6_2_4.html

3.6 Artificial Humidity

It may be possible to artificially increase the relative humidity in and around the pit during the dry season months, subject to water availability. Foggers or water spray cannons, commonly used to evaporate excess water from storage ponds (or as used in snow making – under very different meteorological conditions), could be deployed as a method of both reducing wind erosion from exposed surfaces and increasing the relative humidity, so as to enhance fine particulate agglomeration. The quantifiable benefits of this are unknown.

4. Core Breeding Area Dust Levels

Time history plots of predicted 24 hour average PM_{10} dust levels in the breeding area have been assessed.

A series of 13 discrete receptors have been modelled that represent the Gouldian Finch core breeding area, as shown in Figure 3, with tabulated Easting and Northing coordinates represented in Table 4.

Table 5 shows time history plots of predicted 24 hour average PM_{10} dust levels for each of the 13 receptors for Year 3 production. It can be seen that at some times of the year dust levels are predicted to be quite low. Those areas of the breeding habitat most affected, DR9 and DR11, are located closest to the mine (Figure 3).

A contour plot of the average PM_{10} level for the entire year is shown in Figure 4. This shows that areas towards the SW corner of the breeding habitat are significantly lower than 50 µg/m³.

Plots of monthly average PM_{10} dust level are shown in Table 6. It is evident that dust levels in the dry season months are considerably higher than those during the wet season. The SE trade winds that are constant through this part of the continent at this time of year (non-Monsoon) dominate the dust dispersion.

Table 4 Modelled Breeding Area Receptors

ID	Easting (m)	Northing (m)
DR1	184500	8432500
DR2	185500	8432500
DR3	186700	8432500
DR4	184500	8433500
DR5	185500	8433500
DR6	186700	8433500
DR7	184600	8434500
DR8	185500	8434500
DR9	186250	8434500
DR10	185000	8435500

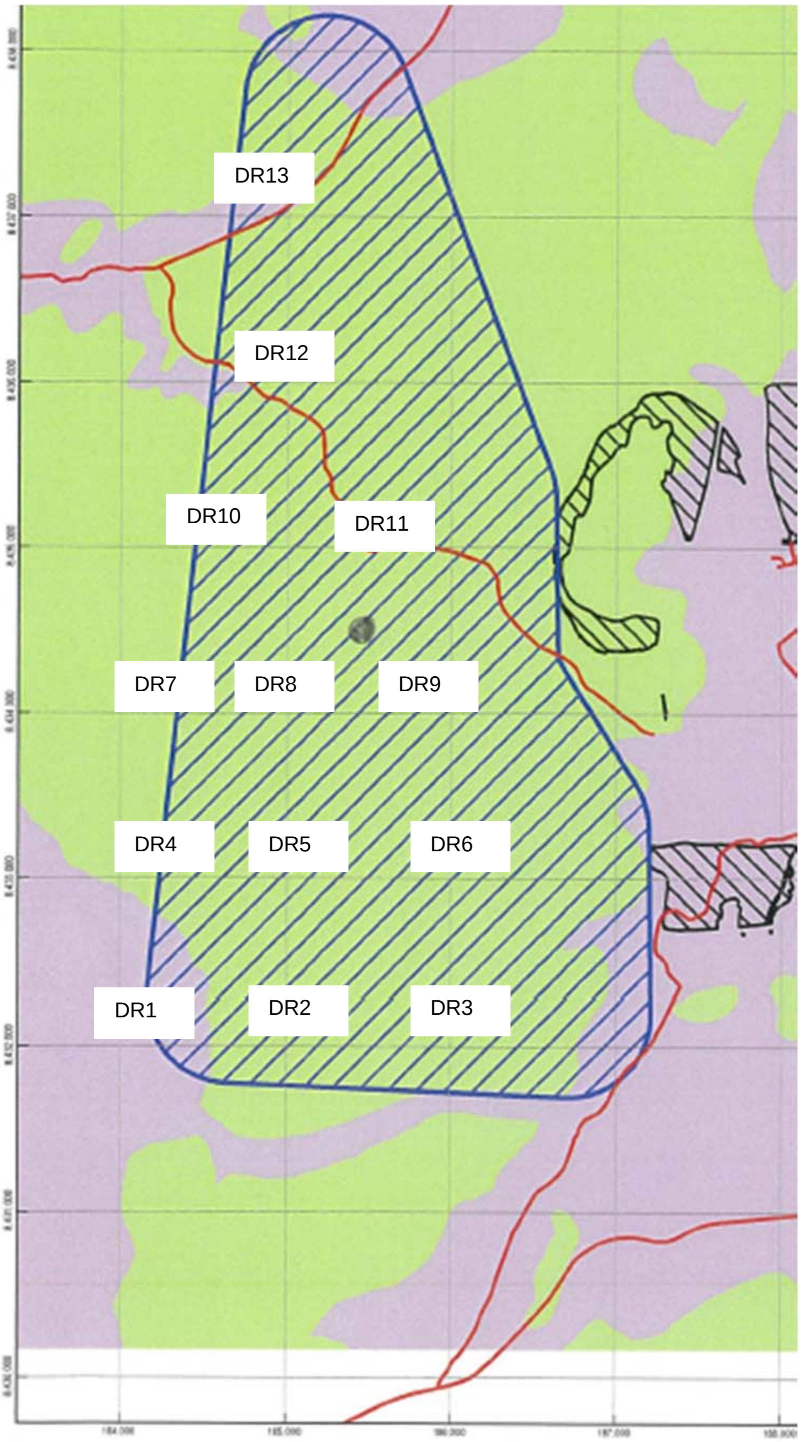
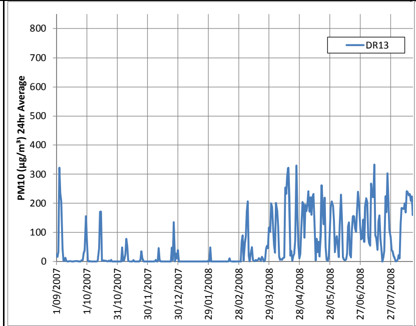


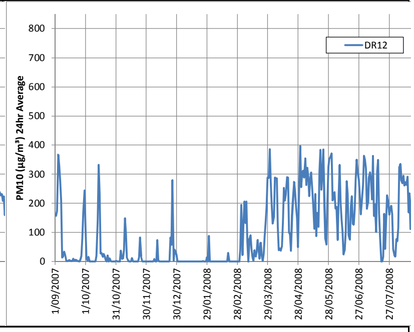
Figure 3 Location of modelled breeding area receptors

Table 5 Time History plots of 24hr average PM_{10} (µg/m³) for each receptor - Year 3 Production from Original EIS Modelling.

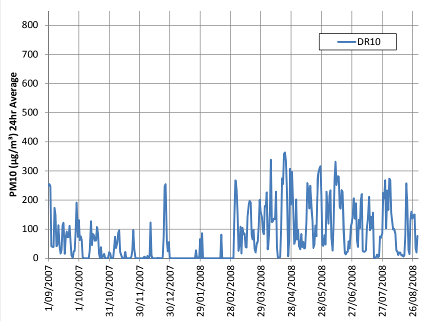
DR13



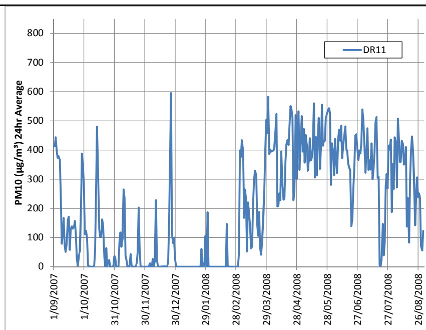
DR12



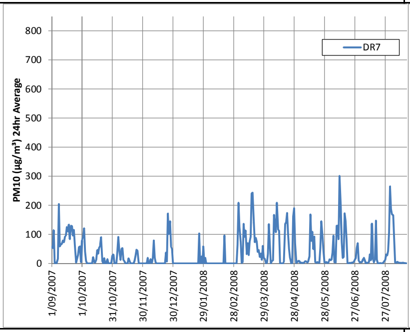
DR10



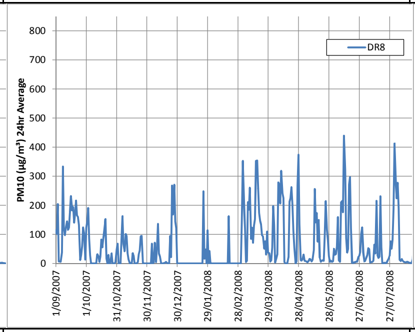
DR11



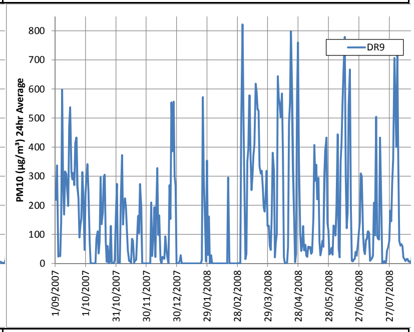
DR7



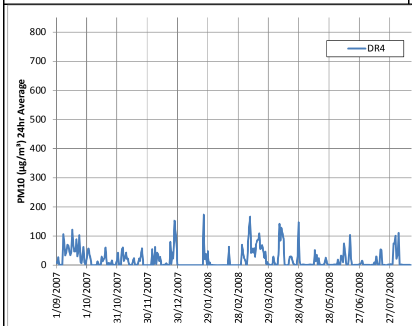
DR8



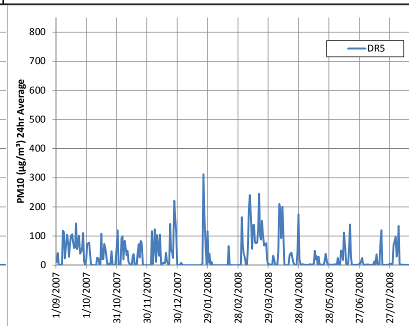
DR9



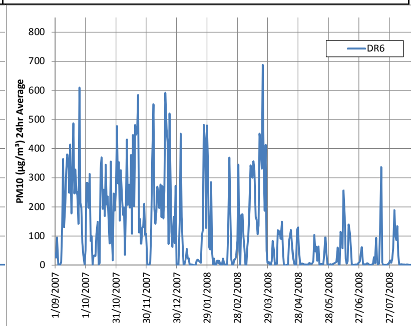
DR4



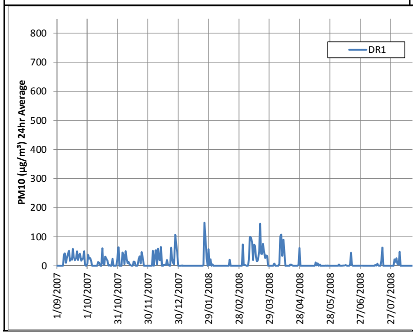
DR5



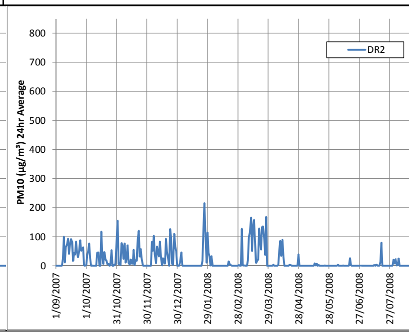
DR6



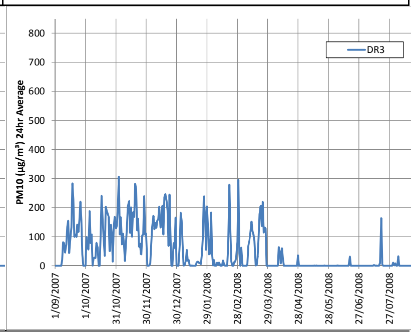
DR1



DR2



DR3



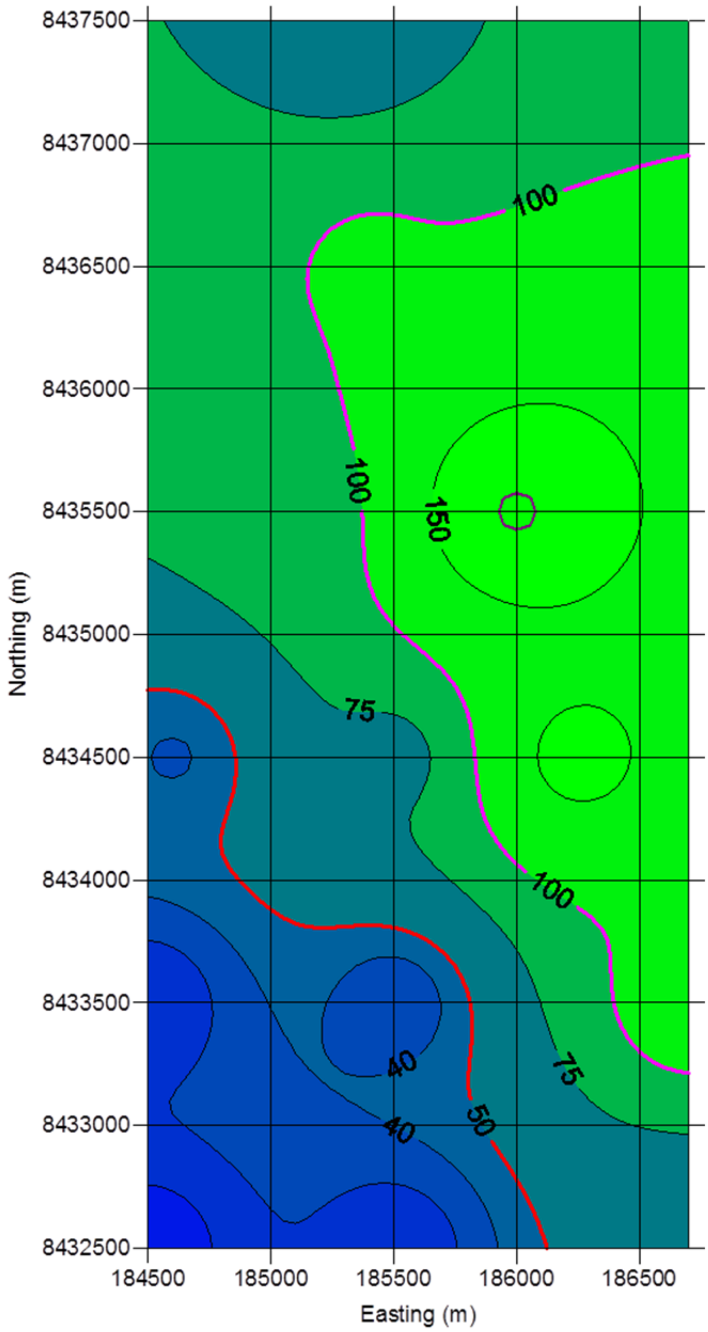
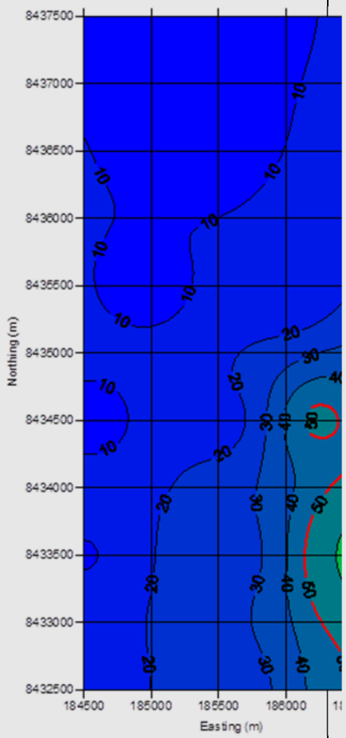
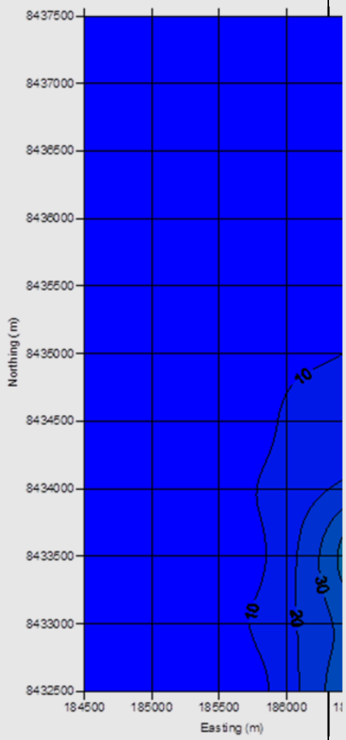
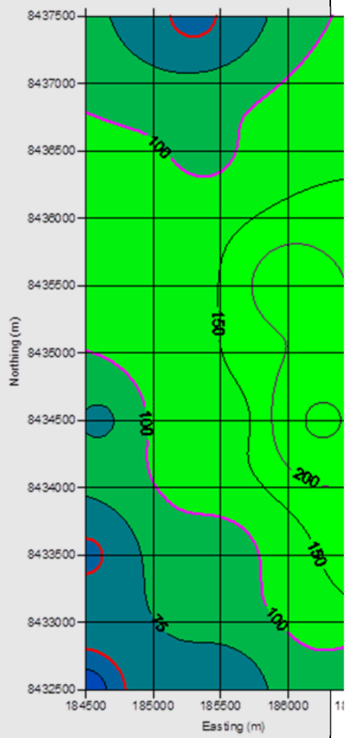
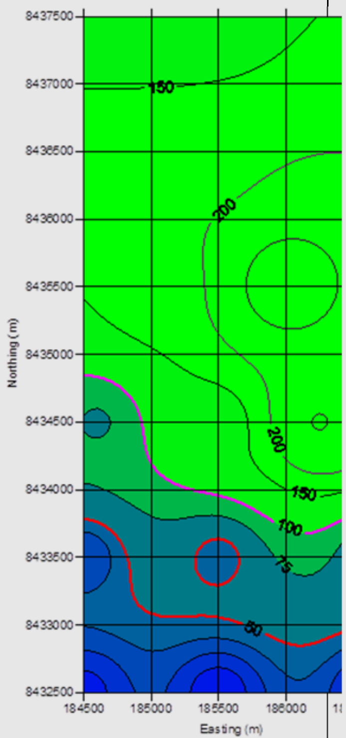
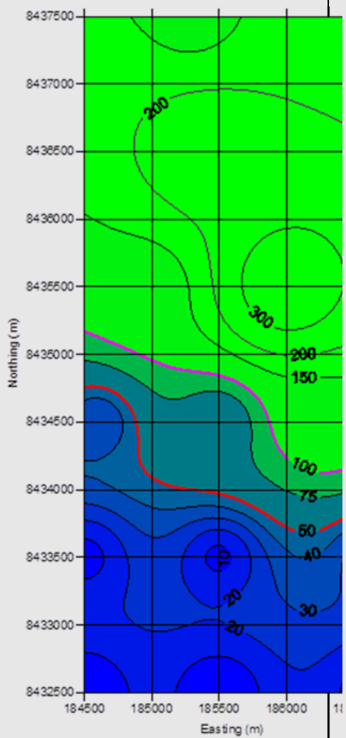
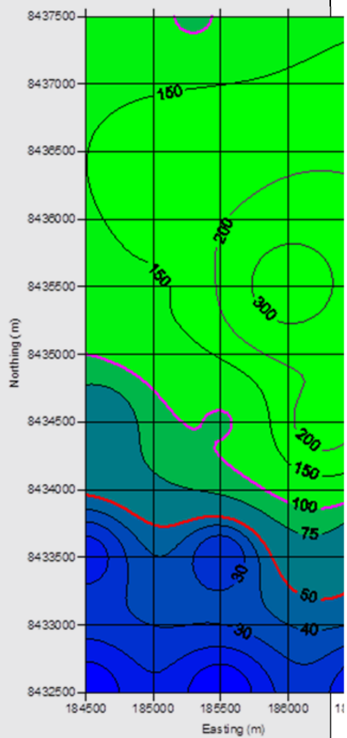
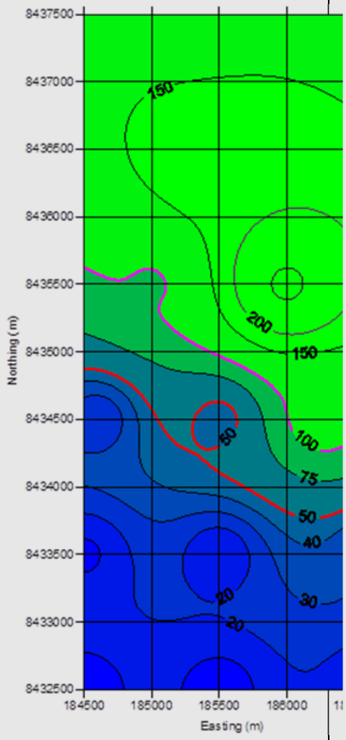


Figure 4 Annual Average PM10 (µg/m³) GLC across breeding habitat. Based on Year 3 Production - Original EIS Modelling.

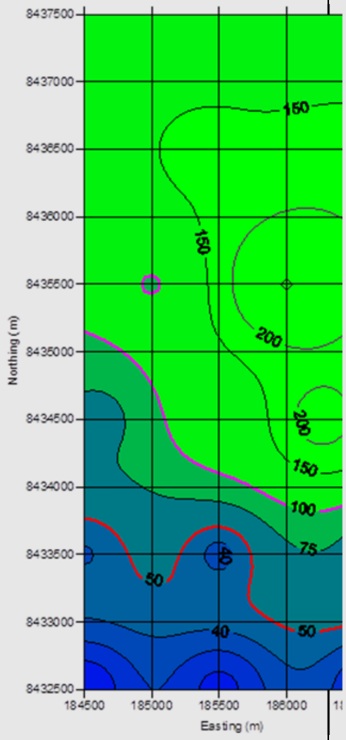
Table 6 Contour plots of monthly PM_{10} (µg/m³) average across breeding habitat based on Year 3 Production - Original EIS Modelling.

January	February	March
		
April	May	June
		

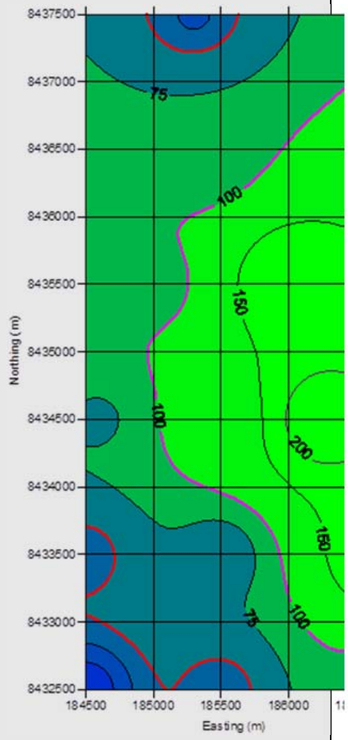
July



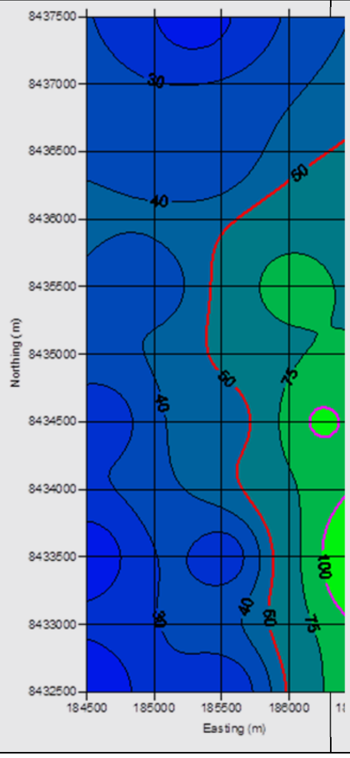
August



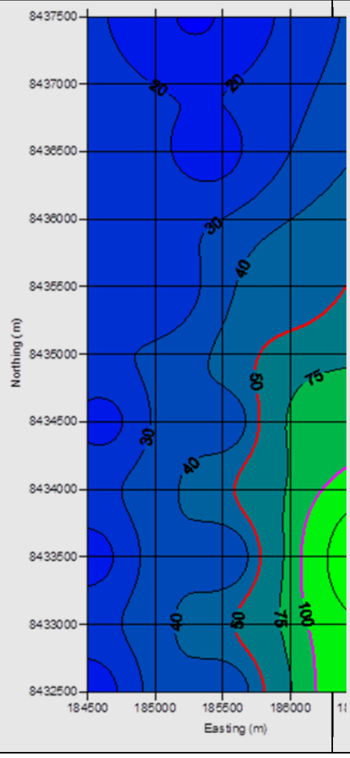
September



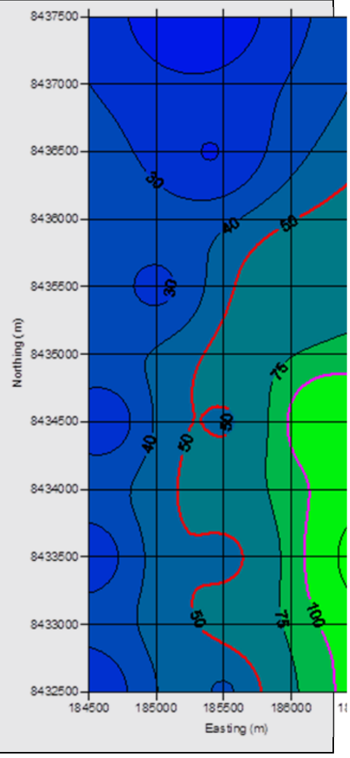
October



November



December



5. Updated Emissions and Modelling

Updated emission inventories, with the more realistic depth-dependant pit retention factor and haul road dust suppression, were constructed for modelling purposes. The updated surface roughness and initial vertical source spread were also included in the model. A summary comparison of the annual average PM_{10} levels at each modelled breeding area receptor is shown in Figure 5.

The updated model results in predicted higher dust levels (on average) to the southern parts of the breeding area (DR's 1, 2, 3, 4 and 5); however all other receptors are lower, some by a significant amount.

The inter-annual average PM_{10} dust levels across the breeding area predicted for the first ten years of mine operation are shown in Figure 6 for the updated air quality model. Across the breeding area as a whole, PM_{10} levels are significantly lower for the updated, more realistic model. The annual average PM_{10} levels across all modelled discrete receptors over the breeding area were reduced from 74.4 µg/m³ to 40.2 µg/m³, a 54 per cent reduction. It is predicted that after a steep increase in emissions during the first three years, there is a continual reduction over the remaining life of the mine.

The day-to-day average across the breeding area is shown in Figure 7. Predicted emissions for years 3 and 9 are also shown in Figure 7. These years are predicted to have the greatest and the least dust emissions respectively. It is clearly evident from Figure 7 that dust levels across the whole breeding area, as a whole, increase markedly from March onwards. Figure 7 clearly shows the dramatic influence of the monsoon onset (reversal of predominate wind) late December and through January to the end of February (with a temporary lull in NW monsoon winds near Australia Day). By March, the dry-season trade winds are re-established (although the ground conditions will remain wet for a little longer).

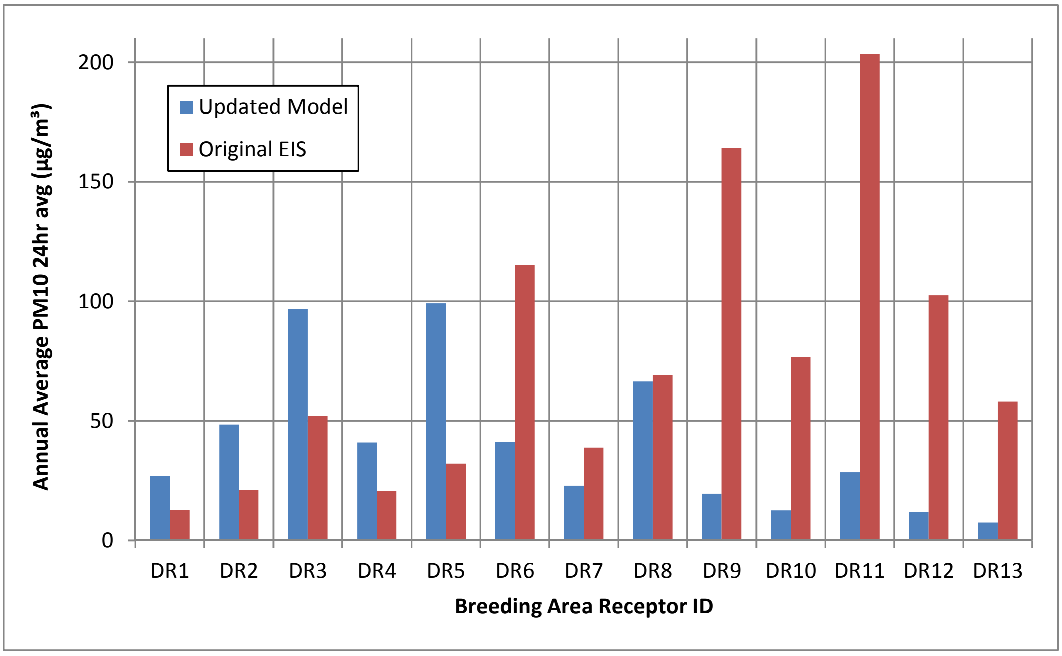


Figure 5 Comparison of Updated Model and Original EIS Model - Annual Average PM_{10} (µg/m³) of Breeding Area Receptors.

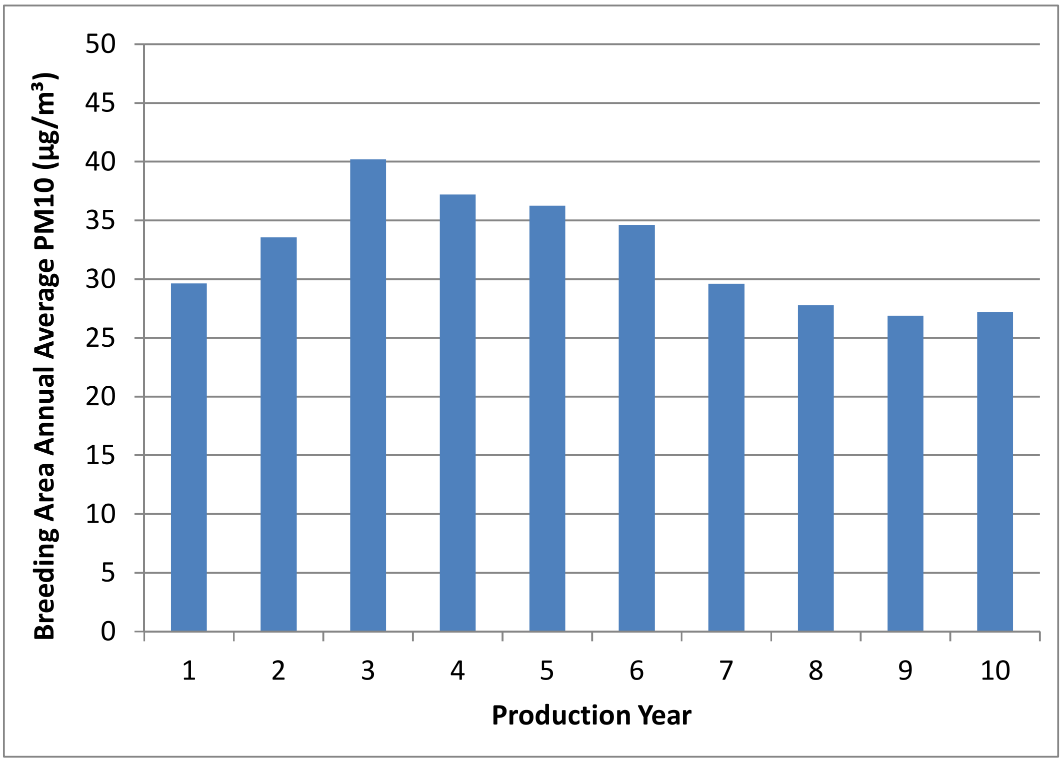


Figure 6 Predicted Annual Average PM_{10} (µg/m³) levels across the Breeding Area for mine production years 1 to 10 - based on updated modelling using realistic assumptions.

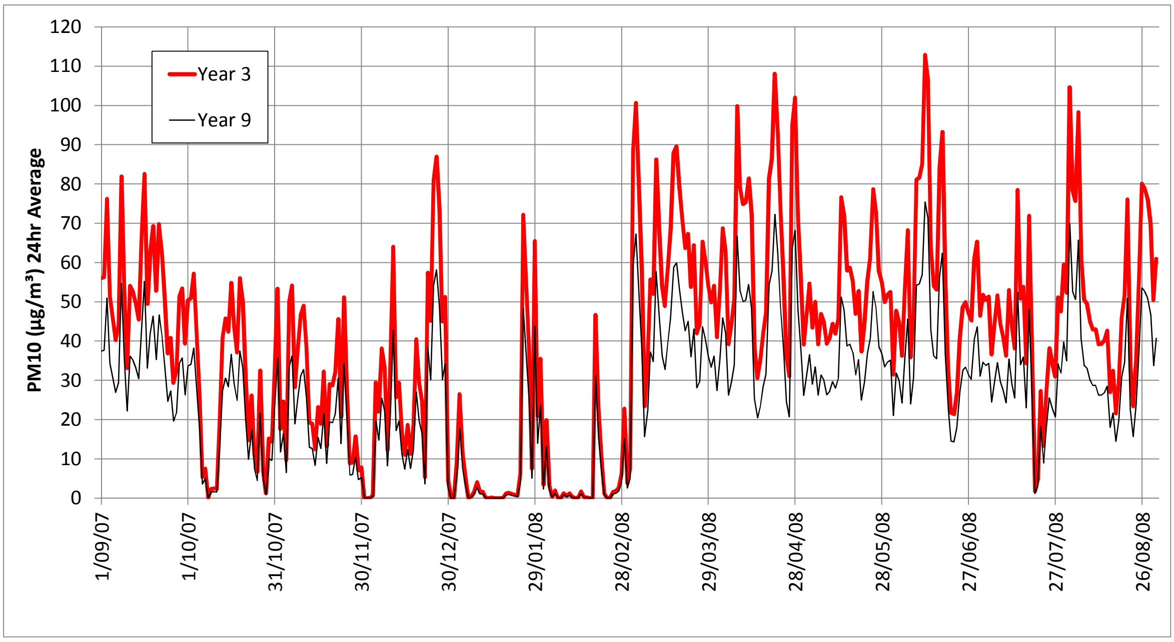


Figure 7 Time History of Average Breeding Area PM_{10} (µg/m³) for Year 3 - Based on updated modelling using realistic assumptions.

6. Atmospheric Stability

It is known that more stable atmospheres, especially those that develop inversion layers[2], lead to a reduction in emissions from inside an open cut mine - the deeper the pit, the greater the dust suppression. This effect has not been examined in great detail for this project. It would require modification to the emissions inventory for those in-pit sources based purely on atmospheric stability class.

Conversely, it is also known that unstable atmospheres enhance dispersion of emissions from inside a pit. The net result may be that there is little difference on an annual average basis; however, there may be some changes to the peak emissions. This issue will need further examination if a quantifiable answer is required.

By using the neutral atmosphere assumption of Thompson (1994), the model has assumed a conservative stance without the effect of stable and unstable atmospheres causing less downwind dust impact (the former due to higher pit retention and the latter by a greater effective pit depth).

[2] Refers to a "temperature inversion", where there is an increase in temperature with height. An inversion layer can lead to pollution being trapped close to the ground by suppressing convection, acting as an effective "cap". Winds are lighter with less energy available to vertically lift dust out of an open pit.

7. Other Dust Sources

A review of the dust emission inventory in Table 3 shows that the other large dust sources include wind erosion from mine and waste rock dump, screening of ore and loading and unloading operations at the waste rock dump.

Dust emissions from screening and crushing operations can be reduced to virtually zero if the machinery were to be enclosed and a high quality bag house filter system employed.

Wind erosion from highly exposed surfaces of the mine and waste rock dump are difficult to control. The wind erosion emissions factors are generally quite conservative and are mostly applicable to active stockpiles. It is likely that wind erosion from areas undisturbed for 12 or more months will reduce substantially as grass and other plants are likely to seed and grow in the months after the wet season rains. This process may be unlikely to occur in the mine pit itself, however, it may occur on some parts of the waste rock dump.

NPI allows for a default value of 90 per cent dust reduction for revegetation. However, only a 40 per cent reduction is applicable for unsustainable vegetation growth.

8. Concluding Comments

A detailed review of modelling methods and the origin of certain NPI default control factors allowed for the dust emissions inventory to be updated. Additional modelling indicates that the original EIS modelling was conservative, possibly as high as twice what is likely to occur in reality, however all model predictions are only as accurate as the basis of the assumptions and the degree to which dust control measures are actually implemented.

This review process has clearly identified that dust emissions from blasting activities are unlikely to be a significant source of dust compared to other sources.

9. Limitations

This document has been prepared by GHD for Vista Gold Australia Pty Ltd and may only be used and relied on by Vista Gold Australia Pty Ltd for the purpose agreed between GHD and the Vista Gold Australia Pty Ltd.

GHD otherwise disclaims responsibility to any person other than Vista Gold Australia Pty Ltd arising in connection with this Report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this document were limited to those specifically detailed in the document and are subject to the scope limitations agreed between GHD and the Vista Gold Australia Pty Ltd.

The opinions, conclusions and any recommendations in this document are based on conditions encountered and information reviewed at the date of preparation of the document. GHD has no responsibility or obligation to update this document to account for events or changes occurring subsequent to the date that the document was prepared.

The opinions, conclusions and any recommendations in this document are based on assumptions made by GHD described in this document. GHD disclaims liability arising from any of the assumptions being incorrect.

This report presents the results of an air quality impact assessment prepared for the purpose of this commission. The data and advice provided herein relate only to the project and structures described herein and in the original EIS study and must be reviewed by a competent engineer / scientist before being used for any other purpose. GHD accepts no responsibility for other use of the data.

An understanding of site's environmental impact depends on the integration of many pieces of information, some regional, some site specific, some structure specific and some experience based. Hence this document should not be altered, amended or abbreviated, issued in part or issued incomplete in any way without prior checking and approval by GHD. GHD accepts no responsibility for any circumstances, which arise from the issue of a document that has been modified in any way as outlined above.

The results and therefore the conclusions from this desktop study are based on a number of assumptions which may or may not alter the outcomes if they were subsequently found to be inaccurate or inappropriate. All reasonable efforts have been made by GHD to use the most appropriate data and models for the specific process.

10. References

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	D Featherstone	B. Cook	*B Cook*	N Conroy		07/05/14

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Attachment 4 - Tetra Tech, Andrew Harley, Technical Memorandum

TETRA TECH

TECHNICAL MEMORANDUM

To:	John Rozelle
From:	Andrew Harley
Date:	February 19, 2014
Cc:	File
Project No.:	114-311285, Task 050.05
Subject:	Mount Todd Project EIS Comment Response to NTEPA Letter 4 February 2014

1.0 INTRODUCTION

In response to the Northern Territory Environment Protection Authority (NTEPA) letter dated 4 February 2014, Tetra Tech has prepared this Technical Memorandum to evaluate several items outlined in Section 3. Contaminated Drainage From Waste Rock Dump.

2.0 GENERAL COMMENTS REGARDING WASTE ROCK DUMP DESIGN

The proposed waste rock dump (WRD) has been developed to accommodate the specific site requirements and the existing layout of features at the site. The proposed height and steepness of the WRD have been modeled previously and considered stable (Golder, 2012). While the overall design of the WRD is expected to remain, additional designs will be evaluated during further project developments including:

- Assessment of other liner materials such as low-density polyethylene (LDPE) and bituminous geomembranes; and
- Potentially completely sealing several of the upper lifts of the WRD.

3.0 RESPONSE TO SPECIFIC INFORMATION REQUIRMENTS

3.1 CLARIFICATION OF GCL BENCH INTERLAYER WIDTH

As stated in the Technical Memorandum titled “Mt Todd Project EIS Comment Response - Waste Rock Dump Design and Drainage Evaluation”, dated January 16, 2014, the Geosynthetic Clay Liner (GCL) is planned to be approximately 52 meters in width, which corresponds to the width necessary to provide full overlap from bench to bench (Tetra Tech, 2014a).

3.2 JUSTIFICATION OF RP1 WATER QUALITY DATA IN MODELLING

Review of available data for RP-1 indicates that this is the data available to Tetra Tech. This data is considered suitable as it represents the worst case scenario as it is collected at the end of the dry season

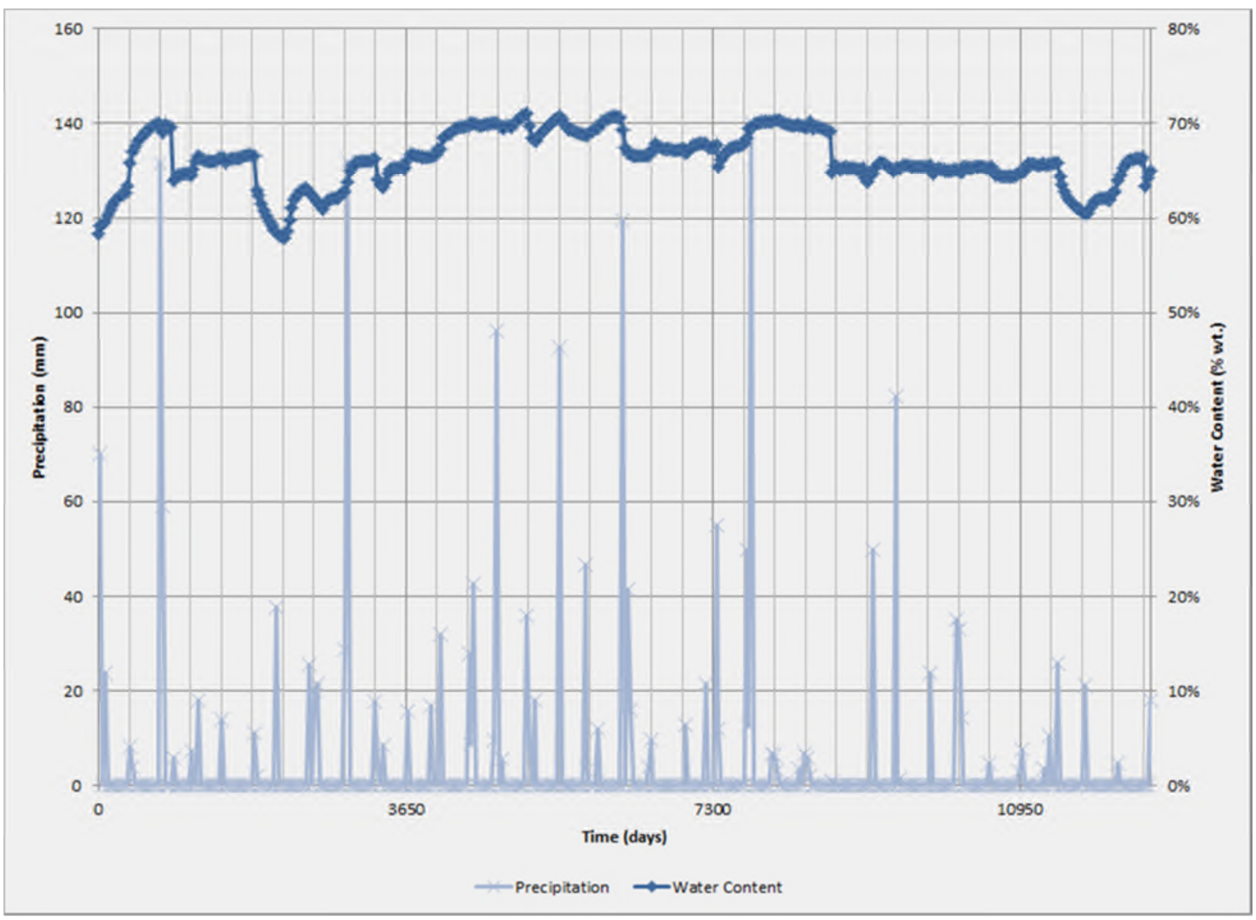
and thus most concentrated. As a result, this is considered the likely worst case scenario, and suitable for modeling.

3.3 TIME SERIES DATA FOR MOISTURE CONTENT OF FINE, COVERING LAYER AND GCL THROUGH WETTING AND DRYING CYCLES, INCLUDING MODELING OUTPUTS

The GCL will have a one foot layer of fines placed over the GCL to provide confining pressure and maintain proper moisture cover. GCL is considered hydrated when the moisture content exceeds 50% by weight (% wt.). Simulation of the proposed Mt. Todd waste rock dump under actual measured climatic conditions showed that the moisture content of the GCL and fines layer does maintain a moisture content greater than 50%, even through multiple wetting and drying cycles (Figure 1).

The modeling outputs presented in Figure 1 are the simulated results of the nodes at the boundary between the fines layer and the GCL in the seepage and infiltration modeling documented in Tetra Tech (2014). The results some variability in moisture content, but generally limited response to the natural drying periods, even drying periods lasting close to two years. The water quality estimates are based on three probable vertical flow paths that the infiltration water is likely to take within the WRDA.

Figure 1: Simulated water content of GCL and Fines layer



3.4 QUANTIFICATION OF NON ACID FORMING (NAF) MATERIAL

The mine production schedule presented in Tetra Tech (2013) for the base case scenario shows that approximately 230,000 KTonnes of non-PAG rock will be produced compared with approximately 330,000 KTonnes of PAG and uncertain waste rock. Thus approximately 30% of the waste rock produced will be available for cover. The non-PAG material is considered suitable for cover, with contact water not anticipated to impact the Edith River as modeled in Attachment A. Scheduling of the waste rock indicates that non-PAG material will be required to be stored prior to being used as cover. During operations, the non-PAG material will be stored within the WRD operational area. As such any metal leachate being generated during operation will report to the equalization pond for treatment.

3.5 GENERATION OF ACID ROCK DRAINAGE AND METALLIFEROUS LEACAHTE (ARD/ML)

As discussed in Section 4.4 of the previous response to the NTEPA comments (Tetra Tech, 2014a), ARD/ML will be generated post closure. It is estimated that approximately 5 years will be required for drainage to equilibrate at approximately 10m^3/day. During this period, the water treatment plant will remain operational. Once static draindown has been achieved, a passive treatment system will be developed to manage the anticipated flow as detailed in Table 1 (reproduced Table 2 from Tetra Tech, 2014a). The viability of a passive treatment system is discussed in Section 2.0 of Tetra Tech (2014b).

Table 1: Modeled Water Quality for Passive Treatment, Post Closure of Water Treatment Plant

Description	Scenario C	Scenario B	Scenario A
	PAG/Uncertain Only (100%)	Non-PAG>PAG/ Uncertain (33.3%, 66.6%)	Non-PAG>PAG>Non-PAG (50%, 37%, 13%)
pH	3.8	3.8	4.0
Sulphate	1,220	816	448
Al	38.8	22.3	6.7
As	0.0119	0.0097	0.0078
Ca	77.4	52.9	31.0
Cd	0.107	0.071	0.039
Cl	9.21	7.64	6.24
Co	1.52	1.02	0.56
Cr	0.00079	0.00061	0.00045
Cu	8.38	5.59	3.10
Fe	0.000060	0.000040	0.000022
K	5.26	3.68	0.60
Mg	191	127	71
Mn	0.0067	0.0045	0.0022
Mo	0.00025	0.00018	0.00012
Na	22.9	15.8	9.4
Ni	12.9	8.64	4.79
Pb	0.053	0.036	0.020
Zn	25.13	16.76	9.30

All units mg/L except pH (S.U.)

4.0 REFERENCES

Golder, 2012. Batman Pit Waste Dump Design Review, Mt Todd, N.T., Australia. Golder Associates Pty Ltd Report Number 117661009-007-R-Rev2.

Tetra Tech, 2013. NI 43-101 Technical Report – Mt. Todd Gold Project 50,000 tpd Preliminary Feasibility Study Northern Territory, Australia. Tetra Tech Document 11431128500-REP-R0001-00 prepared for Vista Gold dated May 29, 2013

Tetra Tech, 2014a. Mt Todd Project EIS Comment Response, Attachment A – Preliminary Waste Rock Dump Design and Drainage Evaluation. Technical Memorandum, dated January 16, 2014.

Tetra Tech, 2014b. Mt Todd Project EIS Comment Response. Technical Memorandum, dated January 16, 2014.

TETRA TECH

ATTACHMENT A

NAF COVER CONTACT WATER MODELING

TECHNICAL MEMORANDUM

To:	John Rozelle
From:	Andrew Harley, Jackie Blumberg
Date:	February 19, 2014
Cc:	File
Project No.:	114-311285, Task 050.05
Subject:	Mount Todd Project – NAF Waste Rock Cover Suitability

1.0 INTRODUCTION

In a Northern Territory Environment Protection Authority (NTEPA) letter dated 4 February 2014, a request was made regarding the suitability of non-acid forming (NAF) material (referred to as non-PAG material with a total sulfur concentration <0.25 wt.%; Tetra Tech, 2013) for use as cover material for the waste rock dump (WRD). As there is no direct testing available, Tetra Tech has prepared this Technical Memorandum to evaluate the suitability of NAF material as cover based on available data.

2.0 NAF MATERIAL CHARACTERISATION

During the geochemical characterization program for the Mt Todd project (Tetra Tech, 2013), the results generated the following waste material handling criteria used for mine planning and proposed for operational considerations:

- Potentially Acid Generating (PAG): Total Sulfur >0.4 wt%;
- Uncertain: Total S 0.25 – 0.4 wt%; and
- Non-PAG: Total Sulfur <0.25 wt%.

While non-PAG material is considered suitable for cover based on low acid-generating potential, samples classified as non-PAG were not evaluated for neutral drainage and associated metal leachate quality. A summary of long-term kinetic testing for several detectable metals is presented in Attachment A, with data compared to ANZECC (2000) Trigger Values for Freshwater, 99% Level of Protection. The total sulfur of samples used for long-term kinetic testing ranged between 0.34 – 0.52 wt %. Regardless of the range of total sulfur, metal leachate was consistent in both the concentration of any metal, and release trends over time. As such, these values are considered a suitable surrogate for evaluating the suitability of NAF material for cover at closure.

General trends for the data are:

- concentrations of Al and As were above Trigger Values, although generally decreasing over time with stable concentrations approximately an order of magnitude higher than Trigger Values;

- concentrations of Cu and Pb fluctuate around the Trigger Value, although predominately lower than Trigger Values;

- concentrations of nickel are generally below the Trigger Value;

- Concentrations of zinc generally increase over time to above the Trigger Value.

Based on this review, the NAF cover rock has the potential to generate metal leachate. The following section provides an estimate of potential runoff within the Edith River following rainfall events.

3.0 WASTE ROCK COVER RUNOFF ESTIMATE

3.1 MODEL APPROACH

Rainfall at the site was modeled stochastically using Goldsim software. Monthly mean and maximum daily observed values were developed from a synthetic data series prepared specifically for the Mount Todd site. The synthetic series relied on real site data where possible, so extreme events like Boxing Day 2011 were adequately captured. Development of the synthetic data series is described in greater detail in a previous memorandum (Tetra Tech, 2010).

Runoff to the Edith River was estimated by applying the Australian Water Balance Model (AWBM; Boughton, 2003) to the stochastic precipitation. Runoff from the Waste Rock Dump (WRD) was modeled using the Soil Conservation Service Curve Number methodology (SCS, 1986). A curve number of 95 was selected to represent the highly impermeable cover material.

A simple dilution mixing model using input concentrations mixed the volume within the Edith River was used to estimate concentrations within the receiving water body.

3.2 MODEL INPUTS

Input concentrations presented in Table 1 include:

- Average steady-state concentrations for several metals calculated for the average of weeks 76 to 144 of the kinetic test. The rationale for this is that the base case scenario presented in Tetra Tech (2013) has the mine operating for 10 years and an estimated five years of closure before the drainage will potentially enter the Edith River. Assuming five major rainfall events each year that potentially generate leachate flowing into the Edith River, over a 15 period that includes operation and closure, 75 wetting and drying cycles are estimated. This is equivalent to week 75 of the kinetic data.
- Maximum concentrations associated for the long-term kinetic data.

Other inputs include:

- Mass Loading (mg/day) = Input Concentration (mg/L) x Covered WRD volumetric runoff (m^3/day);

- Concentration in the Edith River (mg/m^3) = Mass Loading (mg/day) x AWBM Edith River Flows (m^3/day); and

- Dilution Factor (dimensionless) = Input Concentration (mg/L)/Concentration in the Edith River (mg/m^3).

The model simulated 10 years and was run for 100 realizations, or equally likely scenarios.

Table 1: GoldSim Model Input Concentrations

Humidity Cell	Constituent	Steady State Average Concentration Weeks 76-144 (mg/L)	Maximum Concentration (mg/L)
HC-1B	Al	0.0372	0.462
HC-1B	As	0.0047	0.067
HC-3B	Cu	0.0043	0.039
HC-3B	Zn	0.0189	0.028

3.3 MODEL RESULTS AND DISCUSSION

Model outputs for typical (mean) concentrations are presented in Attachments B (long-term average concentrations) and C (maximum concentrations).

Modeled concentrations within the Edith River for any given rainfall event based on long-term average concentrations (Attachment B) show that for all constituents modeled, expected concentrations will be less than ANZECC (2000) Trigger Values for Freshwater at 99% protection. Based on this modeling, there is no anticipated impact to the Edith River of contact water of the WRD following closure.

Modelled concentrations within the Edith River for any given rainfall event based on maximum concentrations (Attachment C) indicate that with the exception of zinc, constituent concentrations are greater than ANZECC (2000) Trigger Values for Freshwater at 99% protection. Several points are to be considered when reviewing these results:

- These concentrations are likely much higher than likely in the field based on the characteristics of the Humidity Cell test procedure. This test is a fixed volume aqueous leach with leach volume to sample mass ratios ranging from 0.5:1 to 1:1, which are unrealistic of field conditions. Additionally, the test cells are prepared with material <6.3mm that is not representative of the material encountered at Mt Todd. Material sizes that are presently within the Mt Todd WRD are in the order of 300-450mm in diameter with virtually no material <2mm. These maximum concentrations reported in the kinetic testing are likely to be much higher than encountered in field conditions for NAF material.
- Concentrations do not consider dilution between the WRD and the Edith River.
- Maximum Al and As concentrations occurred within the projected period that includes management of the WRD drainage such that any surface water runoff is sent to the equalization pond for treatment.
- The maximum Cu concentration occurred as an isolated spike in all humidity cells within the same sampling week, suggesting an analytical inconsistency (Attachment A). Assuming this is

the case, the next maximum value is considerably lower and in line with steady-state average concentrations presented in Attachment B.

- Although the maximum concentration of zinc occurred in the later stages of the kinetic testing, the modeled concentrations within the Edith River are below the Trigger Value.
- The input concentrations used in this model were for waste material classified as Uncertain. This material has a higher sulfur (expected to be as sulfide) than the NAF material, and subsequently lower total metal concentration. As a result, leachate metal concentrations are expected to be lower.

4.0 CONCLUSIONS

Based on the modeling of long-term kinetic data, concentrations of metals that are anticipated to be released from NAF material used as cover at closure is not anticipated to impact the Edith River with regard to aquatic life.

5.0 REFERENCES

ANZEEC 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 1 The Guidelines. Australia and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand.

Boughton, W and Chew, F 2003. Calibrations of the AWBM to Ungauged Catchments. Technical Report 03/15, December 2003.

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Tetra Tech, 2013. NI 43-101 Technical Report – Mt. Todd Gold Project 50,000 tpd Preliminary Feasibility Study Northern Territory, Australia. Tetra Tech Document 11431128500-REP-R0001-00 prepared for Vista Gold dated May 29, 2013

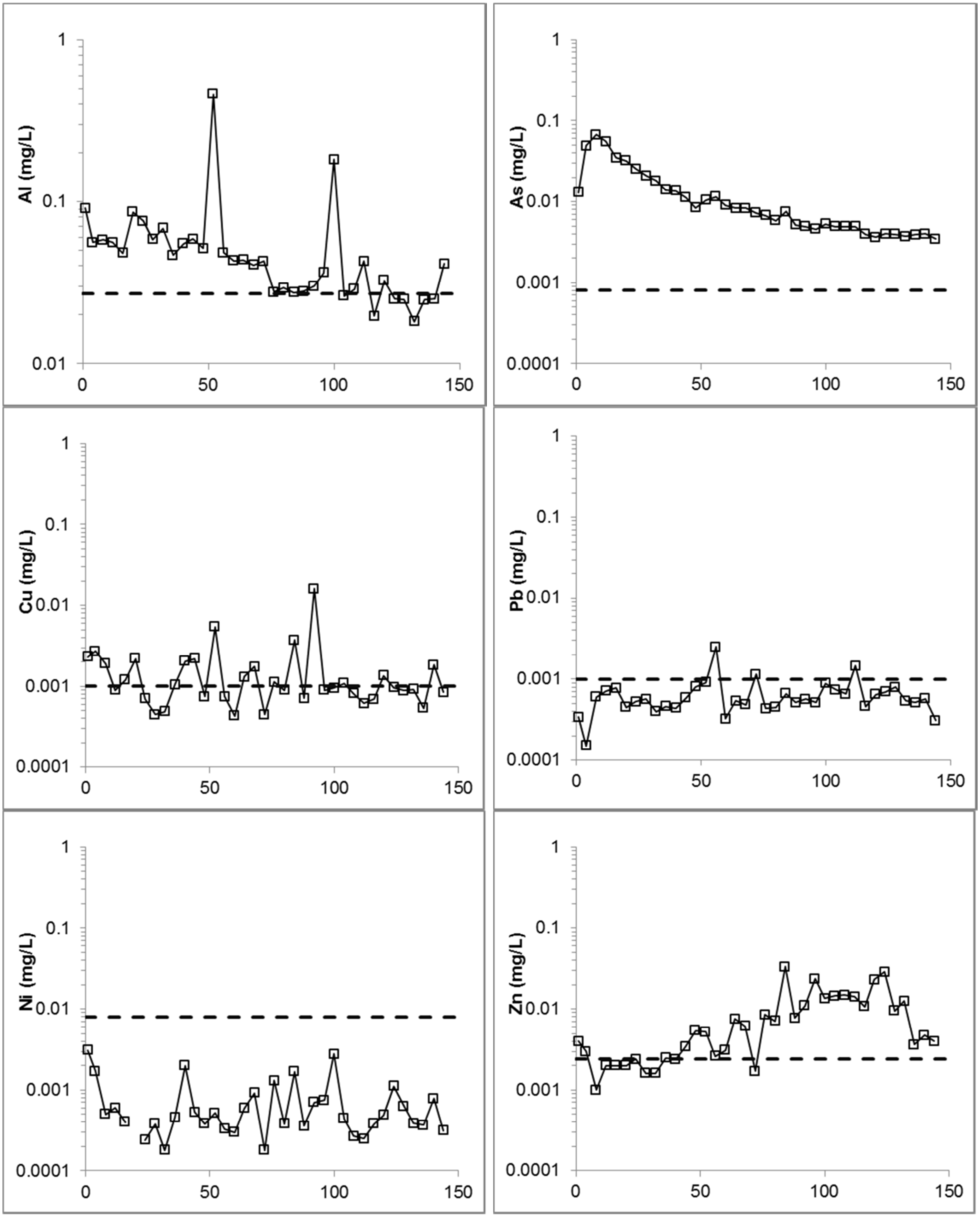
Tetra Tech, 2014a. Mt Todd Project EIS Comment Response, Attachment A – Preliminary Waste Rock Dump Design and Drainage Evaluation. Technical Memorandum, dated January 16, 2014.

Tetra Tech, 2014b. Mt Todd Project EIS Comment Response. Technical Memorandum, dated January 16, 2014.

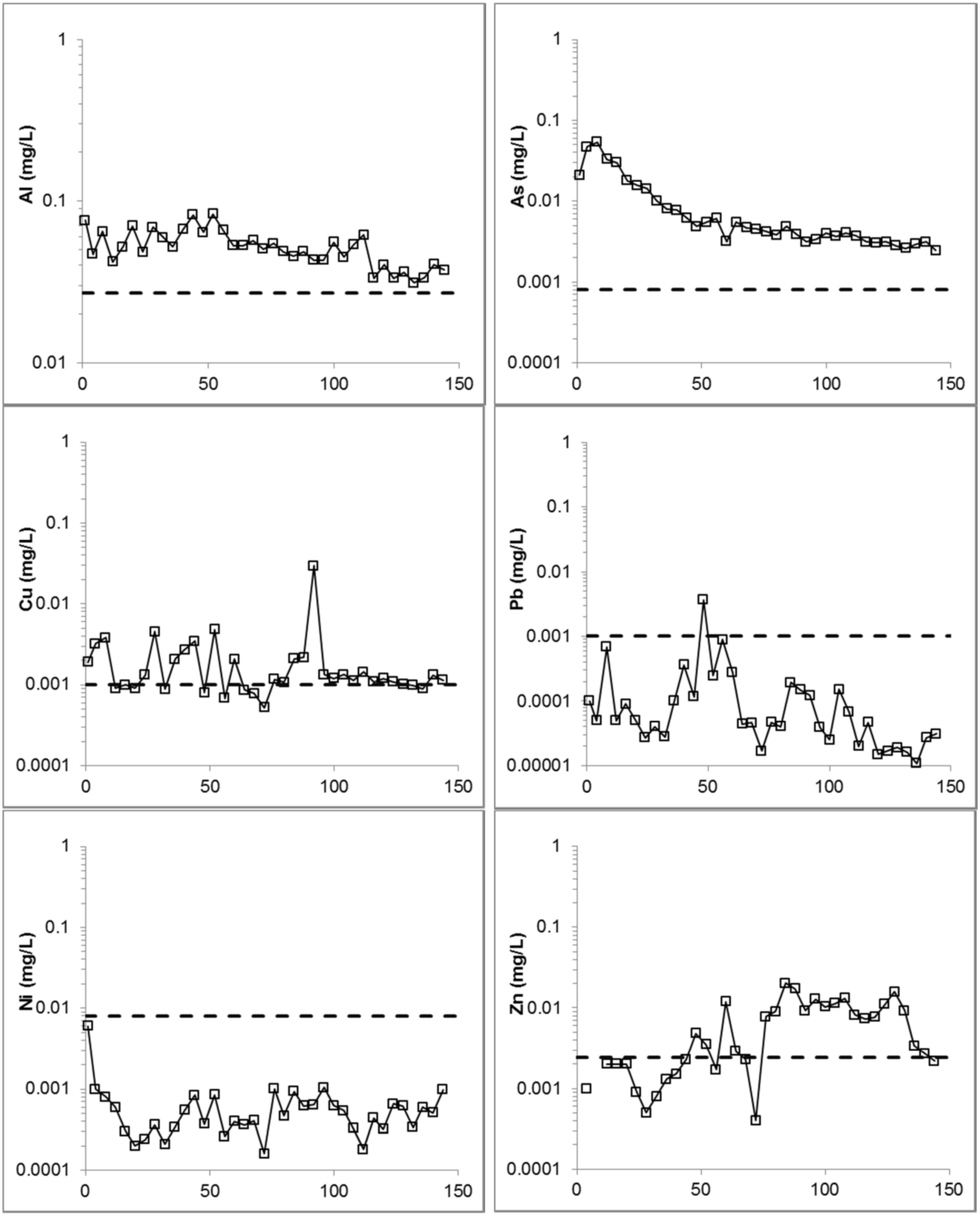
TETRA TECH

ATTACHMENT A
KINETIC DATA

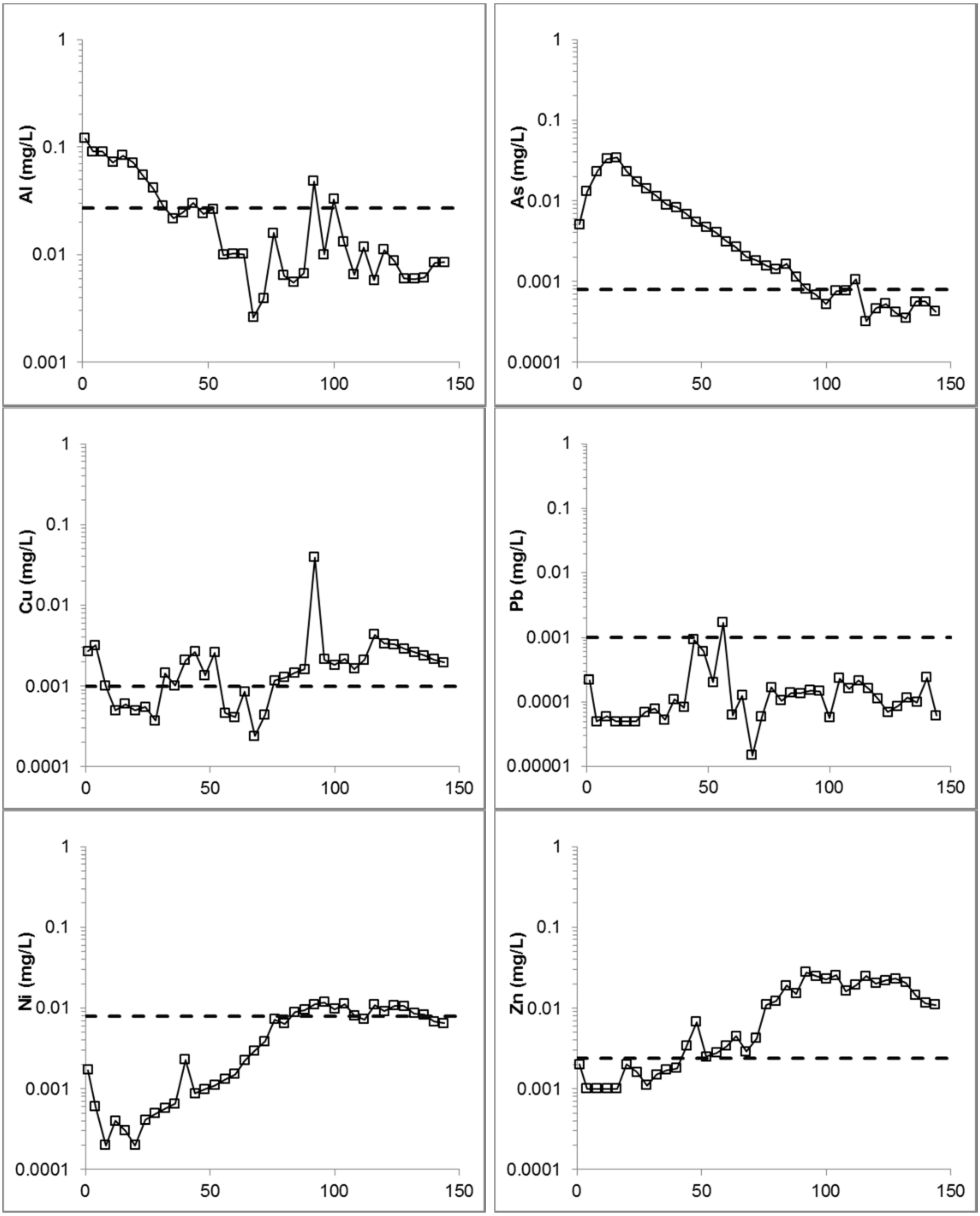
HC-1B 0.34% Total Sulfur



HC-2B 0.52% Total Sulfur



HC-3B 0.37% Total Sulfur

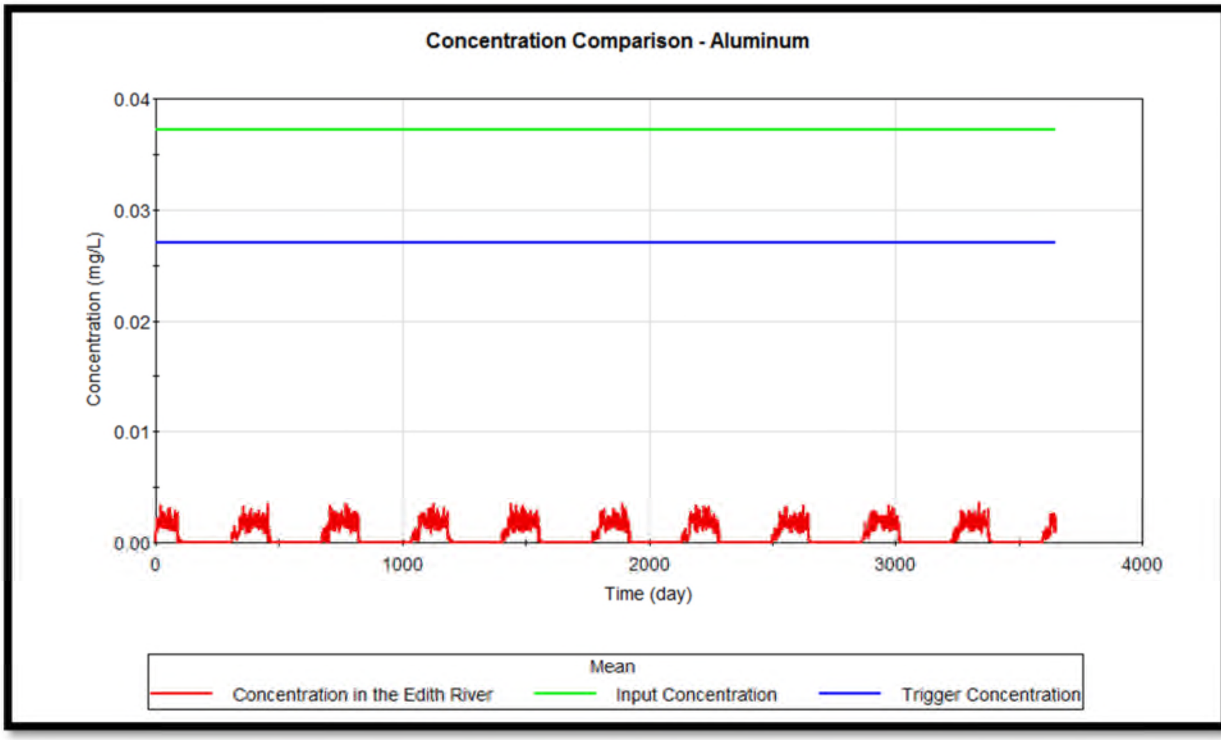


TETRA TECH

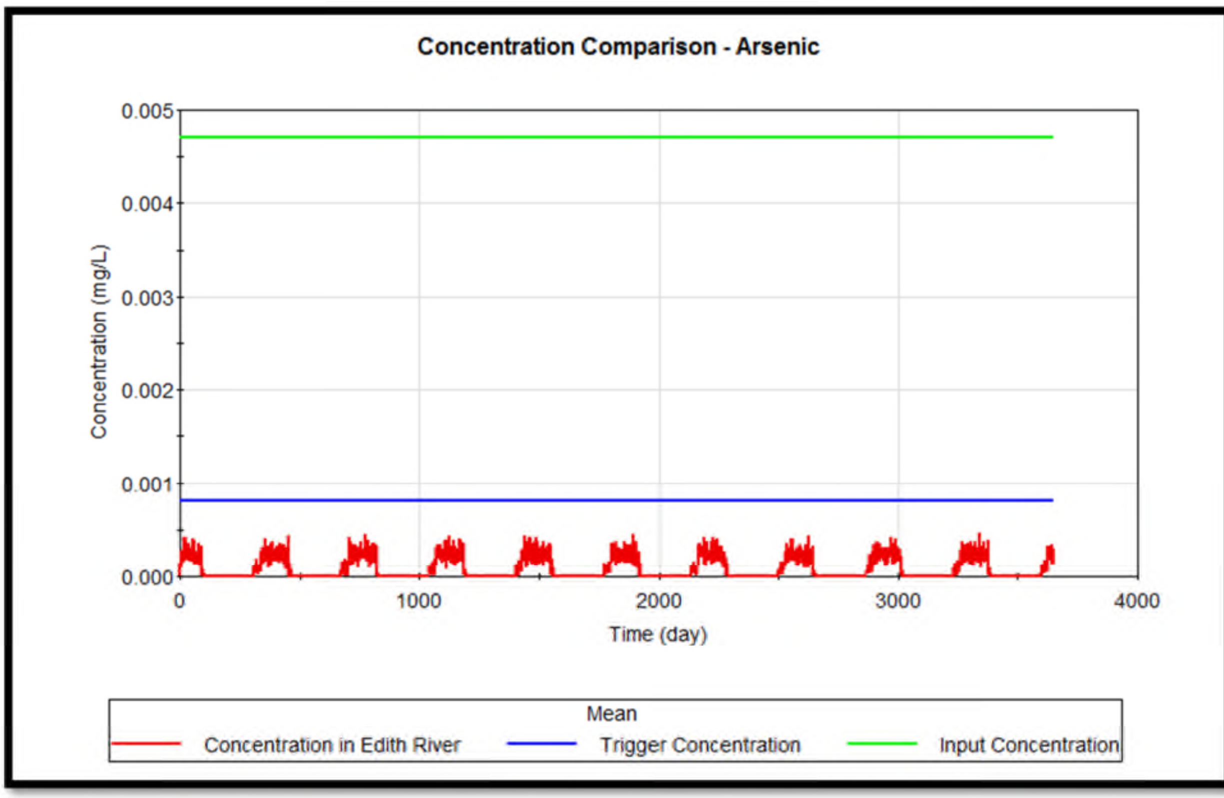
ATTACHMENT B

MODEL RESULTS

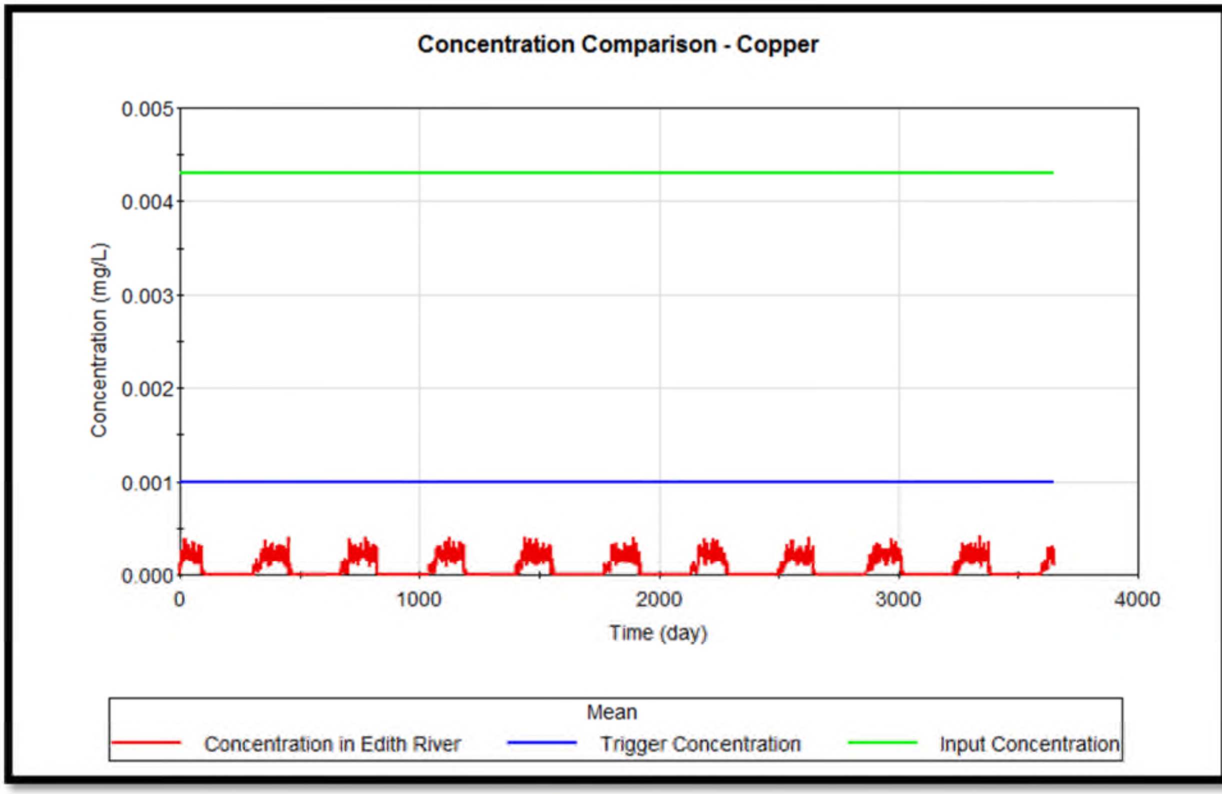
LONG TERM AVERAGE CONCENTRATION INPUTS



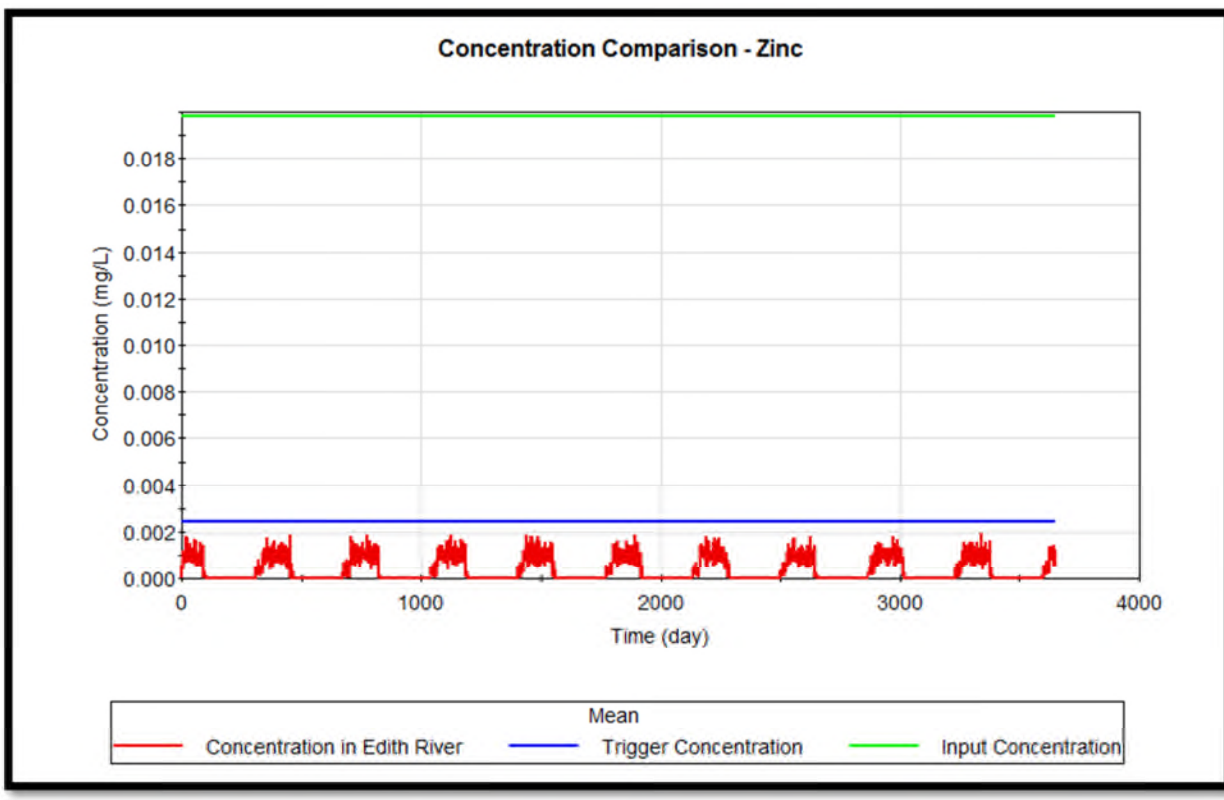
Concentration Comparison - Aluminum
Concentration (mg/L)
0.04
0.03
0.02
0.01
0.00
0
1000
2000
3000
4000
Time (day)
Mean
Concentration in the Edith River
Input Concentration
Trigger Concentration



Concentration Comparison - Arsenic
Concentration (mg/L)
0.005
0.004
0.003
0.002
0.001
0.000
0
1000
2000
3000
4000
Time (day)
Mean
Concentration in Edith River
Trigger Concentration
Input Concentration



Concentration Comparison - Copper
0.005
0.004
0.003
0.002
0.001
0.000
Concentration (mg/L)
0
1000
2000
3000
4000
Time (day)
Mean
Concentration in Edith River
Trigger Concentration
Input Concentration



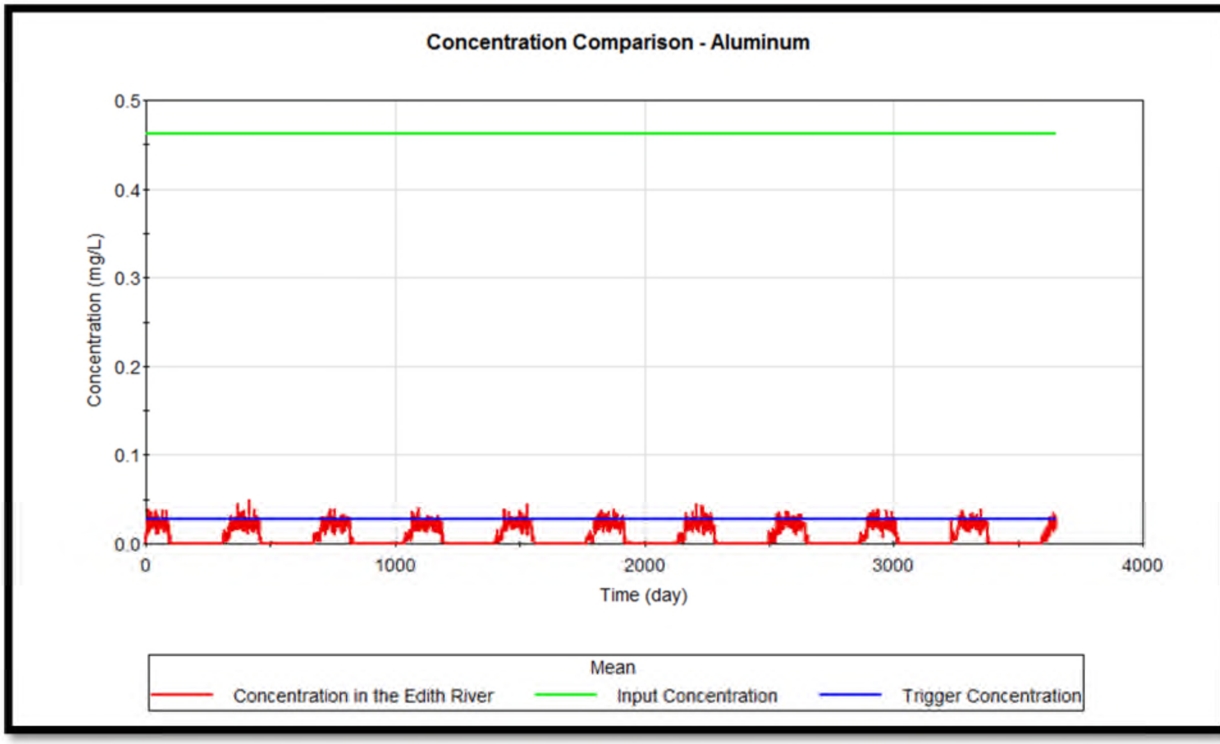
Concentration Comparison - Zinc
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Concentration (mg/L)
0
1000
2000
3000
4000
Time (day)
Mean
Concentration in Edith River
Trigger Concentration
Input Concentration

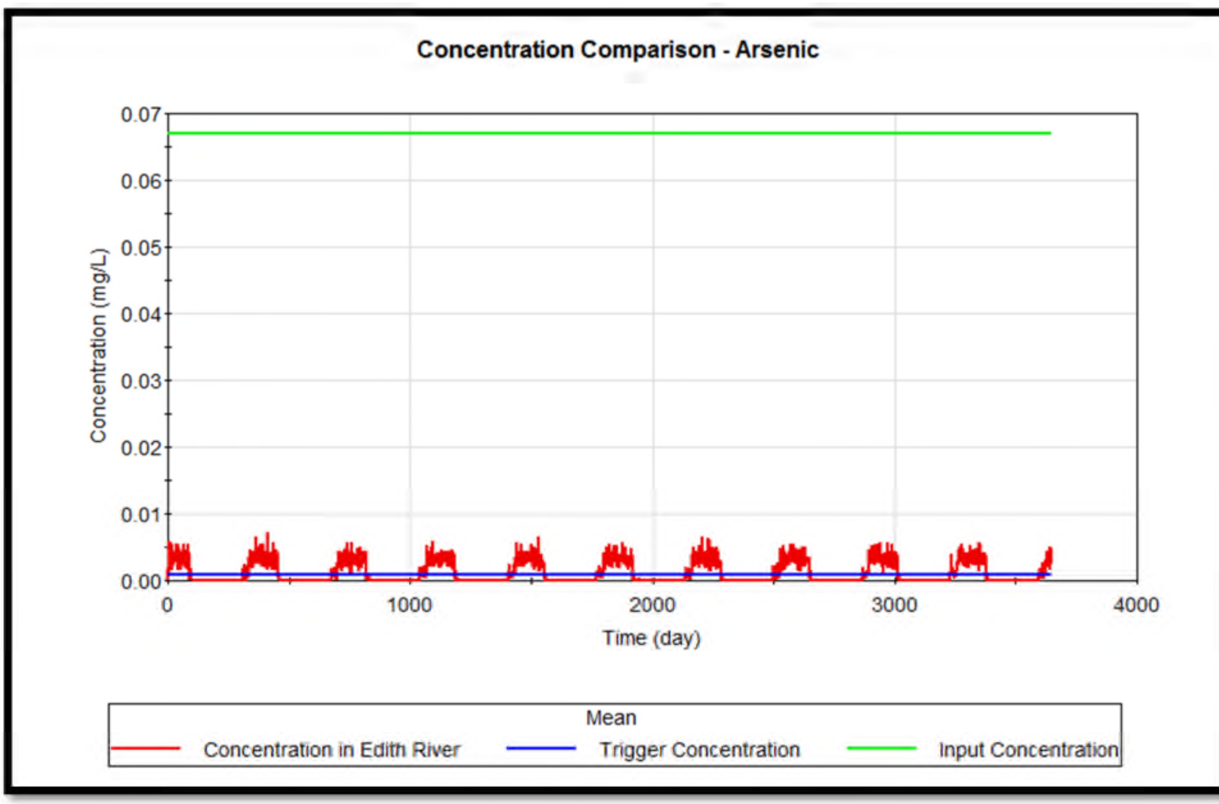
TETRA TECH

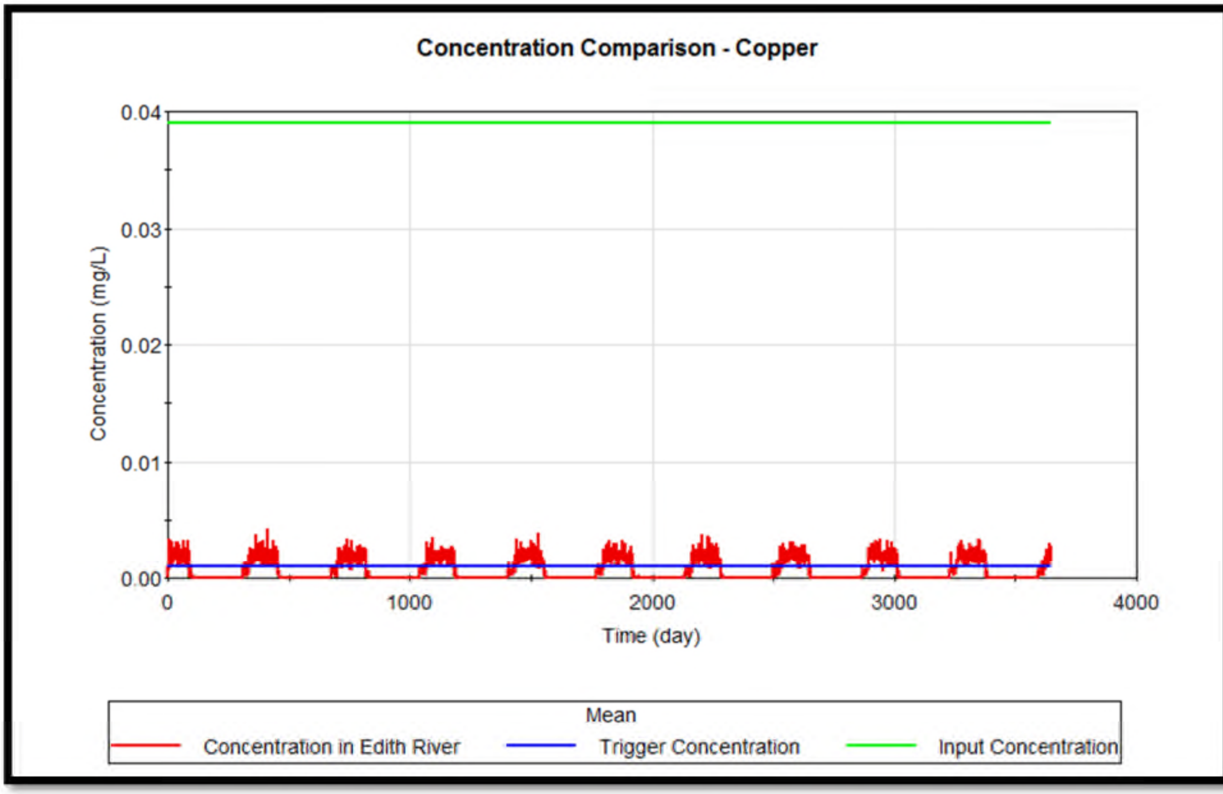
ATTACHMENT C

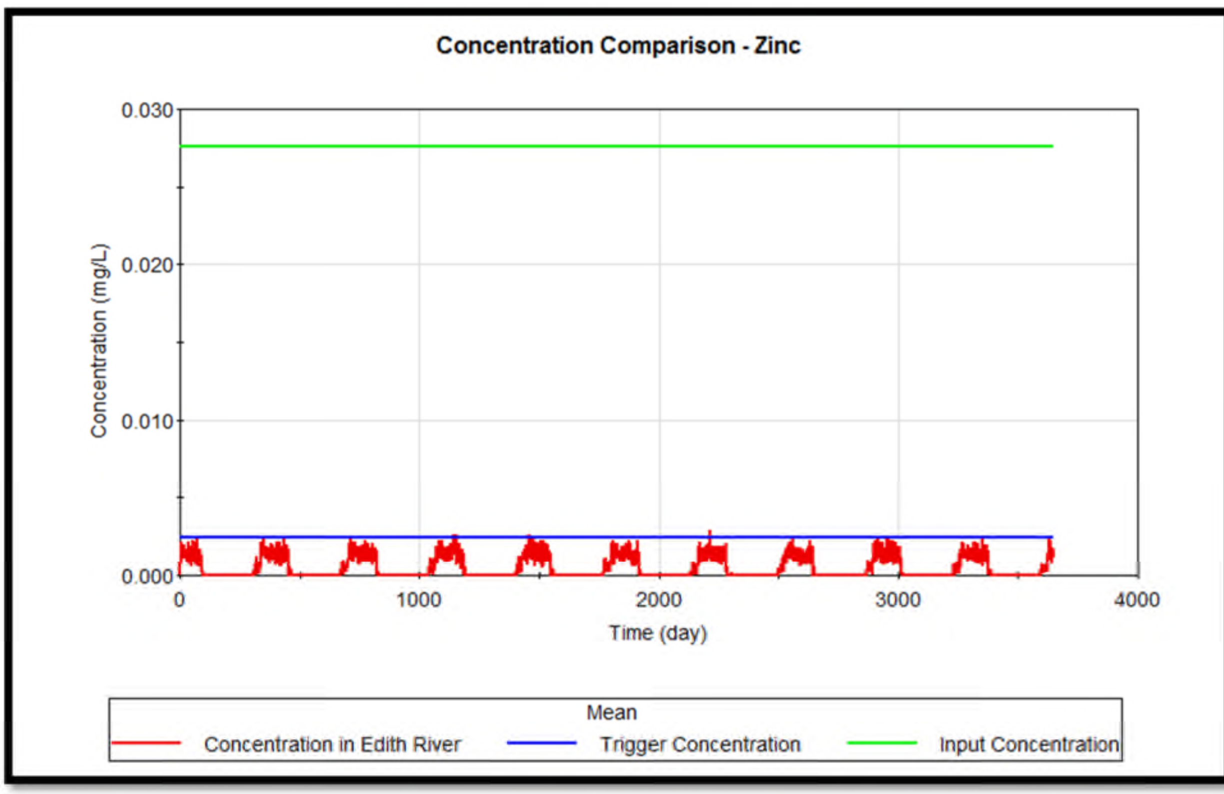
MODEL RESULTS

MAXIMUM CONCENTRATION INPUTS


Concentration Comparison - Aluminum
Concentration (mg/L)
0.5
0.4
0.3
0.2
0.1
0.0
0
1000
2000
3000
4000
Time (day)
Mean
Concentration in the Edith River
Input Concentration
Trigger Concentration


Concentration Comparison - Arsenic
Concentration (mg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
1000
2000
3000
4000
Time (day)
Mean
Concentration in Edith River
Trigger Concentration
Input Concentration


Concentration Comparison - Copper
0.04
0.03
0.02
0.01
0.00
Concentration (mg/L)
0
1000
2000
3000
4000
Time (day)
Mean
Concentration in Edith River
Trigger Concentration
Input Concentration


Concentration Comparison - Zinc
0.030
0.020
0.010
0.000
Concentration (mg/L)
0
1000
2000
3000
4000
Time (day)
Mean
Concentration in Edith River
Trigger Concentration
Input Concentration